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# Global Agro-Ecological Zones Assessment: Methodology and Results

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**FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS**

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## Foreword

The collaboration between the Food and Agriculture Organization of the United Nations (FAO) and the International Institute for Applied Systems Analysis (IIASA) goes back more than twenty years, when FAO started a joint project on Land Resources for the Populations of the Future, completed in 1984. Since then, a number of collaborative programmes were undertaken to underpin perspective studies that allowed prediction and estimates on how agriculture would develop towards the 21st century, and where problems were most likely to develop for achieving food security, particularly in developing countries. Those estimates, which are currently being revisited and extended in FAO's study "Agriculture towards 2015/30", have proved to be quite accurate, widely quoted and appreciated..

Originating from an internationally accepted Framework for Land Evaluation, the Agro-ecological Zones (AEZ) methodology enables rational land management options to be formulated on the basis of an inventory of land resources and evaluation of biophysical limitations and potentials. The recent enhanced availability of digital global databases of climatic parameters, topography, soil and terrain, land cover, and population distribution has now enabled revisions and improvements in AEZ calculation procedures. Also, these data have facilitated expansion of AEZ crop suitability and land productivity assessments to temperate and boreal environments, resulting in a global coverage for assessments of agricultural potentials.

A major challenge facing any scientific analysis of complex societal issues is the communication of research results in a way that provides policy makers and the public with helpful and reliable insights. The IIASA Land Use Project has developed, in cooperation with FAO**,** a CD-ROM application to take advantage of the new ways of communication offered by the electronic media. The hyperlinked document presents the methodology and global data sets applied in the assessment and demonstrates the regional potentials and limitations of land and biological resources. It also discusses various agricultural issues related to regional food security and sustainable resource development.

The CD-ROM begins to address several key resource questions: Will there be sufficient land for agricultural production to meet food and fiber demands of future populations? Where are shortages of agricultural land, and where there is room for agricultural expansion? What contribution can be expected from irrigation? Is land under forest ecosystems potentially good agricultural land? What are the main physical constraints to agricultural production? Will global warming affect agricultural potentials?

It is hoped that the massive amount of analyzed information gathered and presented here, will contribute significantly to a sound use of scarce land resources, and to enhanced food security for all.

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IIASA, Laxenburg, November, 2000

## Abstract

Over the past twenty years, the term *agro-ecological zones methodology* (AEZ) has become widely used. However, it has been associated with a wide range of different activities that are often related yet quite different in scope and objectives. FAO and IIASA differentiate the AEZ methodology in the following activities:

First, AEZ provides a standardized framework for the characterization of climate, soil and terrain conditions relevant to agricultural production. In this context, the concepts of Length of Growing Period (LGP) and of latitudinal thermal climates have been applied in mapping activities focussing on zoning at various scales, from sub-national to global level. Second, AEZ matching procedures are used to identify crop-specific limitations of prevailing climate, soil and terrain resources, under assumed levels of inputs and management conditions. This part of the AEZ methodology provides estimates of maximum potential and agronomically attainable crop yields for basic land resources units. Third, AEZ provides the frame for various applications. The previous two sets of activities result in very large databases. The information contained in these data sets form the basis for a number of AEZ applications, such as quantification of land productivity, extents of land with rain-fed or irrigated cultivation potential, estimation of the land's population supporting capacity, and multi-criteria optimization of land resources use and development.

The AEZ methodology utilizes a land resources inventory to assess, for specified management conditions and levels of inputs, all feasible agricultural land-use options and to quantify expected production of cropping activities relevant in the specific agro-ecological context. The characterization of land resources includes components of climate, soils and landform. Recent availability of digital global databases of climatic parameters, topography, soil and terrain, and land cover has allowed for revisions and improvements in calculation procedures and to expand assessments of AEZ crop suitability and land productivity potentials to temperate and boreal environments. This effectively enables global coverage for assessments of agricultural potentials.

The AEZ methodologies and procedures have been extended and newly implemented to make use of these digital geographical databases, and to cope with the specific characteristics of growing periods in the seasonal temperate and boreal climates. This report describes the methodological adaptations necessary for the global assessment and illustrates with numerous results a wide range of global AEZ applications.

## Executive Summary

### Background

Land is an indispensable resource for the most essential human activities: it provides the basis for agriculture and forest production, water catchment, recreation, and settlement. The range of uses that can be made of land for human needs, is limited by environmental factors including climate, topography and soil characteristics, and is to a large extent determined by demographic, socioeconomic, cultural, and political factors, such as population density, land tenure, markets, institutions, and agricultural policies.

The Food and Agriculture Organization of the United Nations (FAO) with the collaboration of the International Institute for Applied Systems Analysis (IIASA), has developed a system that enables rational land use planning on the basis of an inventory of land resources and evaluation of biophysical limitations and potentials. This is referred to as the Agro-Ecological Zones (**AEZ**) methodology.

Recent availability of digital global databases of climatic parameters, topography, soil and terrain, vegetation, and population distribution has called for revisions and improvements in calculation procedures and in turn has allowed for expanding assessments of AEZ crop suitability and land productivity potentials to temperate and boreal environments.

### Methodology

The AEZ methodology follows an environmental approach; it provides a standardized framework for the characterization of climate, soil and terrain conditions relevant to agricultural production. Crop modeling and environmental matching procedures are used to identify crop-specific limitations of prevailing climate, soil and terrain resources, under assumed levels of inputs and management conditions. This part of the AEZ methodology provides maximum potential and agronomically attainable crop yields for basic land resources units (usually grid-cells in the recent digital databases).

The AEZ computations were completed for a range of climatic conditions, including a reference climate (average of period 1961-1990), individual historical years of 1960 to 1996, and scenarios of future climate based on the published outputs of various global climate models. Hence, the AEZ results consistently quantify impacts on land productivity of historical climate variability as well as of potential future climate change.

The FAO/Unesco Digital Soil Map of the World (**DSMW**) has been made the reference for constructing a land surface database comprising of more than 2.2 million grid-cells at 5' latitude/longitude within a raster of 2160 rows and 4320 columns. On the input side, the key components of the database applied in AEZ include the FAO DSMW and linked soil association and attribute tables, a slope distribution database, and a layer providing distributions in terms of eleven aggregate land-cover classes derived from a global 1 km seasonal land cover data set. On the output side, many new data sets have been compiled at grid-cell level and have been tabulated at country and regional level, including general agro-climatic characterizations of temperature and moisture profiles, and time-series of attainable crop yields for major food and fiber crops.

The information contained in these data sets forms the basis for several further AEZ applications. Examples are: the quantification of land productivity, the estimation of extents of land with rain-fed or irrigated cultivation potential, the occurrences of environmental constraints to agricultural production, the identification of potential 'hot spots' of agricultural conversion, and the possible geographical shifts of agricultural land potentials as result of changing climate. Finally, the results of AEZ land productivity assessments provide a spatially explicit and agronomically sound basis for applications of multi-criteria optimization of land resources use and development.

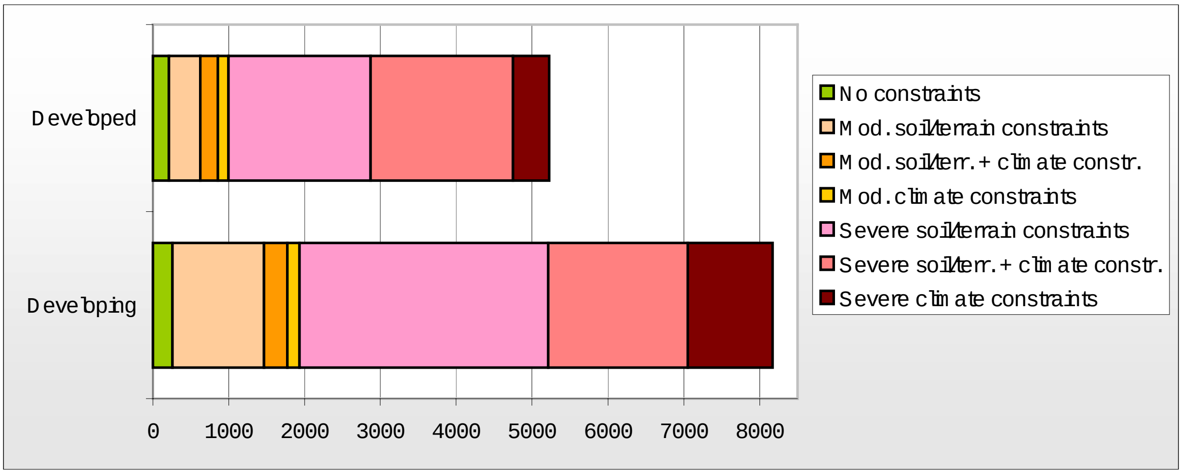
**Findings**

In the 1998 Revision, the United Nations medium variant population projection indicates an increase of world population to about 8.9 thousand million by the year 2050, with a possible range of 7.3 to 10.7 thousand million. Most experts agree that through full and adequate application of modern agricultural technology, the world's land resources could provide sufficient food, fiber, animal feed, biofuel and timber for such a world population. In practice, however, there will very likely be acute land shortages in some regions, especially in several developing countries. The AEZ procedures and applications have been used to provide an up-to-date environmental assessment of global food and fiber prospects.

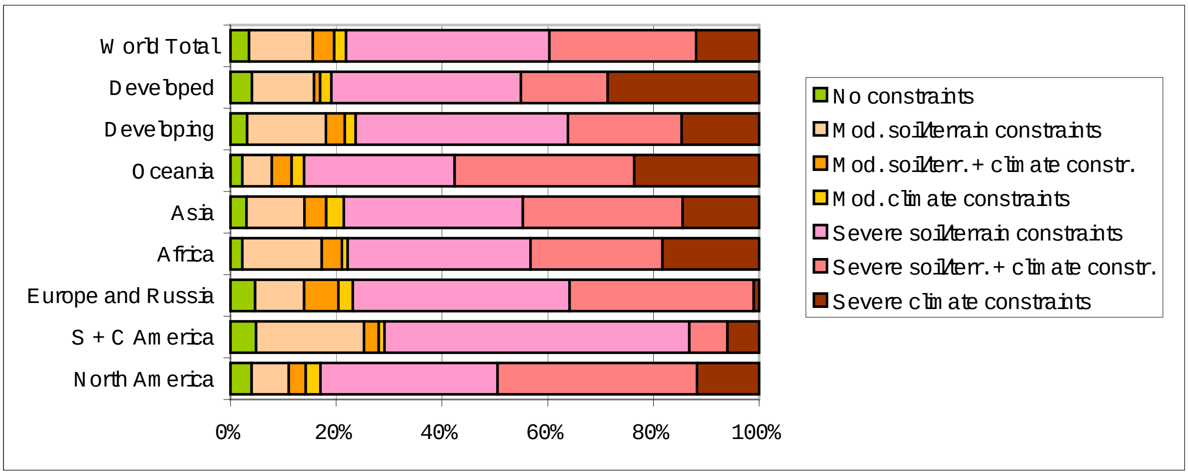
1. The AEZ results confirm that the Earth's land, climate and biological resources are sufficient to meet the needs of food and fiber of future generations, and more in particular for a world population of 8.9 thousand million, as projected for the year 2050 by the UN medium variant.

2. Despite this affirmative aggregate picture, there are also reasons for profound concerns. Several regions exist, where the rain-fed cultivation potential has already been exhausted, as for example is the case in parts of Asia. Land degradation, if continuing unchecked, may exacerbate regional land scarcities. Concerns for the environment may prevent some resources from being developed for agriculture. Global warming may alter the condition and distribution of land suitable for cropping. In addition, socioeconomic development may infringe on the current agricultural resource base for want of rapidly expanding industrial and service sectors.

3. On the basis of currently available global soil, terrain and climate data, the AEZ approach estimates that 10.5 thousand million hectares of land, i.e., more than three-quarters of the global land surface (excluding Antarctica), suffer rather severe constraints for rain-fed crop cultivation. Some 13 percent is too cold, 27 percent is too dry, 12 percent is too steep, and about 65 percent are constrained by unfavorable soil conditions (multiple constraints coinciding in some locations).




Extents of land with climate and soil/terrain constraints




Distribution of climate and soil/terrain constraints by region

4. Various ways are available for estimating the extent of land with cultivation potential for rain-fed crops. Any quantification depends on a variety of assumptions: the range of crop types considered, the definition of what level of output qualifies as acceptable, the social acceptance of land-cover conversions (in particular of forests), and the assumptions on what land constraints may be alleviated with modern inputs and investment. Hence, our estimates range from 1.3 thousand million ha (land very suitable and suitable for major cereal crops, under high inputs and mechanization, outside current forest areas) to 3.3 thousand million ha (land very suitable, suitable or moderately suitable for at least one of the AEZ crop types, within or outside current forest areas). The results presented in this study are based on the following calculation procedures for each grid-cell:

(1) Determine all land very suitable and suitable at high level of inputs for the crops offering the largest total extent;

(2) Of the balance of land after (1), determine all land very suitable, suitable or moderately suitable at intermediate level of inputs for the crops offering the largest extent, and

(3) Of the balance of land after (1) and (2), determine all suitable land (i.e. very suitable, suitable, moderately suitable or marginally suitable) at low level of inputs for the crops offering the largest extent.

The total extents obtained in this way for each grid-cell, referred to as mixed level of inputs, were calculated for rain-fed and rain-fed plus irrigated conditions. When considering all modeled Global AEZ crop types (excluding silage maize, forage legumes and grasses), mixing all three input levels, and assuming no restrictions for land-cover conversion, we conclude that about one-quarter of the global land surface (excluding Antarctica) can be regarded as potentially suitable for crop cultivation. In developed countries about one-fifth comprises of land with rain-fed cultivation potential. In developing countries it amounts to about 28 percent. This estimate, based on a rather generous definition of land with cultivation potential, is twice the area estimated as actually in use for cultivation in 1995-97 (FAO, 2000; Table 4.7, p. 104).

| Region | Total Land | Land with cultivation potential | | Housing, Infrastr. | Not suitable |
|---|---|---|---|---|---|
| | | Total | Under forest | | |
| North America | 2138 | 384 | 135 | 9 | 1637 |
| South & Central America | 2049 | 858 | 346 | 16 | 1048 |
| Europe and Russia | 2259 | 511 | 97 | 21 | 1645 |
| Africa | 2990 | 939 | 132 | 26 | 1909 |
| Asia | 3113 | 516 | 47 | 83 | 2407 |
| Oceania | 850 | 116 | 17 | 1 | 694 |
| Developing | 8171 | 2313 | 527 | 124 | 5383 |
| Developed | 5228 | 1012 | 247 | 33 | 3956 |
| World Total | 13400 | 3325 | 774 | 156 | 9338 |

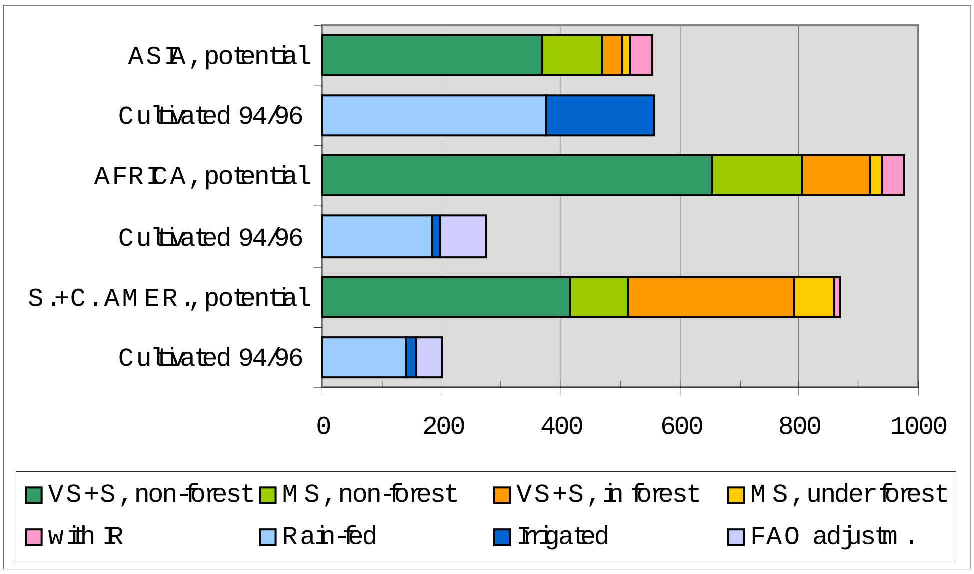
Land with rain-fed cultivation potential for major food and fiber crops (million ha)

Nevertheless, there are several regions where the rain-fed cultivation potential is nearly fully exhausted or has already been exceeded. If forests were to be maintained, then less than 2.55 thousand million ha would qualify as land with cultivation potential, of which 1.94 thousand million ha are adjudged very good or good suitability.

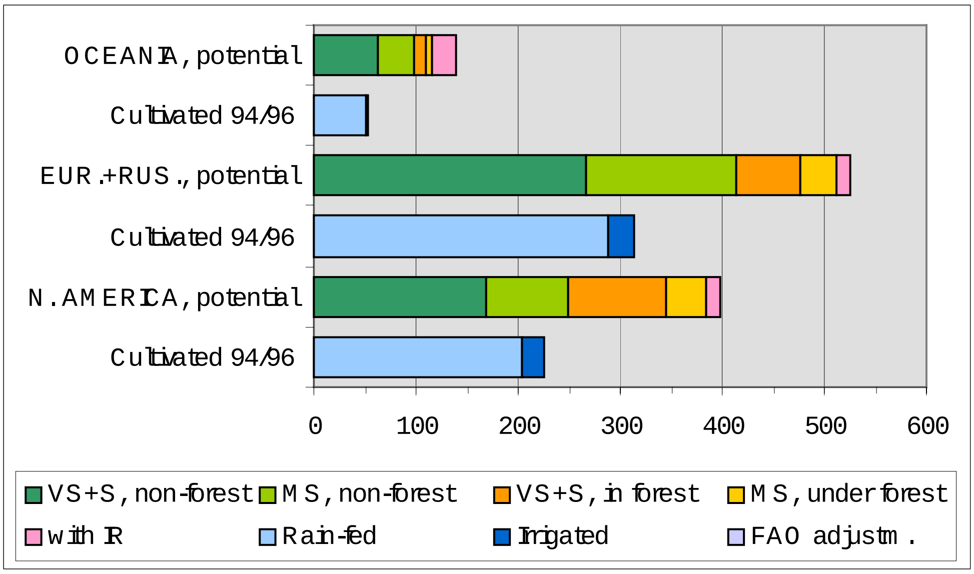
| Region | Rain-fed cultivated land 1994-96 | Land with good cultivation potential | | Land with moderate cultivation potential | |
|---|---|---|---|---|---|
| | | Total | Under forest | Total | Under forest |
| North America | 203 | 266 | 96 | 118 | 39 |
| South & Central America | 141 | 698 | 281 | 161 | 65 |
| Europe and Russia | 289 | 329 | 61 | 183 | 35 |
| Africa | 185 | 767 | 114 | 172 | 18 |
| Asia | 376 | 406 | 36 | 110 | 11 |
| Oceania | 50 | 75 | 12 | 40 | 5 |
| Developing | 702 | 1871 | 433 | 441 | 94 |
| Developed | 543 | 669 | 168 | 343 | 79 |
| World Total | 1245 | 2541 | 601 | 784 | 174 |

Rain-fed cultivated land in 1994-96 (Source: FAOSTAT) and suitability of rain-fed cultivation potential for major food and fiber crops (million ha)

5. Despite recognizing that statistics of land in cultivation are likely to be underestimating actual use in developing countries by some 10 to 20 percent (see FAO, 2000), the Global AEZ results indicate that there is still a significant potential for conversion to arable use in Africa and South America, including from current forest areas. In other regions this potential is either exhausted (e.g., Asia) or unlikely to be exploited for agriculture under current and expected future conditions (i.e., Europe, North America and Oceania).




Comparison of land with crop production potential and land used for cultivation in 1994-96 (million ha) in developing regions




Comparison of land with crop production potential and land used for cultivation in 1994-96 (million ha) in developed regions

VS = very suitable, S = suitable, MS = moderately suitable

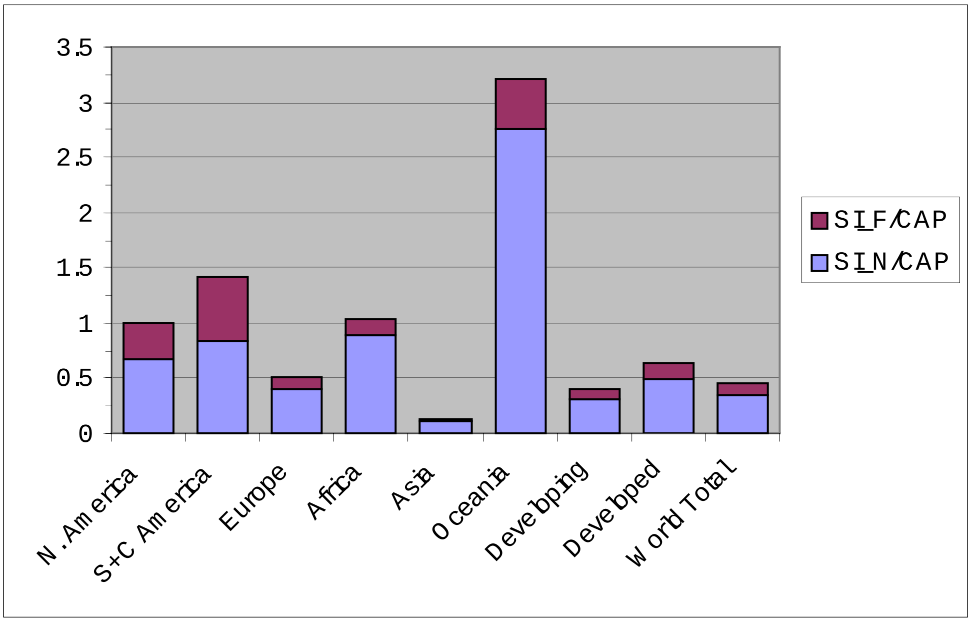
6. By looking at the full range of crop types, without consideration of the demand for different products, we may over-estimate the useful extents of land with cultivation potential. When restricting the considered crop types to the three major cereals, namely wheat, rice, and grain-maize, and allowing for nonagricultural land uses, an estimate of about 2.4 thousand million ha of land with rain-fed cultivation potential was obtained. Of these, 1.5 thousand million ha were found in developing countries and 0.9 thousand million ha in developed regions.

| Region | Total Land | Land with good cultivation potential | | Land with moderate cultivation potential | |
|---|---|---|---|---|---|
| | | Total | Under forest | Total | Under forest |
| North America | 2138 | 235 | 82 | 107 | 33 |
| South & Central America | 2049 | 283 | 128 | 191 | 72 |
| Europe and Russia | 2259 | 282 | 41 | 181 | 35 |
| Africa | 2990 | 404 | 25 | 188 | 18 |
| Asia | 3113 | 263 | 14 | 121 | 11 |
| Oceania | 850 | 44 | 7 | 29 | 4 |
| Developing | 8171 | 1076 | 166 | 498 | 100 |
| Developed | 5228 | 565 | 132 | 319 | 72 |
| World Total | 13400 | 1612 | 298 | 817 | 172 |

Land with rain-fed cultivation potential for wheat, rice or grain-maize (million ha)

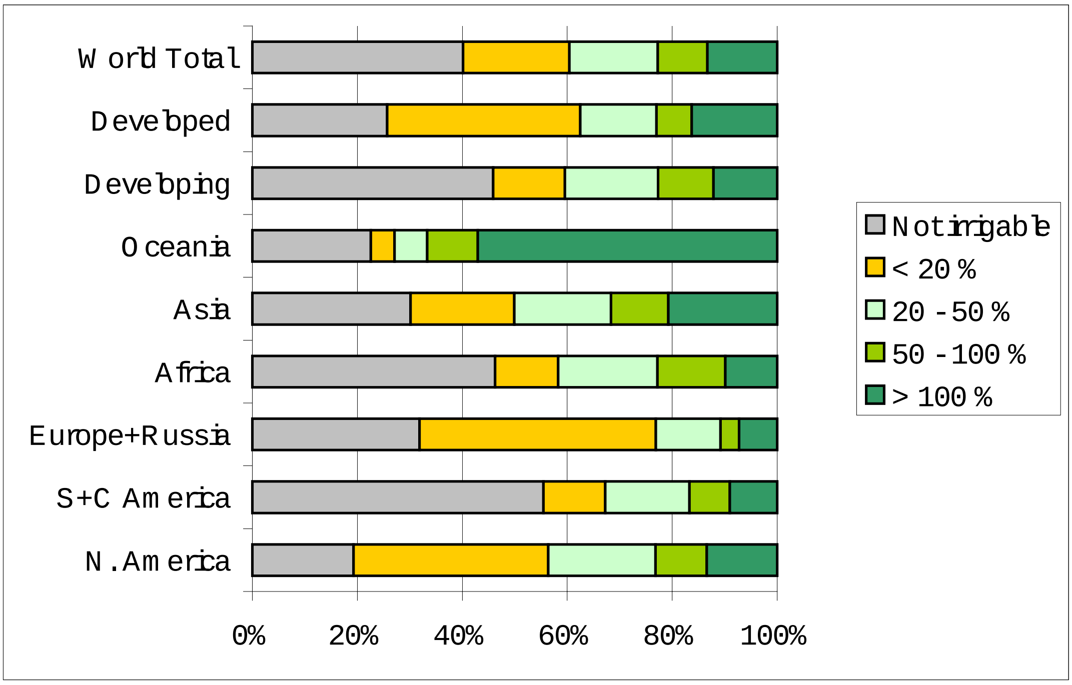
**7.** Combining AEZ results with spatial land cover data, the extent of land with cultivation potential presently under forest ecosystems was estimated. About 237 million hectares of the area classified as forest ecosystems was assessed as very suitable or suitable for cultivation of wheat, rice or grain-maize at high level of inputs. On the other hand, the analysis shows that globally almost 85 percent of forest ecosystems are considered not suitable or at best marginally suitable for cereal cultivation.

8. The study highlights the uneven distribution of land and climate resources. We use population estimates of 1995 and a suitability index SI (a weighted sum of different land suitability classes optimizing over all AEZ food crops and for mixed input levels) to compare availability of land with crop cultivation potential across regions, both with and without consideration of areas classified as dominantly forests. SI_N and SI_F refer respectively to the index numbers calculated for areas outside and within forest areas. For total availability (SI_N plus SI_F) the world average is 0.45 suitability index units per person, ranging between 0.12 units in Asia to 3.2 units in Oceania.




Per capita availability of land with crop cultivation potential (SI units/person)

9. Assuming availability of water resources, but limiting the analysis to soil conditions indicating presence of water (such as Gleysols and Fluvisols), some 65 million hectares, i.e., only about 1.8 percent of arid and hyper-arid zones, were assessed as prime land for cereals under irrigation, which in turn equates to less than 3 percent of total prime land for cereals. The results suggest that irrigation is more important in providing stable water supply in areas of climatic variability rather than for bringing land in hyper-arid and arid regions into cultivation.




Distribution of land with cultivation potential by irrigation impact classes, showing increase in potential output with full exploitation of irrigation.

Full exploitation of all potential irrigable land would increase the global gross extent of suitable land for cereals by 6 to 9 percent. The impact of irrigation is more pronounced on the increase of potential production than on potential area. The global cereal production potential would increase by 30 to 40 percent.

10. The application of a set of temperature and rainfall sensitivity scenarios revealed a modest increase of cultivable rain-fed land for temperature increases up to 2°C on global scale. With a higher temperature increase alone, extents of cultivable rain-fed land start to decrease. When both temperature and rainfall amounts increase, the extents of cultivable rain-fed land increase steadily. For example, a temperature increase of 3°C paired with a rainfall increase of 10 percent would lead globally to about 4 percent more cultivable rain-fed land. In the developed countries this increase is even markedly higher; it exceeds 25 percent. Contrariwise, for developing countries there would be a decrease of 11 percent.

**Limitations of the study**

The Global AEZ results presented are based on a half-degree latitude/longitude world climate data set, 5' soils data derived from the digital version of the FAO Soil Map of the World, the 1 km Global Land Cover Characteristics Database, and a 30 arc-second digital elevation data set. While representing the most recent global data compilations, the quality and reliability of these data sets is known to be uneven across regions. Especially the quality of the world soil map is reason for concern. It is based on a 1:5,000,000 scale map and it is generally accepted that its reliability may vary considerably between different areas. At present substantial improvements to the soil information is in progress and several regional updates were published recently.

Another issue is that the current status of land degradation cannot be inferred from the FAO Soil Map of the World. The only study available with global coverage, the Global Assessment of Soil Degradation (GLASOD) offers insufficient detail and quantification for useful application within Global AEZ.

Socioeconomic needs of rapidly increasing and wealthier populations are the main driving force in the allocation of land resources to various kinds of uses, and socioeconomic considerations are crucial for rational planning of sustainable agricultural development. So far, in Global AEZ the use of socioeconomic information is limited to two elements: spatial distribution of population, and the definition of modes of production and the quantification of 'input-output packages'. The latter are referred to as the land utilization types, taking, to some extent, into account the socioeconomic context of production decisions and conditions.

For the above reasons, the results obtained from this Global AEZ study should be treated in a conservative manner at appropriate aggregation levels, which are commensurate with the resolution of basic data and the scale of the study.

While various modes have been pursued for “ground-truthing” and verifying results of the Global AEZ suitability analysis, there is a need for further validation of results and underlying databases

**Next steps**

The present study has outlined various applications, where biophysical assessments based on AEZ can substantially contribute. While improvement of the basic methodology and data is a general aim, the planned work is concerned with regional applications and case studies. Several activities related to Agro-ecological Zones are currently under way or under consideration:

- An AEZ application dealing with the impacts of climate variability and climate change on agricultural production on global scale. In this, we intend to include water resources data and modeling to enhance the assessment of irrigation production potentials at watershed level.
- A CD-ROM dealing with various data sets including results of AEZ applications generated by IIASA's Land Use Change Project (LUC) covering the Former Soviet Union, Mongolia and China at a 5 km resolution grid. This CD-ROM will also include an AEZ application for forestry, i.e., for biomass plantation forestry, traditional forestry, and conservation forestry.
- Specific AEZ studies for so-called "hot spots" with special reference to the effect of climatic variability on food security. Proposed study areas are: Horn of Africa, (IGADD countries). Southern Africa (Zimbabwe, Mozambique, South Africa), Bangladesh, and China. Because of limited availability of ground data for the Africa studies, we will to a large extent rely on historical remote sensing data, such as AVHRR and LANDSAT data.
- Using results of the present study by FAO and IIASA and other institutions for linking with agricultural, demographic and socio-economic statistics.

It is expected that the Global AEZ basic suitability procedures and model parameters will benefit from scrutiny and updating while routinely used or as result of newly developed applications.

## Acknowledgments

This important study would not have been initiated and carried out in its full breath without the intellectual and financial support of FAO and the ample facilities made available in IIASA's Land Use Change (LUC) project. In particular we wish to acknowledge the foresight and the support of the respective former Directors of the Land and Water Development Division of FAO, Dr. Wim Sombroek and Dr. Robert Brinkman and the former Director of IIASA, Dr. Gordon MacDonald.

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The CRU 0.5×0.5˚ latitude/longitude gridded monthly climate data has been supplied by the Climate Impact LINK Project (UK Department of the Environment, Contract EPG 1/1/16) on behalf of the Climate Research Unit, University of East Anglia.

We wish to express our sincere gratitude to the colleagues in the LUC Project at IIASA: to Ms. Sylvia Prieler for providing help with GIS and data issues in numerous instances, and to Ms. Cynthia Enzlberger-Vaughan for editing the report.

## About the Authors

Günther Fischer is the leader of a major research project at IIASA on *Modeling Land Use and Land Cover Changes in Europe and Northern Asia (LUC)*. A primary research objective of this project is the development of a GIS-based modelling framework, which combines economic theory and advanced mathematical methods with biophysical land evaluation approaches to model spatial and dynamic aspects of land-resources use. He was a member of the IGBP-HDP Core Project Planning Committee on Land-Use and Land-Cover Change (LUCC), and is a co-author of the LUCC Science Plan. He serves on the Scientific Steering Committee of the joint LUCC Core Project/Programme of the IGBP-IHDP, and leads the *LUCC Focus 3 office* at IIASA.

Harrij van Velthuizen has over twenty years experience in applied land resources ecology. He was a member of the working group that developed FAO's Agro-Ecological Zones (AEZ) methodology. As senior consultant and chief technical advisor, van Velthuizen has been working for projects on agro-ecological assessments for agricultural development planning in countries in Asia, Africa and South America. Since 1995, van Velthuizen has been working closely with the IIASA-Land Use Change Project on enhancement of the AEZ methodologies and various applications for the Former Soviet Union, China, Bangladesh, Kenya and Nigeria and at the global level. Recently he has also been serving as land resources ecologist in a FAO/UNDP project concerned with *Utilization of Agro-ecological Zones Databases* at the Bangladesh Agricultural Research Council, and as an advisor on agro-ecological zoning in a DANIDA/World Bank project on *Environmental Information Systems Development* in Ghana.

Freddy Nachtergaele is an agronomist who has been working for the Food and Agriculture Organization of the United Nations in Rome as a Technical Officer for Soil Resources and Land Classification with the Land and Water Development Division since 1989. Prior to that he was a land resources expert for FAO in field projects in North and East Africa and in Southeast Asia. He is Vice-Chairman of the IUSS working group on the World Reference Base for Soil Resources, and coordinates the update of the FAO/Unesco Soil Map of the World at FAO. He is the author of numerous scientific articles in the field of agro-ecological zoning, land evaluation, land-use planning and soil classification.

## Acronyms and Abbreviations

| | |
|---|---|
| AEZ | Agro-Ecological Zones |
| ALES | Automated Land Evaluation System |
| ASSOD | Assessment of the Status of Human-induced Soil Degradation in South and Southeast Asia |
| AVHRR | Advanced Very High Resolution Radiometer |
| AWC | Available Water-holding Capacity |
| $C_3$ | Plants with a 3-carbon organic acid photosynthesis pathway |
| $C_4$ | Plants with a 4-carbon organic acid photosynthesis pathway |
| CABI | Commonwealth Agricultural Bureau International (UK) |
| CGCM1 | Canadian Global Coupled Model |
| CGIAR | Consultative Group on International Agricultural Research |
| CHARM | Climate and Human Activities- sensitive Runoff Model - IIASA |
| CIAT | International Centre for Tropical Agriculture (CGIAR, Colombia) |
| CIESIN | Center for International Earth Science Information Network |
| CRES | Centre for Resources and Environmental Studies |
| CROPWAT | Computer Program for Irrigation planning and management. FAO, Land and Water Development Division. |
| CRU | Climate Research Unit, University of East Anglia, U.K. |
| CSD | Commission on Sustainable Development (UN) |
| DDC | Data Distribution Center |
| DEM | Digital elevation model |
| DSMW | Digital Soil Map of the World (FAO) |
| ECHAM4 | Climate model developed at the German Climate Research Centre, Max-Planck Institute for Meteorology, Hamburg, Germany |
| EMAP | Environmental Monitoring and Assessment Program |
| ENRIN | Environment and National Resources Information Network |
| EPA | Environmental Protection Agency (USA) |
| EPIC | Erosion Productivity Impact Calculator |
| EROS | Earth Resource Observation System |
| ERS | Economic Research Service (USDA, USA) |
| EU | European Union |
| FAO | Food and Agriculture Organization of the United Nations, Rome, Italy |
| FAOCLIM | World-wide Agroclimatic Database. Agrometeorology Series Working Paper No. 11, FAO, Rome |
| FAOSTAT | Food and Agriculture Organization of the United Nations (FAO) Statistical Databases |
| FESLM | Framework for Evaluating Sustainable Land Management |
| GAEZ | Global Agro-Ecological Zones |
| GCM | General Circulation Models |
| GCOS | Global Climate Observing System |

| | |
|---|---|
| GEF | Global Environmental Facility |
| GEMS | Global Environmental Monitoring System |
| GEO | Global Environment Outlook |
| GIS | Geographical Information System |
| GLASOD | Global Assessment of the Status of Human-induced Soil Degradation |
| GLCC | Global Land Cover Characteristics 1-KM Database (EROS Data Center, 2000) |
| GOOS | Global Ocean Observing System |
| GRASS | Geographic Resources Analysis Support System |
| GRID | Global Resource Information Data Base |
| GRT | Gross Registered Tonnage |
| GTOPO30 | 30-arc second digital elevation model |
| GTOS | Global Terrestrial Observing System |
| HADCM2 | Hadley Centre Climate Prediction and Research Model, U.K. |
| IBSRAM | International Board for Soil Resources and Management (Thailand) |
| ICRAF | International Center for Research in Agroforestry (CGIAR, Kenya) |
| ICRISAT | International Crops Research Institute for the Semi-arid Tropics (CGIAR, India) |
| ICSU | International Council of Scientific Unions |
| IDRC | International Development Research Centre (Canada) |
| IFPRI | International Food Policy Research Institute (CGIAR, USA) |
| IGADD | Inter-Governmental Authority on Drought and Development |
| IGBP | International Geosphere-Biosphere Programme |
| IHDP | International Human Dimensions of Global Environmental Change Programme |
| IIASA | International Institute for Applied Systems Analysis, Laxenburg, Austria |
| IIED | International Institute for Environment and Development (UK) |
| IISD | International Institute for Sustainable Development (Canada) |
| IITA | International Institute of Tropical Agriculture (CGIAR, Nigeria) |
| IJC | International Joint Commission (EPA, USA) |
| ILO | International Labour Office (UN) |
| ILRI | International Institute for Land Reclamation and Improvement (Netherlands) |
| IMF | International Monetary Fund |
| IPCC | Intergovernmental Panel on Climate Change (WMO/UNEP) |
| ISCO | International Soil Conservation Organization |
| ISIS | ISRIC Soil Information System |
| ISRIC | International Soil Reference and Information Centre, Wageningen, The Netherlands |
| ISSS | International Society of Soil Science |
| ITC | International Institute for Aerospace Survey and Earth Sciences (Netherlands) |
| ITE | Institute of Terrestrial Ecology (UK) |
| IUCN | World Conservation Union |
| JRC | Joint Research Centre of the European Commission |
| LAI | Leaf area index |
| LANDSAT | Earth Observation Satellites |
| LQI | Land Quality Indicators |
| LUC | Land Use Change Project (IIASA) |
| LUCC | Land-Use and Land-Cover Change (IGBP/IHDP) |
| LUT | Land utilization type |
| MCS | Monitoring, Control and Surveillance LGP Length of growing period |
| MPI | Max Planck Institute for Meteorology, Hamburg, Germany |

| | |
|---|---|
| MSY | Maximum Sustainable Yield |
| NASA | National Aeronautics and Space Administration (USA) |
| NGO | Non-governmental Organization |
| NOAA | National Oceanic and Atmospheric Administration (USA) |
| NOVIB | Netherlands Organization for International Development Corporation |
| NRCS | Natural Resources Conservation Service (USA) |
| OECD | Organization for Economic Cooperation and Development |
| PSR | Pressure-State-Response |
| RIVM | National Institute for Public Health and the Environment (Netherlands) |
| RMD | Resource Management Domain |
| SARD | Sustainable Agriculture and Rural Development |
| SCOPE | Scientific Committee on Problems of the Environment |
| SI | Sustainability Indicator |
| SOTER | Global and National Soils and Terrain Digital Database |
| SRS | Sustainability Reference Systems |
| TR | Thermal Regime |
| UN | United Nations |
| UNCED | United Nations Conference on Environment and Development |
| UNDPCSD | United Nations Department for Policy Coordination and Sustainable Development |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNIDO | United Nations Industrial and Development Organization |
| UNL | University of Nebraska-Lincoln |
| USDA | United States Department of Agriculture |
| USGS | US Geological Survey |
| USLE | Universal Soil Loss Equation |
| WAICENT | World Agricultural Information Centre (FAO) |
| WASWC | World Association of Soil of Water Conservation |
| WB | World Bank |
| WCED | World Commission on Environment and Development |
| WISE | World Inventory of Soil Emissions Potentials |
| WMO | World Meteorological Organization (UN) |
| WOCAT | World Overview of Conservation Approaches and Technologies |
| WRI | World Resources Institute (USA) |
| WWF | World Wide Fund for Nature |

## Disclaimer

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# Global Agro-Ecological Zones Assessment: Methodology and Results[1]

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## 1. INTRODUCTION

### 1.1 Background

In the 1998 Revision, the United Nations medium variant population projection indicates an increase of world population to about 8.9 billion by the year 2050 (United Nations, 1998), with a possible range of 7.3 to 10.7 billion. Most experts agree that through full and adequate application of modern agricultural technology, the world's land resources could provide sufficient food, fiber, animal feed, biofuel and timber for such a world population. In practice, however, there will very likely be acute land shortages in some countries, especially in several developing countries (Fischer and Heilig, 1997).

Land use is largely conditioned by environmental factors including climate, topography and soil characteristics, and it depends on demographic, socioeconomic, cultural, and political factors, such as population pressure, land tenure, markets and agricultural policies. Land is an indispensable resource for the most essential human activities: it provides the basis for agriculture, energy and timber production, water catchment, recreation, and settlement.

In most developing countries, the needs and demands of rapidly increasing populations have been the principal driving force in the allocation of land resources to various kinds of uses, with food production as the primary land use. Population pressure and the increased competition among different land users have emphasized the need for more effective land-use planning and policies. Rational and sustainable land use is an issue of great concern to governments and to land users interested in preserving the land resources for the benefit of present and future populations. Policy-makers and land users face two basic challenges: the need to reverse trends of land degradation in already cultivated areas by improving conditions and re-establishing their level of fertility; and to prevent the degradation of land resources in new development areas through appropriate allocation and adequate use of these resources to maintain productivity and minimize soil erosion. In both cases an integrated approach to planning and management of land resources is a key factor to implementing solutions, which will ensure that land is allocated to uses providing the greatest sustainable benefit.

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[1] An electronic version of this document is available from the LUC Project Web-site at IIASA: http://www.iiasa.ac.at/Research/LUC

The increasing human population in developing countries is putting pressure on their finite land resources, sometimes causing over-exploitation and land degradation. Sectoral and single objective approaches to alleviate this situation have frequently not been effective, and an integrated approach is required that involves all stakeholders, accommodates the qualities and limitations of each land unit, and produces viable land use options (FAO, 1995a).

In order to enable rational land use planning, an inventory of land resources and evaluation of its biophysical limitations and constraints are required. This has long been recognized by the Food and Agriculture Organization of the United Nations (FAO). Starting in 1976, the FAO, with the collaboration of the International Institute for Applied Systems Analysis (IIASA), has developed and applied the Agro-ecological Zones (AEZ) methodology, supporting databases and software packages.

## 1.2 Agro-Ecological Zones approach

Basic principles to be observed in sound land evaluation were first put forward in the 1970s. In 1976 FAO published *A Framework for Land Evaluation* (FAO, 1976a). The Framework defines land units in terms of their characteristics (measurable factors such as slope, soil texture, rainfall, etc.), and qualities (effects such as temperature regime, moisture availability, which result from a combination of characteristics), matches them with potential uses in terms of the requirements of such uses, and then rates the land in terms of suitability for the use. Also, a land use could not be rated as suitable unless it was sustainable. The Framework, and a number of subsequent publications, provide fairly exhaustive lists of land characteristics and land qualities (FAO, 1984b; FAO, 1985; FAO/IIASA, 1991). In a first main application, the methodology was applied to assessing the production capacity of lands in the developing world (FAO/IIASA/UNFPA, 1982). While this assessment was severely limited by the availability and quality of data and the rather poor capability, at that time, to compile and process spatial data sets by computer, the importance of such work for development was recognized by the 1983 FAO Conference. Consequently, the approach was further developed in a case study concerned with the development and implementation of a national level methodology for the determination of land use potentials in Kenya, as a tool for policy formulation and development planning (FAO/IIASA, 1991). The specific role of this policy tool can be defined as assisting in the planning of sectors and regions, bridging the gap between conventional macro-planning and specific project planning.

The AEZ methodology utilizes a land resources inventory to assess, for specified management conditions and levels of inputs, all feasible agricultural land-use options and to quantify expected production of cropping activities relevant in the specific agro-ecological context. The characterization of land resources includes components of climate, soils and landform, which are basic for the supply of water, energy, nutrients and physical support to plants. On the basis of this agronomic evaluation, and using available socioeconomic data to formulate constraints, targets and production options, the attainment of spatial resource allocation objectives can be optimized (Fischer *et al.*, 1998).

The concept of AEZ climatic resources inventories, as described in FAO (1978-81a), has been applied in many continental, regional and country-level studies. Most of these studies were conducted in tropical and subtropical environments. Only a few attempts have been undertaken to extend AEZ applications to temperate, boreal and polar environments (e.g., Stewart, 1983; van Velthuizen and Kassam, 1983; Verheye *et al*., 1987; UNDP/SSTC/FAO/ SLA, 1994). The approaches proposed in these studies diverge owing to differences in specific purpose, prevailing climatic conditions, data availability and scales.

Recent availability of digital global databases of climatic parameters, topography, soil and terrain, and land cover has allowed for revisions and improvements in calculation procedures and to expand assessments of AEZ crop suitability and land productivity potentials to temperate and boreal environments. This effectively enables global coverage for assessments of agricultural potentials.

The AEZ methodologies and procedures have been extended and newly implemented to make use of these digital geographical databases, and to cope with the specific characteristics of growing periods in the seasonal temperate and boreal climates. These methodological adaptations were necessary for the global application and include: (i) enhancement of the thermal regime analysis with quantification of temperature seasonality, (ii) extension of the moisture regime analysis for frozen soils, snow stocks and soil specific water holding capacities, (iii) determination of crop-specific water requirements, deficits, and optimal cropping calendar, and (iv) the application of digital elevation models.

In summary, the following methodological enhancements have been accomplished:

- Selection and definition of additional crop/LUTs relevant to temperate and boreal environments;
- Extension of the crop/LUT definitions to cover irrigated conditions;
- Expansion of crop ecological adaptability inventory;
- Application of soil specific moisture regimes, frozen soil conditions, and snow stocks for the calculation of length of growing periods;
- Application of gridded monthly average (period 1961 to 1990) and historical year-by-year climatic resources databases;
- Application of FAO's Digital Soil Map of the World according to the FAO ’74 legend and where available application of soil maps classified according to the revised FAO ‘90 legend (currently applied for the Former Soviet Union (FSU), Mongolia and China);
- Application of 30-arc second Digital Elevation Model (GTOPO30) for the compilation of a terrain-slope database and integration of the terrain slopes with soil resources database (refining of slope information of soil maps with the slopes derived from the DEM);
- Enhancement of the assessment procedures for year-by-year crop suitability analysis;
- Expansion of the agro-climatic constraints inventory to cover additional crop/LUTs and temperate and boreal environments;
- Assessment of agro-climatic crop suitability by grid-cell (enabling calculations of biomass, constraint-free yields, agro-climatically attainable yields, crop water requirements and deficits);
- Expansion of the land suitability assessment procedures for irrigated crop production.

## 2. AGRO-ECOLOGICAL ZONES METHODOLOGY

### 2.1 Introduction

In its simplest form, the AEZ framework contains three basic elements (see Figure 1):

(i) selected agricultural production systems with defined input and management relationships, and crop-specific environmental requirements and adaptability characteristics. These are termed Land Utilization Types (LUT);

(ii) geo-referenced climate, soil and terrain data which are combined into a land resources database, and

(iii) procedures for the calculation of potential yields and for matching crop/LUT environmental requirements with the respective environmental characteristics contained in the land resources database, by land unit and grid-cell.

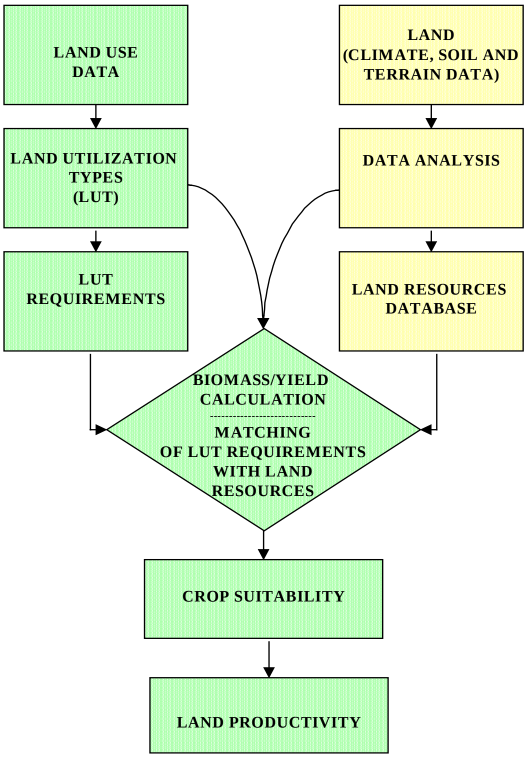


**Figure 1 Conceptual framework of Agro-Ecological Zones methodology**

Over the past twenty years, the term *agro-ecological zones methodology* has become widely used. However, it has been associated with a wide range of different activities which are often related yet quite different in scope and objectives. FAO and IIASA differentiate the AEZ methodology in the following activities:

First, AEZ provides a standardized framework for the characterization of climate, soil and terrain conditions relevant to agricultural production. In this context, the concepts of Length of Growing Period (LGP) and of latitudinal thermal climates have been applied in mapping activities focussing on zoning at various scales, from sub-national to global level.

Second, AEZ matching procedures are used to identify crop-specific limitations of prevailing climate, soil and terrain resources, under assumed levels of inputs and management conditions. This part of the AEZ methodology provides maximum potential and agronomically attainable crop yields for basic land resources units (usually grid-cells in the recent digital databases).

Third, AEZ provides the frame for various applications. The previous two sets of activities result in very large databases. The information contained in these data sets form the basis for a number of AEZ applications, such as quantification of land productivity, extents of land with rain-fed or irrigated cultivation potential, estimation of the land's population supporting capacity, and multi-criteria optimization of land resources use and development.

Chapters 2 to 4 present the calculation procedures as used in the Global AEZ (GAEZ) assessment to establish the land resources characterization and the crop yield and suitability databases. Chapter 5 introduces examples of results from a number of basic applications of the AEZ databases.

## 2.2 Overview

Figure 2 provides a general overview of the flow and integration of information as implemented in the GAEZ assessment. The figure is explained in the following sub-sections. The sub-section numbering corresponds with the numbers used in the figure.

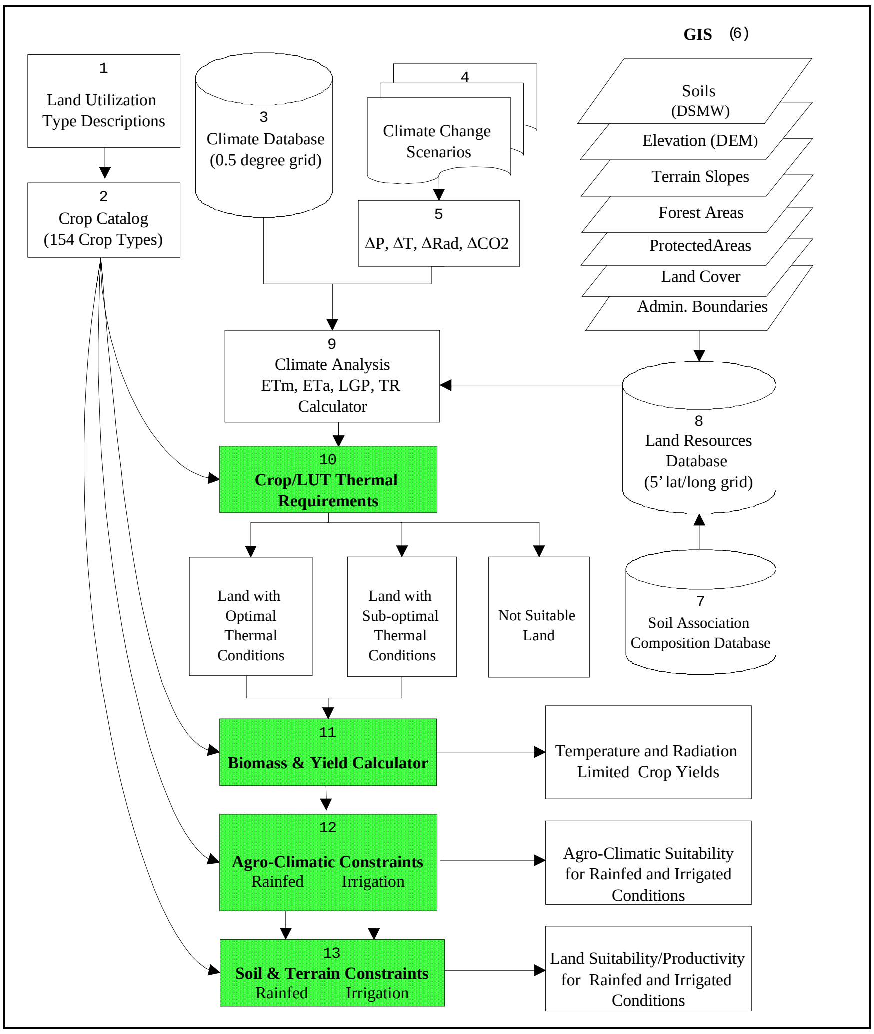


**Figure 2 Global Agro-Ecological Zones methodology**

***(1) Land utilization types (LUT)*****:** The first step in an AEZ application is the selection and description of land utilization types to be considered in the study. FAO (1984a) defines LUT as follows: *'A Land Utilization Type consists of a set of technical specifications within a socioeconomic setting. As a minimum requirement, both the nature of the produce and the setting must be specified'*.

Attributes specific to particular land utilization types include crop information such as cultivation practices, input requirements, crop calendars, utilization of main produce, crop residues and by-products. For the global study, the AEZ implementation distinguishes 154 crop, fodder and pasture LUTs, each at three generically defined levels of inputs and management, termed high, intermediate and low level of inputs, respectively.

***(2) Crop catalogue*****:** The crop catalogue database provides a quantified description of LUTs. An example for winter wheat is shown in Table 1.

**Table 1 An example of crop parameterization in GAEZ: winter wheat, high level of inputs**

| | | |
|---|---|---|
| **Crop characteristics** | | |
| Adaptability Group | | C3/1 |
| Growth Cycle | | 110-130 days |
| Pre-dormancy period | | 30 days |
| Post-dormancy period | | 90 days |
| Maximum Leaf Area Index | | 4.5 |
| Crop stages (%) | D1 | 10 |
| | D2 | 30 |
| | D3 | 35 |
| | D4 | 25 |
| Crop water requirement | D1 | 0.4 |
| (Kc-factor) | D2 | 0.4-1.1 |
| | D3 | 1.1 |
| | D4 | 1.1-0.4 |
| Moisture-stress related yield reduction | D1 | 0.2 |
| (Ky-factor) | D2 | 0.6 |
| | D3 | 0.75 |
| | D4 | 0.50 |
| **Crop requirements** | | |
| Thermal climates | | Boreal, Temperate, Subtropics |
| Temperature profile | | see Chapter 4 |
| Growing period | | see Chapter 4 |
| Dormancy | | required |
| Post-dormancy accumulated temperature (optimal) | | >1,300 |
| Post-dormancy accumulated temperature (sub-optimal) | | >1,200 |
| Sensitivity to soil moisture depletion | | Class 3 |
| Soil and terrain conditions | | see Chapter 4 |
| **Crop conversion factors** | | |
| Harvest index | | 0.45 |
| Cereal equivalent ratio | | 1.0 |
| Extraction rate | | 75% |
| Energy contents (Kcal/1000 g) | | 3640 |
| Protein contents (g/1000 g) | | 110 |
| Crop residue-factor | | 1.0 |
| Crop residue utilization rate | | 40% |
| Crop by-product factor | | 0.20 |
| Crop by-product utilization rate | | 90% |

Factors included are crop characteristics such as: crop growth cycle lengths, length of individual crop development stages, photosynthetic pathway, crop adaptability group, maximum leaf area index, harvest index, development stage specific crop water requirement coefficients, yield reduction factors relating moisture stress and yield loss according to FAO (1979), food content coefficients (energy, protein), extraction/conversion rates, crop by-product/residue coefficients, and commodity aggregation weights. Also included are parameters describing for both rain-fed and irrigated LUTs, thermal requirements, growing period requirements and soil and terrain requirements, applicable respectively in tropical, subtropical, temperate and boreal environments.

***(3) Climate database:*** Climatic data are an essential requirement for agro-ecological assessments. In the past various efforts have been undertaken to develop global climate databases (e.g., see Kineman and Ohrenschall, 1992). In the GAEZ study a data set has been used which was recently published by the Climate Research Unit (CRU) of the University of East Anglia (New *et al.*, 1998). The CRU database covers all the climate parameters required for GAEZ and consists of data sets describing average climate conditions (years 1961 - 90) as well as data for individual years from 1901 to 1996. Data are organized in a global 30-minute latitude/longitude grid (720x360 grid-cells).

At the present stage computations for average climate conditions, and historical year-by-year calculations for the years 1960 to 1996 have been completed in the GAEZ study[2].

***(4) Climate scenarios*****:** A number of sensitivity tests and general circulation models (GCM) based climate scenarios were selected for use in GAEZ. Outputs from six GCM experiments were obtained through the IPCC Data Distribution Centre (DDC). They include the following models/scenarios for the periods 2010-2039, 2040-2069, and 2070-2099:

(i) *The ECHAM4 model*. This model was developed at the German Climate Research Centre of the Max-Planck-Institute for Meteorology in Hamburg, Germany (Oberhuber, 1993; Roeckner *et al.*, 1992; Roeckner *et al.*, 1996). Model results were taken from the greenhouse gasses forcing scenario and from the greenhouse gasses plus sulfate aerosols forcing scenario. For the latter only the 2010-2039 period was available. The scenario results from ECHAM4 are provided at spatial resolution of approximately 2.8 x 2.8 degrees.

(ii) *The Canadian Global Coupled Model (CGCM1)*. This model was developed at the Canadian Centre of Climate Modelling and Analysis. Model results were taken from the greenhouse gasses forcing scenario and from the average of “ensemble” simulations (ensemble simulations are based on identical historical and future changes in greenhouse gasses, however initiated from different points on the control run). The average “ensemble forcing scenario” was taken for the greenhouse gasses plus sulfate aerosols. The scenario results from CGCM1 are provided at spatial resolutions of 3.75 x 3.75 degrees (Boer *et al.*, 1998; Flato *et al.*, 1998).

(iii) *The HadCM2 model*. This model is based on recent experiments performed at the Hadley Centre for Climate Prediction and Research (Murphy, 1995; Murphy and Mitchell, 1995). Model results were taken from the average of “ensemble” simulations. The average of “ensemble forcing scenarios” were used for respectively

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2 For average climate conditions results were obtained also with the CLIMATE database of Cramer and Leemans (an update and extension of Leemans and Cramer (1991)). Note also, that these climate data sets are not available from FAO or IIASA, but can be obtained from the respective authors.

greenhouse gasses only and for greenhouse gasses plus sulfate aerosols. The scenario results from HadCM2 are available at a spatial resolution of 3.75 x 2.75 degrees.

For use in GAEZ, outputs of the above six climate model experiments, available for three time periods and with various spatial resolutions, have been interpolated to 0.5 x 0.5 degrees.

***(5) Scenario-derived climatic parameters*:** At minimum, four climatic parameters from the GCM results were used to adjust the baseline climate conditions of each grid-cell. The *difference* in monthly mean maximum and minimum temperatures, between a GCM climate change run and the respective GCM control experiment (representing approximately current base climate), were added respectively to the mean monthly maximum and minimum temperatures of the baseline climate surfaces. Multipliers, i.e., the *ratio* between GCM climate change and control experiment, were used to impose changes in precipitation and incident solar radiation, respectively. When available from a GCM, changes in wind speed and relative humidity were considered as well. Each climate scenario is also characterized by level of atmospheric $CO_2$ concentrations and assumed changes of crop water-use efficiency. These parameters affect both the estimated reference evapotranspiration as well as the crop biomass estimations.

***(6) Land characteristics coverages (GIS):*** Soils, physiography, elevation, terrain slopes, protected areas, present land cover, and administrative divisions are kept as individual layers in the geographical information system and can be combined as needed.

Digital soil information for GAEZ was obtained from FAO. The Digital Soil Map of the World (DSMW, version 3.5) provides classification at 5-minutes latitude/longitude grid-cells and global coverage of soils according to the FAO ’74 legend (FAO, 1995c)[3].

For elevation the GTOPO30 data set was used (EROS Data Center, 1998a). At IIASA rules based on altitude differences of neighboring grid-cells were applied to compile a terrain-slope distribution database (by FAO DSMW 5-minute grid-cell) in terms of seven average slope range classes[4].

A coverage of protected areas was obtained from the FAO GIS in Rome. The version currently available in the GIS covers legally protected areas in developing countries only.

Distributions of present land cover for each 5-minute latitude/longitude grid-cell of the DSMW were derived from a global 1km land cover data set (EROS Data Center, 1998b).

***(7) Soil association composition database*:** The composition of the soil associations in terms of percentage occurrence of soil units, soil phases, textures and terrain-slope classes is stored in the soil association composition database. For the characterization of the soil units in terms of physical and chemical properties, use has been made of (i) the soil unit characteristics database from the FAO DSMW CD-ROM (FAO, 1995c), and (ii) the soil profile database of the World Inventory of Soil Emissions Potential (WISE) (Batjes, 1995). The latter database provides information on physical and chemical soil attributes for soil units of both the FAO ’74 and the FAO ’90 classifications. (FAO/IIASA/ISRIC, 1997).

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3 It should be noted that GAEZ is also ready to operate with updates of the DSMW. For instance, for the countries of the former Soviet Union (FSU), Mongolia and China recently updated soil maps in digital format provide classifications in terms of the FAO ’90 revised legend (Stolbovoi, 1998; FAO/IIASA, 1999).

4 Due to the size of grid-cells, algorithms calculating slope angles among neighboring 30 arc-sec grid-cells of GTOPO30 give unrealistic slope distributions that overestimate extents of terrain with flat and undulating slopes.

***(8) Land resources database (GIS)*: ** The individual GIS layers with their attribute data and distributions at 5-minutes latitude/longitude constitute the land resources database. The key components of this database include the FAO DSMW and linked soil association composition table, the 5-minute latitude/longitude slope distribution database derived from GTOPO30, and a database derived from the USGS 1 km seasonal land cover data set providing distributions in terms of eleven aggregate land-cover classes for each 5-minute grid-cell of the DSMW.

The DSMW has been made the reference for constructing a land surface mask, i.e., a binary layer that distinguishes grid-cells as land or sea, respectively. Also, each 5-minute grid-cell is uniquely assigned to an administrative unit, a country or disputed area.

***(9) Climate data analysis ($ET_0$, ETa, LGP and TR calculation)*: ** From the attributes in the climate database, monthly totals of reference evapotranspiration ($ET_0$) are calculated for each grid-cell according to the Penman-Monteith equation (FAO, 1992b). A water-balance model, comparing moisture supply to crops from precipitation and storage in soils with potential evapotranspiration, provides estimations of actual evapotranspiration ($ET_a$), and length of growing period (LGP). The LGP calculations also indicate the number and type of growing periods per year, their starting and ending dates, and moisture excess and deficits during the growing periods. Further explanations of the moisture balance calculations are provided in Section 3.1.4; calculation of $ET_0$ is described in Appendix V.

**Table 2 Climate parameters for Bangkok, Harbin, Manaus, Marseille, Nairobi and Vienna**

| Parameter | Bangkok | Harbin | Manaus | Marseille | Nairobi | Vienna |
|---|---|---|---|---|---|---|
| **Mean temperature** | 28.4 | 4.1 | 27.3 | 13.4 | 18.3 | 9.8 |
| **Thermal climate**[5] | 1 | 6 | 1 | 3 | 1 | 5 |
| **Temperature profile** | Table 3.3 | Table 3.3 | Table 3.3 | Table 3.3 | Table 3.3 | Table 3.3 |
| **Precipitation** | 1,188 | 524 | 2,273 | 749 | 976 | 622 |
| **$ET_o$** | 1,641 | 968 | 1,481 | 1,215 | 1,629 | 860 |
| **$ET_a$** | 1,042 | 510 | 1,354 | 745 | 932 | 602 |
| **$LGP_{t=0}$** | 365 | 305 | 365 | 365 | 365 | 318 |
| **$LGP_{t=5}$** | 365 | 291 | 365 | 365 | 365 | 243 |
| **$LGP_{t=10}$** | 365 | 274 | 365 | 226 | 365 | 185 |
| **$TSUM_{t=0}$** | 10,350 | 3,211 | 9,950 | 4,906 | 6,688 | 3,625 |
| **$TSUM_{t=5}$** | 10,350 | 3,143 | 9,950 | 4,906 | 6,688 | 3,454 |
| **$TSUM_{t=10}$** | 10,350 | 2,885 | 9,950 | 3,922 | 6,688 | 3,020 |
| **LGP (total)** | 239 | 129 | 365 | 269 | 208 | 243 |
| **Number of LGPs** | 1 | 2 | 1 | 1 | 2 | 1 |
| **Beginning LGP 1** | 124 | day 175 | n.a. | day 262 | day 84 | day 74 |
| **End LGP 1** | 362 | day 291 | n.a. | day 165 | day 218 | day 314 |
| **Beginning LGP 2** | n.a. | day100 | n.a. | n.a. | day 306 | n.a. |
| **End LGP 2** | n.a. | day 111 | n.a. | n.a. | day 13 | n.a. |
| **Annual $P/ET_o$** | 0.72 | 0.54 | 1.53 | 0.62 | 0.60 | 0.72 |

Thermal regimes (TR) are quantified for each grid-cell in terms of four kinds of attributes (see also examples in Table 2), namely: thermal climates, temperature profiles, temperature growing periods ($LGP_t$), and accumulated temperature (TSUM) calculated for various base temperatures both over an entire year as well as over growing period days. Thermal regimes are further discussed in Section 3.1.3.

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5 1: Tropics, 3: Sub-tropics winter rainfall, 5: Temperate sub-continental, 6: Temperate continental

***(10)*** ***Crop/LUT thermal requirements:*** Temperature profile requirements, temperature growing period requirements, and temperature sum requirements of LUTs are matched with actual temperature regimes in grid-cells. The temperature profile requirements of crops are formulated on the basis of temperature intervals of 5°C, determined separately for seasons with increasing and decreasing temperature trends. These periods are matched with the temperature profiles calculated from temperature data. When the temperature characteristics in a particular grid-cell match respectively the temperature profile requirement, minimum length of temperature growing period, and accumulated temperature requirements, then the crop LUT is considered for cultivation and biomass/yield calculations are performed. A more detailed discussion of crop/LUT thermal requirements is presented in Chapter 4.

***(11)*** ***Biomass and yield calculation*****:** The calculation of biomass and crop yield used in GAEZ is based on Kassam (1977) and FAO (1979, 1992a). The *constraint-free crop yields* computed in the biomass module (see Appendix VI) reflect yield potentials with regard to temperature and radiation regimes prevailing in the respective grid-cells. Results are geographical distributions of temperature and radiation limited yields of individual crop/LUTs.

***(12)*** ***Agro-climatic constraints:*** Agro-climatic constraints have their origin primarily due to climate, and cause direct or indirect losses in the yield and quality of produce. Yield losses of a rain-fed crop due to agro-climatic constraints are influenced by the following conditions:

- The variability and degree of water-stress during the growing period;
- The yield-quality reducing factors of pests, diseases and weeds;
- The climatic factors, operating directly or indirectly, that reduce yield and quality of produce mainly through their effects on yield components and yield formation;
- The climatic factors which effect the efficiency of farming operations and costs of production;
- The risk of occurrence of late and early frost.

The agro-climatic constraints in GAEZ are specified by means of adjustment factors linked to the standardized evaluation of the temperature and moisture regimes in each grid-cell, i.e., they are essentially formulated based on length of thermal growing period ($LGP_t$) and length of moisture growing period (LGP). In addition, the factors depend on crop type and level of inputs/management.

***(13)*** ***Soil and terrain constraints:*** The agro-edaphic suitability assessment is based on the comparison of edaphic requirements of rain-fed and irrigated crop/LUTs and prevailing soil and terrain conditions. The edaphic assessment also reflects constraints imposed by landform and other features that do not directly form a part of the soil but may have a significant influence on the use that can be made of the soil. Distinction is made between *internal* soil requirements of crop/LUTs, such as soil temperature regime, soil moisture regime, soil fertility, effective soil depth for root development, and other physical and chemical soil properties, and *external* requirements related to soil slope, occurrence of flooding and soil accessibility.

The results of matching the crop/LUT-specific edaphic requirements to the soil and terrain attributes of individual grid-cells, in combination with calculated potential biomass and agro-climatically attainable yields, provides a suitability classification for each rain-fed and irrigated crop/LUT respectively at high, intermediate and low levels of input circumstances.

In order to safeguard production to be achievable on a sustainable basis, two further considerations are applied in the assessment:

- Fallow requirements are imposed to enable maintenance of soil fertility and structure and counteracting soil degradation caused by cultivation. Fallow requirements vary by environmental conditions, crop, and level of inputs/management (FAO/IIASA, 1991). Principles of formulating fallow requirement factors in GAEZ are discussed in Section 4.4.3.
- The terrain-slope suitability classification is concerned not only with workability and accessibility of the land but also with the prevention of intolerable levels of topsoil erosion and fertility loss. Depending on prevailing rainfall aggressivity, level of inputs/management, and crop/LUT, upper limits have been set to slope gradients considered suitable for cultivation.

# 3. LAND RESOURCES

The AEZ methodology for land productivity assessments follows an environmental approach; it provides a framework for establishing a spatial inventory and database of land resources and crop production potentials. This land resources inventory is used to assess, for specified management conditions and levels of inputs, the suitability of crops/LUTs in relation to both rain-fed and irrigated conditions, and to quantify expected production of cropping activities relevant in the specific agro-ecological context. The characterization of land resources includes components of climate, soils, landform, and present land cover.

Inherent in the methodology is the generation of a climatic inventory to predict agro-climatic yield potentials of crops. The Global AEZ study uses a recent global climatic data set compiled by the Climate Research Unit at the University of East Anglia. The database offers a spatial resolution of 30 minutes latitude/longitude and contains climate averages for the period 1961-90 as well as year-by-year data of the period 1901-1996. These are used to characterize each half-degree grid-cell in terms of applicable thermal climates, temperature profiles, accumulated temperature sums, length of growing periods, moisture deficits, etc.

Adequate agricultural exploitation of the climatic potentials and maintenance of land productivity largely depend on soil fertility and the management of soils on an ecologically sustained basis. Hence, the climatic inventory was superimposed on FAO's Digital Soil Map of the World (DSMW). The DSMW is derived from the FAO/UNESCO Soil Map of the World at scale 1:5 million and presents soil associations in grid-cells of 5-minutes latitude/longitude, forming the basis of soil information in Global AEZ. The composition of soil associations is described in terms of percentage occurrence of soil units, soil phases and textures. Therefore, each 5-minute grid-cell is considered as consisting of several land units.

Terrain slopes were derived from the GTOPO30 database developed at the USGS Eros Data Center, providing digital elevation information in a regular grid of 30 arc-seconds latitude/longitude. At IIASA rules based on altitude differences of neighboring grid-cells were applied to compile a terrain-slope distribution database (for each 5-minute grid-cell of FAO's DSMW) in terms of seven average slope range classes.

The individual GIS layers with attribute data and distributions at 5-minutes latitude/longitude constitute the land resources database. The key components of this database include: the FAO DSMW and linked soil association composition table, the slope distribution database derived from GTOPO30, and an ecosystem database derived from the USGS 30 arc-second seasonal land cover data set providing distributions in terms of twelve aggregate land-cover classes for each 5-minute grid-cell. The DSMW has been made the reference for constructing a land surface mask, i.e., a binary layer that distinguishes grid-cells as land or sea, respectively. Also, each 5-minute grid-cell is uniquely assigned to an administrative unit (a country or region).

## 3.1 Climate resources

### 3.1.1 Introduction

Living organisms require heat, light and water in varying amounts. Their distribution, in space and time, is governed by these climatic elements. In the AEZ approach, as in any bio-geographic inventory, temperature, water and solar radiation are the key climatic parameters. These parameters condition rates of net photosynthesis allowing plants to accumulate dry matter and to accomplish the successive plant development stages. Data on climatic requirements of crop growth, development and yield formation are the basis for the compilation of the AEZ climatic inventory. Also, crops need to be characterized for their thermal and moisture adaptability. Prevailing temperatures determine crop performance when moisture conditions are met. Similarly, when temperature requirements are met, the growth of a crop is dependent on how well its growth cycle fits within the period when water is available. The latter has led to the concept of *length of growing period* (LGP). It provides for an environmental characterization particularly relevant to agricultural assessments. The length of growing period is defined as the number of days when water availability and prevailing temperatures permit crop growth. Depending on its length, the growing period may allow for no or for only one crop per year (e.g., in arid or dry semi-arid tropics), or it may allow to grow a sequence of crops within one year (e.g., in humid tropics or subtropics). In the Global AEZ implementation, LGP is used to determine periods within a year available for rain-fed crop production, and to select applicable agro-climatic constraints.

### 3.1.2 Climate data

The Global AEZ study uses a recent global climate data set, which is here referred to as the 'CRU' climate database. It has been compiled by the Climate Research Unit (CRU) of the University of East Anglia (New *et al.*, 1998). This database comprises a suite of nine climatic variables interpolated from observed station data to a 30 minutes latitude/longitude grid. Each data set contains 720x360 grid-cells (however, only grid-cells over land are provided). In addition to the 1961-90 climate averages, historical gridded data was obtained from CRU, comprising year-by-year data of the period 1901-1996 also in the form of 30 minutes latitude/longitude grids. The mean monthly climate attributes include: precipitation, wet-days frequency, mean temperature, diurnal temperature range, sunshine duration, windspeed, and vapour pressure. Table 3 presents the climate parameters held in the CRU database by grid-cell.

**Table 3 Attributes in the CRU climate databases**

| **Monthly variables (Normals 1961-1990)** | **Monthly variables (Historical data 1901-1996)** |
|---|---|
| • Precipitation | • Precipitation |
| • Wet days frequency | • Wet days frequency |
| • Mean temperature | • Mean temperature |
| • Diurnal temperature range | • Diurnal temperature range |
| • Vapour pressure | • Vapour pressure |
| • Cloud cover | |
| • Sunshine (n/N) | |
| • Ground-frost frequency | |
| • Windspeed | |

The year-by-year historical databases, along with the 1961-90 average climate database, have been used to quantify growing period variability and to estimate for each grid-cell by crop/LUT the variability of agro-climatically attainable crop yields. Average annual rainfall and estimated reference evapotranspiration, calculated according to Penman-Monteith have been compared with average data from climate stations of the FAOCLIM database (FAO, 1995b). Their correlation is shown in Figure 3 below[6].

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6 There are several important reasons why station data and values obtained from grid-cells can (and should) be different: (i) the observation period of stations and the 1961-90 climate normals of the CRU grid can be quite different both in time and number of years; (ii) the grid values represent average conditions for a 0.5 degree latitude/longitude cell-size; in complex terrain or for areas with strong moisture gradients this heterogeneity can lead to large discrepancies.

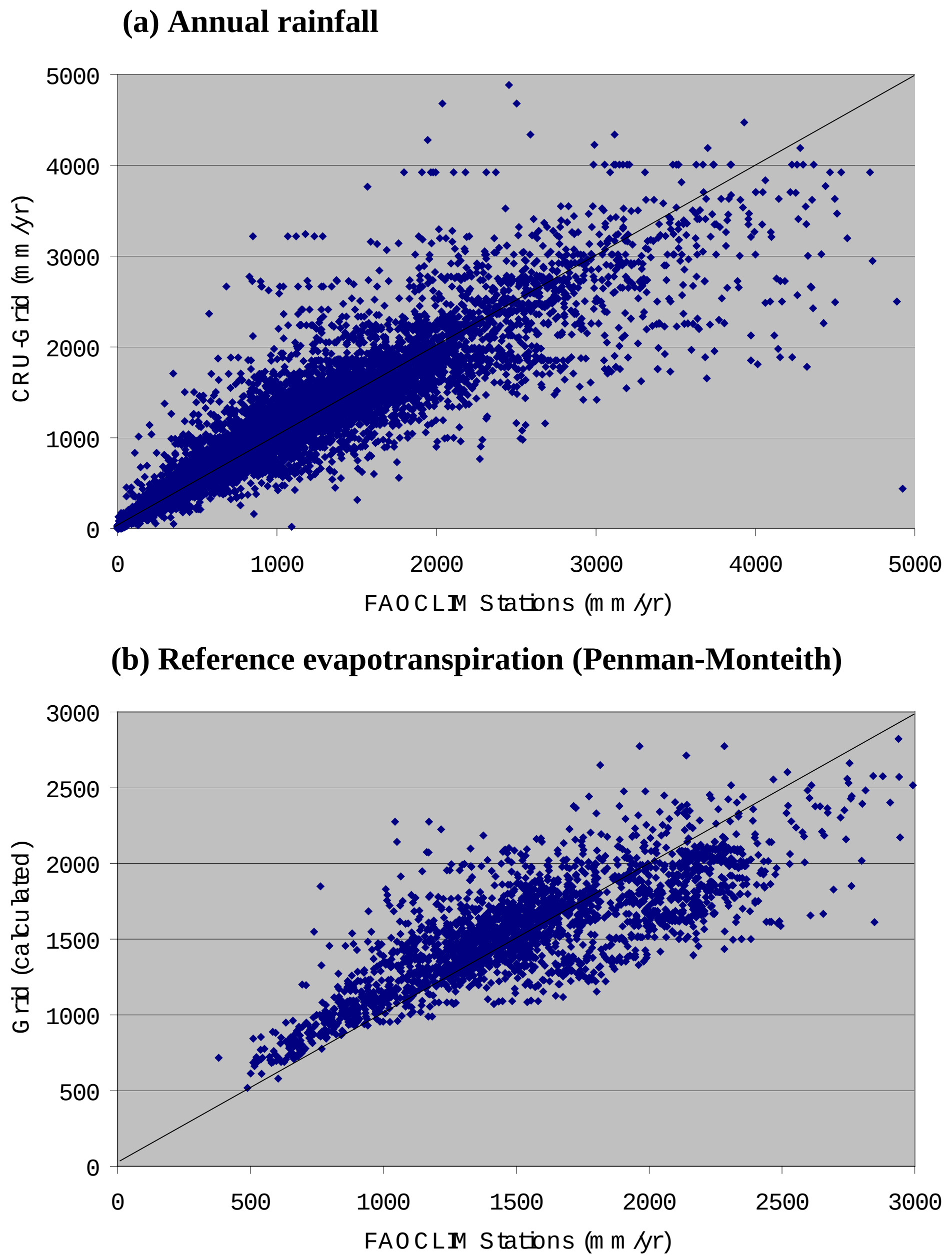


**Figure 3** **Scattergram of (a) annual rainfall and (b) reference evapotranspiration (Penman-Monteith), between grid-cell data from the CRU 1961-90 climate normals database and average station data of the FAOCLIM database.**

Maps of annual rainfall and reference evapotranspiration totals are reproduced in Appendix XV, i.e., Plate 1 – Average annual precipitation, and Plate 2 – Average annual reference evapotranspiration (according to Penman-Monteith).

### 3.1.3 Thermal regimes

Photosynthesis produces the sources of assimilates which plants use for growth and development. Temperature and radiation influence the rate of photosynthesis. However, plants also have an obligatory development in time, which must be met if the photosynthetic assimilates are to be converted into economically useful yields of satisfactory quantity and quality. Temperature (and day-length in case of photosensitive crops) influences the developmental sequence of crop growth in relation to crop phenology. Therefore, the temperature regime and photo-periodicity govern the selection of the crops that can be cultivated. In some cases, temperature may determine whether a particular development process will be initiated or not (e.g., chilling requirements for initiation of flower buds). Low temperatures can also delay flowering and fruit setting. For photosensitive cultivars, day-length plays an important role in determining the time of flowering. For instance, many soybean varieties will not flower under equatorial conditions. Deepwater rice flowers after the day-length has shortened to a certain amount of day-light hours, which coincides in Southeast Asia with the end of the rainy season.

The evolutionary changes that have occurred in the biochemical and physical characteristics of photosynthesis have resulted in a large variation between crops in both their optimum temperature requirements and the responses of photosynthesis to changes in temperature and radiation. These responses depend on the nature of the photosynthetic pathway. In general, the $C_3$ pathway of assimilation is adapted to operate at optimum rates under lower temperature conditions than the $C_4$ assimilation pathway. However, breeding and selection (both natural and under human influence) have changed temperature responses of photosynthesis in some $C_3$ and $C_4$ species. It is therefore possible to make a division of the major food crops according to their assimilation pathway and corresponding temperature requirements. Four groups have been recognized in AEZ:

*Group I* $C_3$ species adapted to lower temperatures (e.g., wheat, potatoes);

*Group II* $C_3$ species adapted to higher temperatures (e.g., soybean, rice, cassava);

*Group III* $C_4$ species adapted to high temperatures (e.g., millet, sorghum, maize, sugarcane);

*Group IV* $C_4$ species adapted to lower temperatures (e.g., sorghum, maize).

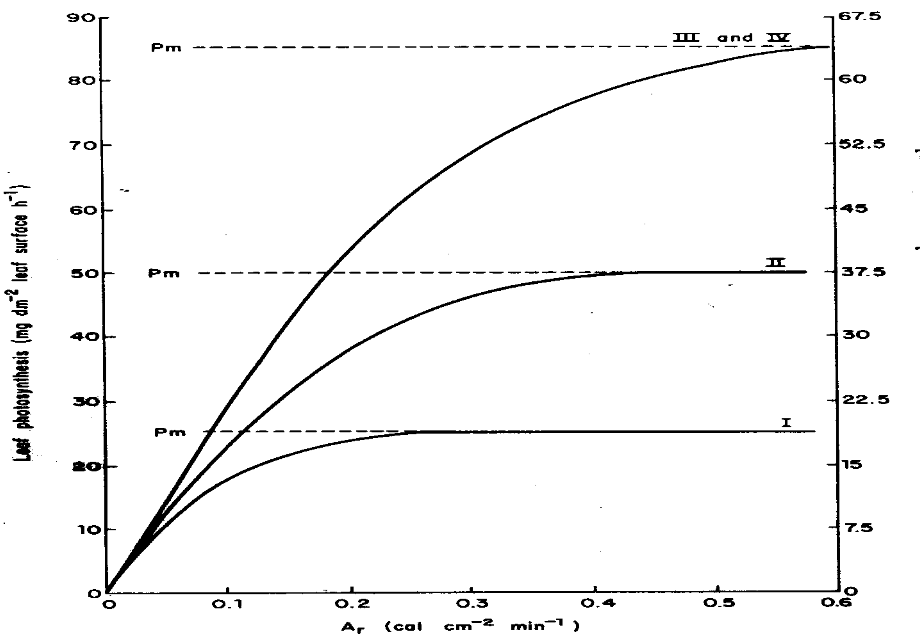


**Figure 4 Relationship between leaf photosynthesis rate[7] at optimum temperature and photosynthetically active radiation (Ar) for crop groups I, II, III and IV (FAO, 1978-81a)**

Figure 4 shows for each crop group examples of the relationship between the rate of photosynthesis at optimum temperature and photosynthetically active radiation. Figure 5

[7] The leaf photosynthesis values presented in Figure 4 and 5 reflect present levels of atmospheric carbon dioxide concentrations.

illustrates for each group of crops the typical (inverted) u-shaped effect of temperature on the leaf photosynthesis.

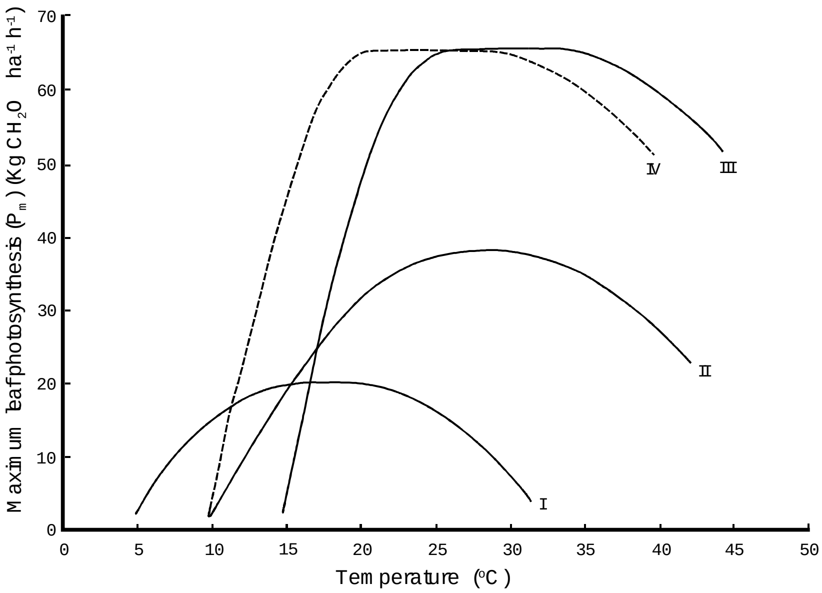


**Figure 5 Examples of relationships between maximum leaf photosynthesis rate (Pm) and temperature for crop groups I, II, III and IV (FAO, 1978-81a)**

To cater for differences in thermal requirements of crops, an adequate characterization of the temperature regimes is required, applicable for a wide range of locations. With the improved spatial availability of climate attributes and the extension of Global AEZ to temperate and boreal seasonal climates, the characterization of the temperature regimes in the present approach comprises four parts, namely:

- Thermal climates, representing major latitudinal climatic zones;
- Temperature profiles, providing quantification of temperature seasonality;
- Temperature growing periods ($LGP_t$), representing the periods during which average daily temperatures exceed specified minimum levels; and
- Accumulated temperature, calculated for various base temperatures.

*Thermal Climates*

The thermal climates are obtained through classifying of monthly temperatures corrected to sea level (with an assumed lapse rate: 0.55°C/100m). For the classification of latitudinal thermal climates, the AEZ major climatic divisions of tropics, subtropics with summer rainfall, subtropics with winter rainfall, and temperate (FAO, 1978-81a), have been expanded with boreal and polar/arctic divisions. The temperate and boreal belts have been further subdivided according to continentality into three classes, namely: oceanic, sub-continental and continental. Table 4 presents the thermal climate classification used in the GAEZ study. The geographic distribution of the thermal climates is presented in Plate 3 (see Appendix XV).

**Table 4 Thermal climates**

| Thermal climate classification | |
|---|---|
| ***Tropics***<br>All months with monthly mean temperatures, corrected to sea level, above 18°C | |
| ***Subtropics***<br>One or more months with monthly mean temperatures, corrected to sea level, below 18°C but above 5°C | ***Subtropics Summer Rainfall***<br>Northern hemisphere: rainfall in April-September ≥ rainfall in October-March<br>Southern hemisphere: rainfall in October-March ≥ rainfall in April-September |
| | ***Subtropics Winter Rainfall***<br>Northern hemisphere: rainfall in October-March ≥ rainfall in April-September<br>Southern hemisphere: rainfall in April-September ≥ rainfall in October-March |
| ***Temperate***<br>At least one month with monthly mean temperatures, corrected to sea level, below 5°C and four or more months above 10°C | ***Oceanic Temperate***<br>Seasonality less than 20°C* |
| | ***Sub-continental Temperate***<br>Seasonality 20-35°C* |
| | ***Continental Temperate***<br>Seasonality more than 35°C* |
| ***Boreal***<br>At least one month with monthly mean temperatures, corrected to sea level, below 5°C and more than one but less than four months above 10°C | ***Oceanic Boreal***<br>Seasonality less than 20°C* |
| | ***Sub-continental Boreal***<br>Seasonality 20-35°C* |
| | ***Continental Boreal***<br>Seasonality more than 35°C* |
| ***Polar/Arctic***<br>All months with monthly mean temperatures, corrected to sea level, below 10°C | |

* Seasonality refers to the difference in mean temperature of the warmest and coldest month, respectively.

### *Temperature profiles*

The quantification of temperature seasonality looks at year-round temperature regimes. They are expressed in number of days falling into pre-defined temperature intervals. These intervals comprise of five-degree centigrade steps, subdivided respectively in periods with increasing and decreasing temperatures. ‘A’ classes are used for increasing temperatures and ‘B’ classes for decreasing temperatures. A complete account of time periods of individual temperature intervals provides a year-round *temperature profile*. These profiles have been calculated for each grid-cell; examples are shown in Table 5.

**Table 5 Examples of average temperature profiles for Bangkok, Harbin, Manaus, Marseille, Nairobi and Vienna**

| Temperature intervals | | Temperature Periods (days) | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Bangkok** | **Harbin** | **Manaus** | **Marseille** | **Nairobi** | **Vienna** |
| **A9** | < -5°C | 0 | **56** | 0 | 0 | 0 | 0 |
| **A8** | -5-0°C | 0 | **14** | 0 | 0 | 0 | **23** |
| **A7** | 0-5°C | 0 | **13** | 0 | 0 | 0 | **36** |
| **A6** | 5-10°C | 0 | **17** | 0 | **79** | 0 | **32** |
| **A5** | 10-15°C | 0 | **22** | 0 | **43** | 0 | **33** |
| **A4** | 15-20°C | 0 | **27** | 0 | **40** | **227** | **74** |
| **A3** | 20-25°C | 0 | **38** | 0 | **33** | **9** | 0 |
| **A2** | 25-30°C | **95** | 0 | **258** | 0 | 0 | 0 |
| **A1** | > 30°C | **21** | 0 | 0 | 0 | 0 | 0 |
| **B1** | > 30°C | **25** | 0 | 0 | 0 | 0 | 0 |
| **B2** | 30-25°C | **224** | 0 | **107** | 0 | 0 | 0 |
| **B3** | 25-20°C | 0 | **32** | 0 | **43** | **8** | 0 |
| **B4** | 20-15°C | 0 | **20** | 0 | **38** | **121** | **49** |
| **B5** | 15-10°C | 0 | **19** | 0 | **29** | 0 | **29** |
| **B6** | 10-5°C | 0 | **17** | 0 | **60** | 0 | **26** |
| **B7** | 5-0°C | 0 | **14** | 0 | 0 | 0 | **39** |
| **B8** | 0- -5°C | 0 | **13** | 0 | 0 | 0 | **24** |
| **B9** | < -5°C | 0 | **63** | 0 | 0 | 0 | 0 |

*Temperature growing periods and temperature sums*

In addition to thermal climates and temperature profiles, temperature growing periods ($LGP_t$) have been inventoried. For instance $LGP_{t=5}$ of 5°C, i.e., the number of days when mean daily temperature exceeds 5°C, represents the period with temperatures suitable for crop growth. Similarly $LGP_{t=10}$ of 10°C approximates the frost-free period (see Plates 4 and 5 in Appendix XV). Lengths, beginning dates and ends of such periods are calculated for each grid-cell and are stored in the attribute database. Also, for various base temperatures, accumulated temperatures have been calculated for each grid-cell. For instance, the accumulated temperature on days with mean daily temperature above 0°C is shown on Plate 6 in Appendix XV.

### 3.1.4 Moisture regimes

A general characterization of moisture conditions is achieved through the concept of *length of growing period* (LGP), i.e. the period during the year when both moisture availability and temperature are conducive to crop growth. Thus, in a formal sense, LGP refers to the number of days within $LGP_{t=5}$ when moisture conditions are considered adequate.

Under rain-fed conditions within $LGP_{t=5}$, the begin of the LGP is linked to the start of the rainy season. Farmers' cropping strategies are undoubtedly influenced by the variability they have experienced in the onset of the rainy season. In general, they will plant or dry-seed their crop when certain amounts of rainfall have accumulated and sufficiently moistened the topsoil. The start of the growing period is therefore dependent on the amount and frequency distribution of early rains. The reliability of precipitation of these early rains increases considerably once the monthly precipitation equals or exceeds half the potential evapotranspiration (FAO, 1978-81a). Furthermore, the amount of moisture required to sustain growth of germinating crops is well below evapotranspiration demand of crops at maximum canopy cover. For establishing crops, 0.4 - 0.5 times the level of reference evapotranspiration (i.e., potential evapotranspiration of a reference crop; see Appendix V) is considered sufficient to meet water requirements of dryland crops (FAO 1978-81a; 1979; 1992a).

The growing period for most crops continues beyond the rainy season and, to a greater or lesser extent, crops mature on moisture stored in the soil profile. However, the amount of soil moisture stored in the soil profile, and available to a crop, varies, e.g., with depth of the soil profile, the soil physical characteristics, and the rooting pattern of the crop. Depletion of soil moisture reserves causes the actual evapotranspiration to fall short of the potential rate. Soil moisture storage capacity of soils (*Smax*) depends on soil physical and chemical characteristics, but above all on effective soil depth or volume. For the soil units of the Legend of the Soil Map of the World (FAO, 1974), FAO has developed procedures for the estimation of Smax (FAO, 1995c). The results are summarized in Table 6. The *Smax* classes are estimated for individual FAO soil units and are presented in Appendix XIII. For each mapping unit (and each grid-cell) the composition in terms of soil units and the occurrence of soil depth/volume limiting soil phases is known from the DSMW. The relevant *Smax* values for individual soil units in a grid-cell were used to set limits to available soil moisture, enabling calculation of possible extension of the growing period beyond the end of the rainy season by soil unit, soil texture class, and soil phase.

**Table 6 Soil moisture storage capacity (*Smax*) classes derived for FAO soil units and for soil depth/volume limiting soil phases**

| CLASS | (mm) | Soils with Lithic Phase (mm) | Soils with Petroferric and Duripan Phases (Revised Legend '90) or Petrocalcic, Petrogypsic, Petroferric and Duripan Phases (Legend '74) | Soils with Skeletic and Rudic Phases (Revised Legend '90) or Petric and Stony Phases (Legend '74) |
|---|---|---|---|---|
| 1 | 150 mm | 50 mm | 115/50 mm | 75 mm |
| 2 | 125 mm | 40 mm | 90/40 mm | 65 mm |
| 3 | 100 mm | 35 mm | 75/35 mm | 50 mm |
| 4 | 75 mm | 25 mm | 55/25 mm | 40 mm |
| 5 | 50 mm | 15 mm | 35/15 mm | 25 mm |
| 6 | 15 mm | n.a. | n.a. | n.a. |

In addition to taking into account soil specific *Smax* values, a number of further modifications in the growing period analysis were introduced. The new elements in the water-balance calculations mainly relate to three types of enhancements:

(i) temperature/moisture interactions which are of special relevance in temperate and boreal thermal climates;
(ii) standardization of the water-balance calculations by prior conversion of monthly climate variables to pseudo-daily data (using quadratic spline functions), and
(iii) enabling $ET_0$ and water-balance calculations for each 0.5 degree grid-cell.

More specifically the main changes are the following:

**A** For the calculation of reference evapotranspiration, the modified Penman equation used in earlier assessments has been replaced by the *Penman-Monteith* equation (FAO, 1992b).

**B** Monthly climate parameters are converted to daily data by means of spline interpolations, ensuring consistency of daily levels with monthly means or totals. This results for each-grid cell in pseudo-daily values[8] for all parameters relevant in the calculation of reference evapotranspiration and water-balance.

From these series a daily *water-balance, W,* and *actual evapotranspiration, ETa,* is calculated according to FAO (1979), as follows:

$$W_{j+1} = \min\left(W_j + P_j - ETa_j,\ Sa\right) \tag{1}$$

$$ETa_j = \begin{cases} ETo_j & if\ (W_j + P_j)\cdot d \geq Sa\cdot d\cdot(1-p) \\ \rho ETo_j & else \end{cases} \tag{2}$$

where,

$$\rho = \frac{ETa_j}{ETo_j} = \frac{W_j + P_j}{Sa\cdot(1-p)} \tag{3}$$

| | |
|---|---|
| *j* | number of day in year |
| *Sa* | available soil moisture holding capacity (mm/m) |
| *d* | rooting depth (m) |
| *p* | soil water depletion fraction below which $ETa < ETo$ |
| ρ | actual evapotranspiration proportionality factor. |

*Sa* and *d* are defined by the respective values of the soil units in individual grid-cells. The beginning of a growing period is reached when three basic conditions are met:

(i) average daily temperature is above 5°C, (ii) actual evapotranspiration (*ETa)* exceeds a specified fraction of the estimated reference evapotranspiration, i.e.,

$$ETa_j \geq \alpha ETo_j, \qquad \alpha = 0.4 - 0.5^{9} \tag{4}$$

and, (iii) sufficient moisture has been accumulated in the soil profile for establishing crops. However, the start of a growing period may be delayed because of excessive wetness due to snowmelt, especially in flat terrain with poorly drained, medium to fine textured soils, e.g., as found in Western Siberia. This might result in saturated soil conditions with low bearing capacities presenting problems for timely seeding/planting. It also will severely affect the oxygen supply to the roots of the hibernating crops.

Depending on the amount of excess moisture the following assumptions were adopted for the delay of the effective start of a growing period:

8 This conversion of monthly (or decade) data to daily values simplifies the calculation of soil moisture balances and the determination of length of growing period and growing period characteristics. Note that these pseudo-daily values should not be applied in instances where actual daily weather data is required. However, it means that the current algorithms are applicable with minor modifications when daily data is available.

9 In the current calculations of GAEZ the value of $\alpha = 0.5$ was used.

**Table 7** **Delay of the growing period start due to excess wetness**

| Excess moisture from snowmelt (mm) | Excess moisture at start of $LGP_{t=5}$ (mm) | | Delay of start of growing period due to excess wetness (days) | |
|---|---|---|---|---|
| | Very poorly drained soils | Poorly/imperfectly drained soils | Very poorly drained soils | Poorly/imperfectly drained soils |
| 40 | 0 | 0 | 0 | 0 |
| 80 | 20 | 0 | 5 | 0 |
| 120 | 60 | 30 | 15 | 10 |
| 180 | 120 | 90 | 30 | 20 |
| 240 | 180 | 150 | 45 | 30 |

Note: Drainage classes are according to the FAO Guidelines for Soil Description (FAO, 1990).

A growing period ends when soil moisture supply becomes insufficient or temperature becomes limiting, i.e., on the day when first

$$ETa_j < \beta \, ETo_j, \qquad \beta = 0.4 - 0.5 \tag{5}$$

or when average daily temperature falls below 5°C. In this way all the growing periods within a year are fully determined with starting and ending dates, length in number of days, and reference *ETa* values. Where applicable, the procedure also records the dates and length of a dormancy period (see below) and of any humid period during a growing period, defined as days when rainfall exceeds reference evapotranspiration, i.e., with $P > ETo$.

**C** The water-balance calculation detects and handles specific conditions during cold-breaks or dormancy:

- frozen topsoil: *Tmean < 0°C, then (ETa = 0),*
- LAI development expressed as transpiration gradients, after start of growing period or restart after dormancy period.

**D** The calculation procedures include accumulation of snow stocks and the time periods required to melt snow stocks. Two temperature thresholds control the calculations. When maximum daily temperature falls below a defined limit, then any precipitation occurring is assumed to be in the form of snow and is accumulated as snow stock. During such periods it is also assumed that no evaporation takes place. When average daily temperature exceeds the freezing point, melting of snow stocks is modeled by a linear relationship in proportion to maximum daily temperature exceeding a defined threshold.

**E** Discontinuous growing periods with a dormancy period have been separated from those with a cold-break on the basis of temperature limits ($T_h$) for survival of hibernating crops. In defining respective limits, the impact of the depth of snow cover ($S_d$) on $T_h$ has been accounted for as follows, defining a threshold in the range between -8 and -22°C:

$$T_h = \begin{cases} -8 - 0.11 \cdot S_d & S_d \le 127cm \\ -22 & S_d > 127cm \end{cases}. \tag{6}$$

An upper limit to the length of the dormancy period can be set. When the duration of the dormancy period exceeds this maximum, the dormancy period is treated as being a cold-break. In the present calculations, the maximum duration of the dormancy period has been set, as a model variable, at 200 days.

**F** The procedures allow calculation of growing periods for individual years by using in the water balance time-series of monthly rainfall. This provides a quantification of year to year variability of the moisture regime. Figure 6 presents for Gan Zhou, in Jiangxi province in China, the results of LGP analysis with averaged monthly rainfall data of 1961-80 (shown as AV) as compared with monthly data of individual years. The figure highlights the importance of assessing year-by-year conditions rather than using results derived from average climate data. For instance, while the calculations based on averaged climate conditions result in a year round LGP, the individual year results fall in between 260 and 365 days, with an average of 326 days.

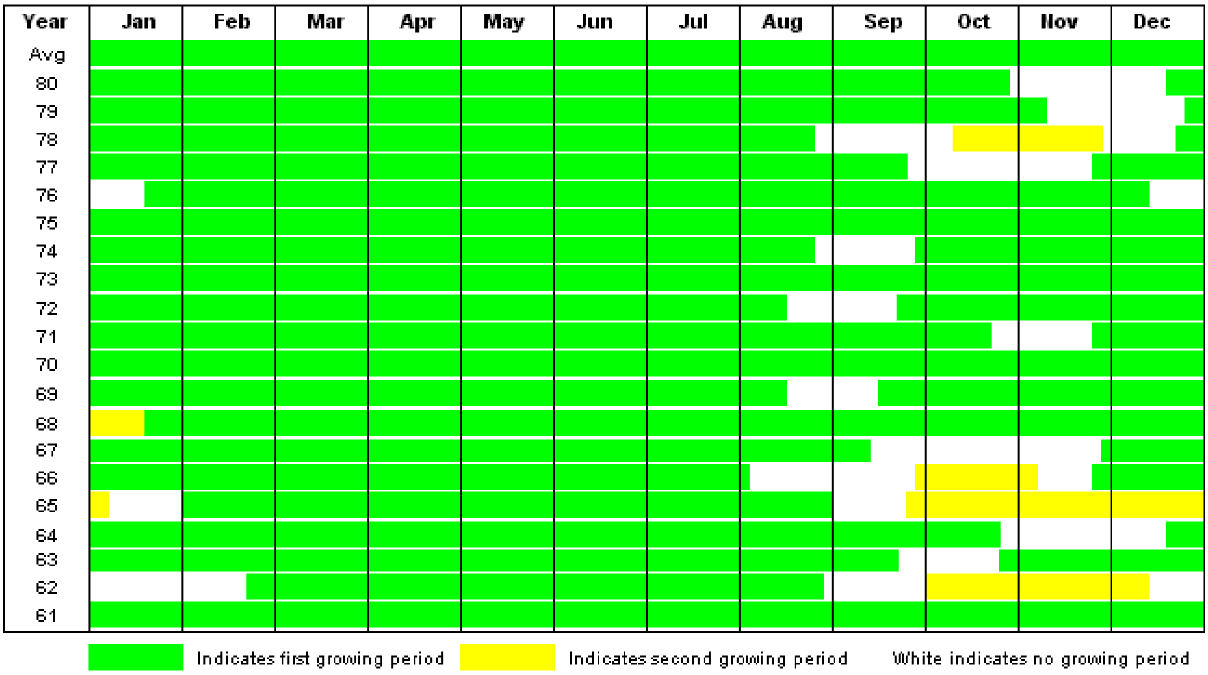


**Figure 6 Comparison of LGP calculations for average and year-by-year rainfall, Gan Zhou, China**

Plate 7 shows a map of average total length of growing periods (1961-1990). For presentation, the results for each grid cell were grouped in 30-day interval classes. Plate 8 shows a map with dominantly mono-modal and bi-modal growing period patterns, respectively.

## 3.2 Soil and terrain resources

### 3.2.1 Soil information

The source of soil information used in Global AEZ is primarily the digital version of the FAO/Unesco Soil Map of the World (FAO, 1995c). It provides classification of soils according to the FAO/Unesco ’74 Legend (FAO/Unesco, 1974).

For an increasing number of countries in Africa, South America and Asia the original Soil Map of the World has been or is being updated according to the FAO ’90 revised Legend (FAO/Unesco/ISRIC, 1990). The available information concerns the updated soil maps for the former Soviet Union (FSU), Mongolia and China, referred to as Soil and Terrain Database for North and Central Eurasia (FAO/IIASA, 1999), which were finalized in the context of the Land Use Change Project (LUC) of IIASA in close collaboration with FAO. The map covering the territory of the FSU (i.e., Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldavia, Russian Federation, Tajikistan, Turkmenistan, Ukraine) and Mongolia were compiled at 1:5M scale by Dokuchaev Soil Institute in Moscow (Stolbovoi, 1998). The map covering China at 1:4M scale was compiled by the Institute of Soil Science, Academia Sinica, in Nanjing (FAO/CAS, 1995). Both sets of digital soils information (FAO, 1995c; and FAO/IIASA, 1999) were used for the development of AEZ applications.

The digital soil information constitutes part of the land resources database and is kept together with other geographic information (i.e., elevation, terrain slopes, distance to coast, protected areas, land cover, and administrative divisions). Additional information, specifying the composition of the soil associations in terms of percentage occurrence of soil units, textures, terrain-slope classes and soil phases, is kept in a soil association composition database. The soil units in the FAO legends are defined in terms of measurable and observable properties of the soil itself. Many of the properties are directly relevant to agricultural production potential.

Quantification of soil unit characteristics in terms of physical and chemical properties was obtained from: (i) the DSMW CD-ROM for the soil units of FAO/Unesco 1974 Legend (FAO, 1995c), and (ii) the World Inventory of Soil Emissions Potential (WISE) database (Batjes, 1995). This latter WISE database contains a wide range of soil attributes for over 4000 soil profiles. The International Soil Reference and Information Centre (ISRIC), with assistance of the Land and Water Development Division of FAO, and the LUC project of IIASA have developed procedures for the extraction of relevant soil attributes by soil unit from this WISE soil profile database (Batjes *et al.*, 1997). The individual profiles were classified by ISRIC for both the FAO ’74 legend and the FAO ’90 revised legend. This facilitates the linkage with the FAO/Unesco Digital Soil Map of the World and the digital soil maps of the FSU, Mongolia and China.

### 3.2.2 Terrain slopes

Two sources of geo-referenced terrain slopes were available for use in the Global AEZ assessment: (i) terrain slopes indicated in the mapping unit expansion tables of the respective soil maps, and (ii) terrain slopes derived from GTOPO30 data (EROS Data Center, 1998a). The latter terrain-slope database was established at IIASA using a rule-based algorithm to calculate slope distributions in terms of seven slope classes per 5-minute grid-cell of the DSMW soil data based on neighborhood relationships among grid-cells in the 30 arc-second GTOPO30 database (see Appendix II).

Terrain slopes indicated in the DSWM distinguish three broad slope classes as follows:

Class a: *level to undulating*, dominant slopes ranging between 0 and 8 percent.
Class b: *rolling to hilly*, dominant slopes ranging between 8 and 30 percent.
Class c: *steeply dissected to mountainous*, dominant slopes over 30 percent.

The terrain slopes of the DSMW apply to the dominant soil unit of a soil association mapping unit. Where two slopes are indicated for a mapping unit (i.e., a/b or b/c), they apply each to 50 percent of the extent of the dominant soil unit. For all associated and included soils default slope classes are assigned to the individual soil units of FAO ’74 according to FAO (1978-81a):

| Default slope class | Soil Units in FAO'74 |
|---|---|
| a | Fluvisols, Gleysols, Histosols, Planosols, Solonchaks, Solonetz and Vertisols |
| a/b | Podzols, Yermosols, Xerosols, Kastanozems, Chernozems, Phaeozems, Greyzems, Luvisols, Podzoluvisols, Ferralsols and Arenosols |
| b | Regosols, Rendzinas, Cambisols, Acrisols, and Nitosols |
| b/c | Andosols, Rankers and Lithosols |

The above procedure was also adapted for application to the FAO '90 revised legend:

| Default slope class | Soil Units in FAO'90 |
|---|---|
| a | Fluvisols, Gleysols, Histosols, Planosols, Solonchaks, Solonetz and Vertisols |
| a/b | Arenosols, Anthrosols, Chernozems, Ferralsols, Greyzems, Gypsisols, Kastanozems, Luvisols, Lixisols, Podzoluvisols, Phaeozems, Plinthosols, and Podzols |
| b | Acrisols, Alisols, Calcisols, Cambisols, Nitisols and Regosols |
| b/c | Andosols, and Lepthosols |

The slope classes of the DSMW are very broad and do not reflect the information contained in recent digital data sets. Hence, the above broad slope classes have been refined on the basis of knowledge about soil unit-slope relationships and information derived from GTOPO30. Slopes derived from the 30 arc-second DEM were allocated to soil units occurring within individual soil associations. This involved five steps:

(i) Determination of slope classes for each 30 arc-second grid-cell of GTOPO30. Results are grouped in the following seven classes: 0-2%, 2-5%, 5-8%, 8-16%, 16-30%, 30-45% and > 45%;
(ii) Aggregation of the results respectively to 5-minute latitude/longitude DSMW grid-cells, and to individual soil association map units resulting in a slope class distribution for each grid-cell;
(iii) Defining 'priority' classes of soil unit/slope relationships;
(iv) Establishing for each soil association consistent rankings of slopes/soil units;
(v) Allocation of individual soil units within a particular soil association map unit to 5-minute grid-cells of DSMW, according to calculated slope distributions.

Details of the above steps are given in the Appendix II. Plate 9 in Appendix XV presents a map of median terrain slopes derived from GTOPO30.

## 3.3 Soil and terrain constraints

Additional to the crop-specific suitability assessments (see Chapter 4), the land resources inventory allows characterization of various regions according to the prevailing soil and terrain constraints. A constraint classification has been formulated and has been applied to each grid-cell of the land resources inventory. The constraints considered include:

- Terrain-slope constraints
- Soil depth constraints
- Soil fertility constraints
- Soil drainage constraints
- Soil texture constraints
- Soil chemical constraints

- Presence of miscellaneous land units

The results by grid-cell have been aggregated to countries and regions. They are presented in terms of six broad LGP classes[10] (0 days, 1-59 days, 60-119 days, 120-179 days, 180-269 days, and ≥ 270 days). Details of the constraint classification are listed in Appendix III. Results are presented in Section 5.3, *Climate, Soil and Terrain Constraints to Rain-fed Crop Production*. The geographical distribution of constraints is shown in Pates 41 - 47 in Appendix XV.

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10 In tropical and subtropical lowland zones, where $LGP_{t=5}$ =365 days, these broad LGP classes are referred to as respectively: hyper-arid areas (LGP 0 days); arid areas (LGP 1-59 days); dry semi-arid areas (LGP 60-119 days); moist semi-arid areas (LGP 120-179 days); sub-humid areas (180-269 days), and humid areas (LGP ≥ 270 days)

# 4. CROP/LUT PRODUCTIVITY

## 4.1 Introduction

This chapter presents the methodology and procedures for the assessment of land productivity potentials for respectively rain-fed and irrigated conditions. For determining irrigated land productivity potentials, it has been assumed that (i) water resources of good quality are available, and (ii) irrigation infrastructure is in place. In other words, the procedures identify areas where climate, soils and terrain permit irrigated crop cultivation, but do not assess availability of sufficient water supply. Note, however, that GAEZ could readily be linked to watershed data to define limits to water availability.

For the assessment of rain-fed land productivity, a water-balance model is used to quantify the beginning and duration of the period when sufficient water is available to sustain crop growth. Soil moisture conditions together with other climate characteristics (radiation and temperature) are used in a simplified and robust crop growth model to calculate potential biomass production and yield. For the assessment of irrigated land productivity the duration of the period with temperatures conducive for crop growth is used for matching the crop cycle length and for the calculation of biomass production and yield. The calculated potential yields are subsequently combined in a semi-quantitative manner with a number of reduction factors directly or indirectly related to climate (e.g., pest and diseases), and with soil and terrain conditions. The reduction factors, which are successively applied to the potential yields, vary with crop type, the environment (in terms of climate, soil and terrain conditions) and assumptions on level of inputs/management.

In order to ensure that the results of the suitability assessment relate to production achievable on a sustainable basis, (i) fallow periods have been imposed, and (ii) terrain slopes have been excluded when inadequate for the assumed level of inputs/management or too susceptible to topsoil erosion.

## 4.2 Land utilization types

A critical step in implementing any AEZ application is the selection and description of land utilization types. The selection of crops for the present Global AEZ study is based on three considerations, namely: (a) to include the most important food crops, (b) to cover a wide range of natural environments, including those in temperate and boreal zones, and (c) to include, for backward compatibility with earlier AEZ work, all crops previously covered.

The GAEZ study distinguishes in total 154 rain-fed crop, fodder and grassland LUTs, each at three generic levels of inputs and management (high, intermediate and low). For the irrigation land potential assessment, crop LUTs are used at two generic levels of inputs and management (high and intermediate). The full list of crops, fodder and grassland types is presented in Table 8

Relevant crop adaptability and crop requirement data are stored in a crop catalog database. These data sets include for each crop/LUT (and by input level where applicable) the following information:

(i) crop characteristics: crop growth cycle lengths; relative lengths of crop development stages; photosynthetic pathway; crop adaptability group (defining maximum rates of photosynthesis); development stage specific coefficients relating crop water requirements to reference evapotranspiration (Kc-factors, see FAO (1992a)); moisture stress related yield reduction coefficients (Ky-factors, see FAO (1992a));

**Table 8 Crop types included in the Global AEZ study**

| CROPS | CROP TYPES | CLIMATE ZONES |
|---|---|---|
| ***Cereals*** | ***(83)*** | |
| **Wheat (hibernating)** | 4 | Boreal, Temperate and Subtropics |
| **Wheat (non-hibernating)** | 12 | Boreal, Temperate, Subtropics and Tropics |
| **Rice, japonica (wetland)** | 4 | Tropics, Subtropics and Temperate |
| **Rice, indica (wetland)** | 4 | Tropics and Subtropics |
| **Rice (dryland)** | 3 | Tropics |
| **Maize (grain)** | 13 | Tropics, Subtropics and Temperate |
| **Maize (silage)** | 6 | Subtropics and Temperate |
| **Barley (hibernating)** | 4 | Boreal, Temperate and Subtropics |
| **Barley (non-hibernating)** | 12 | Boreal, Temperate, Subtropics and Tropics |
| **Sorghum** | 7 | Tropics, Subtropics and Temperate |
| **Pearl Millet** | 2 | Tropics |
| **Foxtail Millet (Setaria)** | 4 | Subtropics and Temperate |
| **Rye (hibernating)** | 4 | Temperate and Subtropics |
| **Rye (non-hibernating)** | 4 | Boreal, Temperate and Subtropics |
| ***Roots and Tubers*** | ***(8)*** | |
| **White Potato** | 4 | Boreal, Temperate, Subtropics and Tropics |
| **Cassava** | 1 | Tropics |
| **Sweet Potato** | 3 | Subtropics and Tropics |
| ***Pulses*** | ***(17)*** | |
| **Phaseolus Bean** | 9 | Tropics, Subtropics and Temperate |
| **Chickpea** | 5 | Subtropics and Tropics |
| **Cowpea** | 3 | Tropics |
| ***Oil Crops*** | ***(25)*** | |
| **Soybean** | 6 | Tropics, Subtropics and Temperate |
| **Rape (hibernating)** | 2 | Temperate and Subtropics |
| **Rape (non-hibernating)** | 6 | Temperate, Subtropics and Tropics |
| **Groundnut** | 3 | Tropics, Subtropics and Temperate |
| **Sunflower** | 6 | Temperate, Subtropics and Tropics |
| **Oil palm** | 1 | Tropics and Subtropics |
| **Olive** | 1 | Subtropics and Temperate |
| ***Fiber Crops*** | ***(7)*** | |
| **Cotton** | 7 | Tropics, Subtropics and Temperate |
| ***Sugar Crops*** | ***(6)*** | |
| **Sugarcane** | 1 | Tropics and Subtropics |
| **Sugar beet** | 5 | Temperate and Subtropics |
| ***Fruit Crops*** | ***(1)*** | |
| **Banana/Plantain** | 1 | Tropics and Subtropics |
| ***Forage/Fodder*** | ***(5)*** | |
| **Forage Legume (Alfalfa)** | 1 | Temperate and Subtropics |
| **Pasture Grasses** | 4 | Boreal, Temperate, Subtropics and Tropics |
| **Pasture Legumes** | 2 | Boreal, Temperate, Subtropics and Tropics |
| ***Total*** | ***154*** | |

(ii) parameters describing for both rain-fed and irrigated LUTs, thermal requirements, growing period requirements, and soil and terrain requirements, respectively applicable in tropical, subtropical, temperate and boreal environments.

(iii) factors converting biomass to useful products and commodity aggregates: harvest index; food content coefficients (energy, protein); extraction/conversion rates; crop by-product/residue coefficients, commodity aggregation weights.

## 4.3 Climatic suitability analysis

The climatic suitability analysis involves matching of crop/LUT requirements with prevailing climatic conditions. It comprises the following activities:

(a) compilation of crop adaptability inventory for the selected crops and specification of crop/LUT specific temperature and moisture requirements;

(b) matching crop temperature requirements with prevailing temperature regime;

(c) determining optimal cropping calendar and calculation of potential biomass and yield;

(d) calculating crop/LUT specific water deficit and applying moisture stress related yield reduction factors (rain-fed); calculating irrigation water requirements (irrigated);

(e) formulating of crop/LUT specific agro-climatic constraints, accounting for expected yield losses due to factors related to climate conditions, such as incidence of pests, diseases and weeds, workability, and frost occurrence; application of relevant reduction factors to estimate average attainable yield in each grid-cell.

The results of the climatic suitability analysis are calculated in three steps. Step 1 produces a grid-cell specific agro-climatic characterization, including calculation of thermal climates, temperature profiles, and temperature and moisture growing period characteristics. Step 2 calculates temperature and radiation limited potential crop yields, quantifies moisture stress related yield reductions, and determines optimal crop calendars. Finally, Step 3 provides the average attainable crop yields. Results have been classified in five basic suitability classes according to attainable yield ranges relative to maximum potential crop yields, as follows:

| **Suitability class** | | **Percentage of maximum** |
|---|---|---|
| **VS** | Very Suitable | 80 -100 |
| **S** | Suitable | 60 - 80 |
| **MS** | Moderately Suitable | 40 - 60 |
| **mS** | Marginally Suitable | 20 - 40 |
| **NS** | Not Suitable | 0 - 20 |

### 4.3.1 Crop thermal requirements and thermal suitability

Temperature and day-length influence the developmental sequence of crop growth in relation to crop phenology. Crop thermal and day-length requirements for both photosynthesis and phenological development have been taken into account in three regards:

*(i)* Crops have been classified for day-length requirements. For example, short-day crops have been restricted to the lower latitude tropical zones while long-day crops have been restricted to the higher latitude boreal and temperate zones.

*(ii)* A thermal requirements scheme has been devised for each of the 154 crop/LUTs, such that: (a) it covers sufficiently the requirements for photosynthesis and growth, and considers requirements for phenological development of each crop type, and (b) it is applicable in equatorial tropics, and in seasonal subtropical, temperate and boreal climates. The thermal requirements have been formulated in accordance with the temperature profiles which reflect seasonality characteristics of the individual grid-cells (see Section 3.1.3). In this way, the temperature requirements are expressed in terms of the length of periods (duration in days) of the crop cycle falling into temperature intervals of 5°C, separately for increasing and decreasing temperatures. The latter accord with the ‘A’ and ‘B’ type temperature profile periods as described in Section 3.1.3. An example of thermal crop cycle requirements for winter wheat is shown in Figure 7.

The procedures for matching thermal requirements to crop temperature profiles distinguish three cases: *Optimal match* when photosynthesis and phenological temperature requirements are fully met; *Sub-optimal match* when the requirements are just sufficiently met for growth and development; and *Not suitable* when either temperature requirements for photosynthesis or for phenological development are not met.

*(iii)* Crop growth cycle heat requirements (accumulated temperature in degree-days) have been compared with the accumulated temperature actually available in a grid-cell during the growth cycle. When heat requirements are not met, the temperature regime is considered *not* suitable and no further evaluation of the particular crop/LUT for such a grid-cell is undertaken.

In the grid-cells where thermal requirements of a particular crop/LUT are met in optimal or sub-optimal terms, biomass and yield calculations are performed. Figure 7 shows a representation of thermal requirements for winter wheat. Appendix IV presents the thermal requirements for all the crops considered in Global AEZ.

<table>
<tr><td colspan="2">CROP</td><td colspan="4">WINTER WHEAT (C3/I)</td></tr>
<tr><td colspan="2">CLIMATES</td><td colspan="4">Subtropics, Temperate, Boreal</td></tr>
<tr><td colspan="2">PHOTO-SENSITIVITY</td><td colspan="4">Day Neutral/Long Day</td></tr>
<tr><td colspan="2">GROWTH CYCLES (days) [11]</td><td colspan="4">a + b<br>30 + 90, 35 +105, 40 +120, 45 +135</td></tr>
<tr><td colspan="2" rowspan="2">TEMPERATURE. PERIODS [12]</td><td colspan="2">Sub-optimal Conditions<br>Percentage of Growth Cycle</td><td colspan="2">Optimal Conditions<br>Percentage of Growth Cycle</td></tr>
<tr><td>1st req.</td><td>2nd req.</td><td>1st req.</td><td>2nd req.</td></tr>
<tr><td>A9</td><td>< -5 °C</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>A8</td><td>-5-0 °C</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>A7</td><td>0-5 °C</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>A6</td><td>5-10 °C</td><td>≤ 50 % b</td><td rowspan="2">> 16.7 % b</td><td>≤ 50 % b</td><td rowspan="2">> 16.7 % b</td></tr>
<tr><td>A5</td><td>10-15 °C</td><td rowspan="4">≤ 100 % b</td><td rowspan="4">≤ 100 % b</td></tr>
<tr><td>A4</td><td>15-20 °C</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>A3</td><td>20-25 °C</td></tr>
<tr><td>A2</td><td>25-30 °C</td><td>≤ 33.3 % b</td><td>≤33.3 % b</td></tr>
<tr><td>A1</td><td>> 30 °C</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>B1</td><td>> 30 °C</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>B2</td><td>30-25 °C</td><td rowspan="4">≤ 50 % b</td><td></td><td rowspan="4">≤ 50 % b</td><td></td></tr>
<tr><td>B3</td><td>25-20 °C</td><td rowspan="4">100% a</td><td rowspan="4">100% a</td></tr>
<tr><td>B4</td><td>20-15 °C</td></tr>
<tr><td>B5</td><td>15-10 °C</td></tr>
<tr><td>B6</td><td>10-5 °C</td><td></td><td></td></tr>
<tr><td>B7</td><td>5-0 °C</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>B8</td><td>0--5 °C</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>B9</td><td>< -5 °C</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="2">Accumulated temperature during growth cycle (TSgc)[13]</td><td colspan="2">TSgc > 1300<br>(post dormancy)</td><td colspan="2">TSgc > 1500<br>(post dormancy)</td></tr>
<tr><td colspan="2">$LGP_{t=5}$</td><td colspan="2">< 365</td><td colspan="2">< 365</td></tr>
<tr><td colspan="2">Dormancy</td><td colspan="2">Required</td><td colspan="2">Required</td></tr>
<tr><td colspan="2">Permafrost tolerance</td><td colspan="2">No permafrost</td><td colspan="2">No permafrost</td></tr>
</table>

**Figure 7 Temperature profile and thermal requirements for winter wheat**

11 a: pre-dormancy part of growth cycle; b: post-dormancy part of growth cycle.

12 A9-A1: temperature periods with increasing temperatures, i.e., during winter to summer; B1-B9: temperature periods with decreasing temperatures, i.e., from summer to winter.

13 Accumulated temperature during post-dormancy part of growth cycle.

### 4.3.2 Biomass and yield

The constraint-free crop yields calculated in the AEZ biomass model[14] reflect yield potentials with regard to temperature and radiation regimes prevailing in the respective grid-cells. This basically eco-physiological model (Kassam, 1977) requires the following crop characteristics: (a) length of growth cycle (days from emergence to full maturity); (b) length of yield formation period; (c) leaf area index (LAI) at maximum growth rate; (d) harvest index (Hi); (e) crop adaptability group; and (f) sensitivity of crop growth cycle length to heat provision. The biomass calculation includes also simple procedures to account for different levels of atmospheric $CO_2$ concentrations (Fischer and van Velthuizen, 1996). Appendix VI provides details of the calculation procedures and Appendix VII lists the model parameters.

The results of the biomass and yield calculation depend on timing of crop growth cycle (crop calendar). Maximum biomass and yields are separately calculated for irrigated and rain-fed conditions, as follows:

*Irrigation:*

For each day within the window of time when crop temperature requirements are met optimally or at least sub-optimally[15], the period resulting in the highest biomass and yield is selected to represent the production and crop calendar of the respective crop/LUT for a particular grid-cell.

*Rain-fed:*

Within the window with optimal or sub-optimal temperature conditions, and starting within the duration of the moisture growing period, the period resulting in the highest expected (moisture-limited) yield is selected to represent maximum biomass and yield for rain-fed conditions of the respective crop/LUT for a particular grid-cell. Moisture limited yields are calculated by applying crop-stage specific and total growing period yield reduction factors (FAO, 1979; FAO 1992a). The yield reduction factors relate relative yield decrease, expressed as (1-*Ya*/*Ym*), to relative evapotranspiration deficit (1-*ETa*/*ETm*). In this formulation, *Ya* and *Ym* denote water-limited and potential yield, respectively; *ETa* and *ETm* refer to crop-specific actual and potential evapotranspiration in a grid-cell. The obtained relative yield decrease is then applied to the calculated temperature/radiation limited biomass and yield.

In other words, for each crop type and grid-cell the starting and ending dates of the crop growth cycle are determined optimally to obtain best possible crop yields, separately for rain-fed and irrigated conditions. This procedure also guarantees maximum adaptation in simulations with year-by-year historical weather conditions, or under climate distortions applied in accordance with various climate change scenarios. Hence, the AEZ method simulates a ‘smart’ farmer. Results of the biomass and yield calculations can be presented in tabular or in map form. For instance, Plate 17 in Appendix XV presents a map of temperature and radiation limited yields for wheat.

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14 The calculated biomass and yields are used to formulate indicative yield ranges for each of the five suitability classes employed at each of the three input circumstances.

15 Only in cases where conclusive data on crop temperature requirements are available, distinction between optimal and sub-optimal conditions could be made.

### 4.3.3 Crop moisture requirements and growing period suitability

Crop water requirements are for most crops well established and published widely. Various aspects relevant to crop moisture requirements are included in the crop catalog data files: crop growth cycle length, crop stage specific water requirement coefficients, moisture deficit related yield reduction coefficients.

To cater for differences in soil types, the crop cycle matching and biomass calculations were performed for each of the six soil moisture storage capacity (Smax) classes (see Table 6). Moisture-limited yields of annual rain-fed crops have been calculated by applying crop stage specific and total growing period yield reduction factors in accordance with procedures developed by FAO (1992a) and as described in the calculation of biomass and yield. This allows the relevant result to be applied for each of the soil types occurring in a particular soil mapping unit of the FAO DSMW.

Perennial crops (i.e., cassava, sugar cane, banana, oil palm, olive, alfalfa, grass/legume mixtures, and grasses) are matched to moisture conditions of the calculated growing periods. This involves the following steps: (i) how well the crop growth cycle fits within the available total length of growing period, and (ii) how well crop water requirements are met by growing period quality parameters (e.g., ratio of actual over potential evapotranspiration (*ETa*/*ETm*), or type of growing periods). Yield losses directly resulting from moisture constraints are quantified through adjustments of both the leaf area index and harvest index. For example, if the crop growth cycle is curtailed due to the length of growing period being insufficient, the leaf area index (LAI) is reduced proportionately relative to the LAI of the normal growth cycle considered. When the yield formation period is curtailed due to the growing period being shorter, the harvest index (*Hi*) is reduced proportionately in relation to the standard *Hi* of the reference yield formation period.

Losses in marketable value of the produce due to poor quality in yield as influenced by incomplete yield formation, however, cannot be accounted for in the biomass and yield calculations. These and other losses have been evaluated separately and are referred to as *agro-climatic constraints*.

### 4.3.4 Agro-climatic constraints

Matching the climatic characteristics by grid-cell with the crop temperature profile requirements and the calculation of net biomass and yield provides quantification of crop production that can be anticipated under conditions that are essentially free from soil constraints but also from agro-climatic constraints.

Agro-climatic constraints cause direct or indirect losses in the yield and quality of produce. Yields losses in a rain-fed crop due to agro-climatic constraints have been formulated based on principles and procedures proposed in FAO (1978-81a). For details of the conditions that are influencing yield losses and a listing of the agro-climatic constraint parameters for all the crop/LUTs considered, reference can be made to Appendix VIII.

In the present study, covering also temperate and boreal environments, one additional category of agro-climatic constraints has been added to the four categories in the original study. This fifth so-called ‘e’ constraint covers yield losses due to the occurrence of early or late frosts. The five categories are:

(a) yield losses due to water-stress constraints on crop growth (e.g., rainfall variability);
(b) yield losses due to the effect of pests, diseases and weed constraints on crop growth;

(c) yield losses due to water-stress, pest and diseases constraints on yield components and yield formation of produce (e.g., affecting quality of produce);

(d) yield losses due to workability constraints (e.g., wetness rendering produce handling difficulties); and

(e) yield losses due to occurrence of early or late frosts.

The availability of historical rainfall data has made it possible to derive the effect of rainfall variability through year-by-year calculation of yield losses due to water stress. Therefore the ‘a’ constraint, related to rainfall variability is no longer applied. However the ‘a‘ constraint has been retained in the agro-climatic constraints database for use with data sets containing average rainfall data and for comparison with results of the presently used year-by-year analysis.

The ‘b’, ‘c’ and ‘d’ constraints are related to wetness and the ratings of these constraints have been linked to the LGP. It appears however, that in different climate zones, wetness conditions, traditionally expressed as *P/ETo* ratios, vary considerably for similar LGPs. Long LGPs with relatively low *P/ETo* ratios occur generally in subtropical, temperate and boreal zones, while relatively high ratios occur in the tropics.

To account for these significant differences in *wetness* conditions of long LGPs (> 225 days), agro-climatic constraints have been related to *P/ETo* ratios by calculating *equivalent LGPs*, i.e., adjustments where *P/ETo* ratios where below average. The equivalent LGPs are then used in the application of the ‘b’, ‘c’, and ‘d’ constraints. Table 9 presents an example of agro-climatic constraints for winter wheat. For irrigated production only the agro-climatic constraints related to excess wetness apply.

**Table 9 Agro-climatic constraints for winter wheat**

| SUBTROPICS, TEMPERATE AND BOREAL | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Growth | 40 days pre-dormancy + 120 days post-dormancy | | | | | | | | | | | |
| $LGP_{t=10}$ | 60-89 | 90- | 120- | 150- | 180- | 210- | 240- | 270- | 300- | 330- | $365^-$ | $365^+$ |
| Low inputs | | | | | | | | | | | | |
| a* | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| c | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| d | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| Intermediate Inputs | | | | | | | | | | | | |
| a | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| c | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| d | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| High inputs | | | | | | | | | | | | |
| a | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| c | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| d | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| $LGP_{t=10}$ | 60-89 | 90- | 120- | 150- | 180- | 210- | 240- | 270- | 300- | 330- | 365 | |
| All input levels | | | | | | | | | | | | |
| e | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

* The ‘a’ constraint (yield losses due to rainfall variability) is not applied in the current assessment. This constraint has become redundant due to explicit quantification of yield variability through the application of historical rainfall data sets.

The application of the agro-climatic constraints to the combined results of temperature suitability and the biomass and yield calculations (see previous Sections) provides agro-climatic suitabilities. Plates 18 and 19 present examples of agro-climatic suitability maps for rain-fed and rain-fed plus irrigated wheat production at the high level of inputs.

### 4.4 Growing period suitability for water-collecting sites

In water-collecting sites substantially more water can be available to plants as compared to upland situations. Water-collecting sites are difficult to locate in a global study but can be approximately determined on the basis of prevalence of specific soil types. Fluvisols[16] and to a lesser extent Gleysols[17] are typically representing the flat terrain of alluvial valleys and other water-collecting sites.

The cultivation of Fluvisols (under unprotected natural conditions) is determined by frequency, duration and depth of flooding. The flooding attributes are generally controlled by external factors such as a river's flood regime which in turn is influenced by hydrological features of the catchment area and catchment/site relations, rather than by the amount of 'on site' precipitation.

Therefore, with the exception of wetland crops, the cultivation of these soils is mainly confined to post-flood periods, with crops growing on residual soil moisture. The flooding regime in arid and semi-arid zones is erratic. Some years, severe flash floods may occur, in other years no floods occur at all. In sub-humid and humid zones flooding is more regular but duration and depth of flooding may vary widely from year to year.

Gleysols are not directly affected by river flooding. These soils are however frequently situated in low-lying water-collecting sites and when not artificially drained, the Gleysols may be subject to water-logging or even inundation as result from combinations of high groundwater tables and ponding rainwater. In arid and semi-arid areas these soils are cultivated in the later part and after rainy seasons; the crops grow and mature on residual soil moisture. In sub-humid and humid areas Gleysols without artificial drainage often remain waterlogged for extensive periods, rendering them unsuitable for cultivation of dryland crops.

On both, Fluvisols and Gleysols, crops of short duration that are adapted to growing and producing yields on residual soil moisture and which are tolerant to flooding, water-logging and high groundwater tables, can be found producing satisfactorily outside the growing period defined by the local rainfall regime. Therefore, a separate crop suitability classification for water-collecting sites is required. In compiling this classification, the logic of the original AEZ study (FAO, 1978-81a) has been followed. This includes accounting for crop-specific tolerances to excess moisture (high ground-water, water-logging and flooding/inundation) and the use of available estimates of flooding regimes of the Fluvisols. Since Gleysols are mostly, but not necessarily, subjected to water-logging and inundation just like the 'natural Fluvisols', it was decided to treat Gleysols with terrain-slopes of less than 2% the same as Fluvisols.

In many parts of the world the flooding of Fluvisols is increasingly being controlled with dikes and other protection means. Fluvisols, in protected conditions, do not benefit additional water supply and regular fresh sediment deposits, nor do they suffer from flooding. The moisture regime of Fluvisols under these protected conditions is similar to other soils and

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[16] Fluvisols are by definition flooded by rivers. Fluvisols are young soils where sedimentary structures are clearly recognizable in the soil profile.

[17] Gleysols are generally not flooded by rivers. However, the soil profiles indicate regular occurrence of high groundwater tables through reduction (gley) features. Low-lying Gleysols may be ponded/water-logged by high groundwater and rainfall during the rainy season.

therefore protected Fluvisols are treated according to the procedures used for crops in upland conditions.

In a similar way, Gleysols may be artificially drained, thereby diminishing a major limitation for the cultivation of these soils. For areas where the Gleysols have been drained, a revised (i.e., less severe) set of soil ratings is used and the rule for natural Fluvisols is not applied.

Since spatial details of the occurrence of protected Fluvisols and artificial drainage of Gleysols are not available at the global scale these factors are assumed to be linked to the level of inputs/management. The application of Fluvisol suitability ratings and soil unit suitability ratings of artificially drained Gleysols are presented below:

| | Fluvisols | | Gleysols | |
|---|---|---|---|---|
| | natural | protected | natural | artificially drained |
| RAIN-FED | | | | |
| High level inputs | no | yes | no | yes |
| Intermediate level inputs | 50% | 50% | 50% | 50% |
| Low level inputs | yes | no | yes | no |
| IRRIGATION | | | | |
| High level inputs | no | yes | no | yes |
| Intermediate level inputs | 50% | 50% | 50% | 50% |

The moisture suitability ratings devised for unprotected Fluvisols and Gleysols without artificial drainage are organized in ten groups of crops with comparable growth cycle lengths and similar tolerances to high groundwater levels, water-logging and flooding. The rating tables are presented in Appendix IX.

## 4.5 Agro-edaphic suitability analysis

Adequate agricultural exploitation of the climatic potentials and maintenance of land productivity largely depend on soil fertility and the management of soils on an ecologically sustained basis. Soil fertility is concerned with the ability of the soil to retain and supply nutrients and water in order to enable crops to maximally utilize the climatic resources of a given location. The fertility of a soil is determined by both its physical and chemical properties. An understanding of these factors and insight in their interrelations is essential to the effective utilization of climate, terrain and crop resources for optimum use and production.

From the basic soil requirements of crops, a number of soil characteristics have been established related to crop yield response. For most crops and cultivars, optimal, sub-optimal, marginal and unsuitable levels of these soil characteristics are known and have been quantified. Beyond critical ranges, crops cannot be expected to yield satisfactorily unless special precautionary management measures are taken. Soil suitability classifications are based on knowledge of crop requirements, of prevailing soil conditions, and of applied soil management. In other words, soil suitability classifications quantify in broad terms to what extent soil conditions match crop requirements under defined input and management circumstances. For a global study this necessitates expert judgement and a semi-quantitative approach.

### 4.5.1 Soil suitability evaluation for rain-fed crop production

FAO's agro-edaphic suitability classification used in AEZ is to a large extent based on experience documented by Prof. C. Sys and others (FAO, 1978-81a; Sys and Riquier, 1980; FAO, 1984b; FAO, 1985; Nachtergaele, 1988; Sys, 1990; Sys *et al*., 1993). The agro-edaphic suitability classification has been intensively used by FAO and other organizations, at various scales in many countries and regions; it passed through several international expert consultations, and hence it constitutes the most recent consolidation of expert knowledge. In this system a suitability rating is proposed for each soil unit, by individual crops at three defined levels of inputs and management circumstances. The agro-edaphic suitability rating is based on a comparison of soil requirements of crops and prevailing edaphic conditions. Data available from various sources have been summarized by Sys *et al*. (1993).

The source of soil information is primarily the digital version of the FAO/Unesco *Soil Map of the World* (FAO, 1995c). A tabulation of the soil ratings by FAO '74 soil unit for all crop/LUTs considered in GAEZ is presented in Appendix X. Soil phase suitability ratings are listed in Appendix XI. Modifications of soil suitability ratings for soil units with coarse textures are treated according to procedures presented in FAO (1978-81a).

### 4.5.2 Terrain suitability evaluation for rain-fed crop production

The influence of topography on agricultural land use is manifold. Farming practices are by necessity adapted to terrain slope, slope aspect, slope configuration and micro-relief. For instance, steep irregular slopes are not practical for mechanized cultivation, while these slopes might very well be cultivated with adapted machinery and hand tools.

Sustainable agricultural production on sloping land is concerned with the prevention of erosion of topsoil and decline of fertility. Usually this is achieved by combining special crop management and soil conservation measures. Slopes cultivated with crop/LUTs providing inadequate soil protection and without sufficient soil conservation measures, cause a considerable risk of accelerated soil erosion. In the short term, cultivation of slopes might lead to yield reductions due to loss of applied fertilizer and fertile topsoil. In the long term, this will result in losses of land productivity due to truncation of the soil profile and consequently reduction of natural soil fertility and of available soil moisture.

Rain-fed annual crops are the most critical to cause topsoil erosion, because of their particular cover dynamics and management. The terrain-slope suitability rating used in the Global AEZ study captures the factors described above which influence production and sustainability. This is achieved through: (i) defining for the various crop/LUTs permissible slope ranges for cultivation, by setting maximum slope limits; (ii) for slopes within the permissible limits, accounting for likely yield reduction due to loss of fertilizer and topsoil, and (iii) distinguishing among farming practices ranging from manual cultivation to fully mechanized cultivation.

Ceteris paribus, i.e., under similar crop cover, soil erodibility and crop and soil management conditions, soil erosion hazards largely depend on amount and intensity of rainfall. Data on rainfall amount is available on a monthly basis in the 0.5 degree latitude/longitude climate databases. Rainfall intensity or energy, as is relevant for soil erosion, is not estimated in these data sets.

To account for clearly existing differences in both amount and within-year distribution of rainfall, use has been made of the modified Fournier index (*Fm*), which reflects the combined effect of rainfall amount and distribution (FAO/UNEP, 1977), as follows:

$$Fm = 12 \sum_{i=1}^{12} \frac{p_i^{\,2}}{Pann}$$

where:

$p_i$ = precipitation of month $i$
*Pann* = total annual precipitation

When precipitation is equally distributed during the year, i.e., in each month one-twelfth of the annual amount is received, then the value of *Fm* is equal to *Pann*. On the other extreme, when all precipitation is received within one month, the value of *Fm* amounts to twelve times *Pann*. Hence, *Fm* is sensitive to both total amount and distribution of rainfall and is limited to the range of $Pann \le Fm \le 12\ Pann$. The *Fm* index has been calculated for all 0.5 degree grid-cells of the climatic inventory. The results have been grouped in six classes, namely: $Fm <$ 1300, 1300-1800, 1800-2200, 2200-2500, 2500-2700, and $Fm >$ 2700.

Slope ratings are defined for the seven slope range classes used in the land resources database, namely: 0-2% flat, 2-5% gently sloping, 5-8 % undulating, 8-16% rolling, 16-30% hilly, 30-45% steep, and > 45% very steep. The following suitability rating classes are employed:

| | |
|---|---|
| S1 | Optimal conditions |
| S2 | Sub-optimal conditions |
| S1/S2 | 50% optimal and 50% sub-optimal conditions |
| S2/N | 50% sub-optimal and 50% not suitable conditions |
| N | Not suitable conditions |

Table 10 presents terrain-slope ratings for rain-fed conditions for eight crop groups at three levels of inputs and management in grid-cells with rainfall such that the level of the Fournier index Fm < 1300. Additional ratings, for levels of the index Fm > 1300, are listed in Appendix XIV.

**Table 10 Terrain-slope ratings for rain-fed conditions (Fm <1300)**

**High Inputs**

| Slope Gradient Classes | 0-2 % | 2-5% | 5-8% | 8-16% | 16-30% | 30-45% | > 45% |
|---|---|---|---|---|---|---|---|
| Annuals 1 | S1 | S1 | S1 | S1/S2 | N | N | N |
| Annuals 2 | S1 | S1 | S1 | S1/S2 | N | N | N |
| Wetland rice | S1 | S1/S2 | S2/N | N | N | N | N |
| Sugarcane | S1 | S1 | S1/S2 | S2/N | N | N | N |
| Olive | S1 | S1 | S1 | S2 | S2/N | N | N |
| Perennials | S1 | S1 | S1 | S2 | N | N | N |
| Pasture | S1 | S1 | S1 | S1 | S2/N | N | N |
| Forage legumes | S1 | S1 | S1 | S1/S2 | N | N | N |

**Intermediate Inputs**

| Slope Gradient Classes | 0-2 % | 2-5% | 5-8% | 8-16% | 16-30% | 30-45% | > 45% |
|---|---|---|---|---|---|---|---|
| Annuals 1 | S1 | S1 | S1 | S1/S2 | S2 | N | N |
| Annuals 2 | S1 | S1 | S1 | S1/S2 | S2 | N | N |
| Wetland rice | S1 | S1/S2 | S2 | N | N | N | N |
| Sugarcane | S1 | S1 | S1/S2 | S2/N | N | N | N |
| Olive | S1 | S1 | S1 | S1/S2 | S2 | N | N |
| Perennials | S1 | S1 | S1 | S2 | S2/N | N | N |
| Pasture | S1 | S1 | S1 | S1 | S1/S2 | S2/N | N |
| Forage legumes | S1 | S1 | S1 | S1 | S1/S2 | S2/N | N |

**Low Inputs**

| Slope Gradient Classes | 0-2 % | 2-5% | 5-8% | 8-16% | 16-30% | 30-45% | > 45% |
|---|---|---|---|---|---|---|---|
| Annuals 1 | S1 | S1 | S1 | S1 | S2 | N | N |
| Annuals 2 | S1 | S1 | S1 | S1/S2 | S2 | N | N |
| Wetland rice | S1 | S1/S2 | S2 | N | N | N | N |
| Sugarcane | S1 | S1 | S1S2 | S2/N | N | N | N |
| Olive | S1 | S1 | S1 | S1/S2 | S2 | S2/N | N |
| Perennials | S1 | S1 | S1 | S2 | S2/N | N | N |
| Pasture | S1 | S1 | S1 | S1 | S1/S2 | S2/N | N |
| Forage legumes | S1 | S1 | S1 | S1 | S1/S2 | S2/N | N |

**Crop Groups**: Annuals 1: wheat, barley, rye;
Annuals 2: maize, sorghum, pearl millet, foxtail millet, white potato, sweet potato, phaseolus bean, chickpea, cowpea, soybean and groundnut, sunflower, cotton, sugar beet, rape;
Perennials: cassava, oil palm, banana, plantain.

### 4.5.3 Soil and terrain suitability evaluation for irrigated crop production

The evaluation procedures for gravity irrigation suitability cover the dryland crops and wetland rice, at both intermediate and high levels of management and input circumstances. Three important assumptions have been made in setting up the procedures[18]: firstly, water resources of good quality are available; secondly, irrigation infrastructure is in place; and thirdly, the crop-specific soil limitations for rain-fed production (such as limitations imposed by soil rooting conditions, soil nutrient availability and soil nutrient retention capacity, soil toxicity, soil salinity, soil alkalinity, and calcium carbonate and gypsum content) also apply to irrigation. For irrigation these limitations are assumed to be similar or more severe. Note, however, that the Global AEZ assessment does not provide a quantification of irrigation water availability. Nevertheless, it can generate useful information for integrated analysis at the watershed level.

The following land and soil characteristics have been interpreted specifically for the irrigation suitability classification: topography; soil drainage; soil texture; surface and sub-surface stoniness; calcium carbonate levels; gypsum status; and salinity and alkalinity conditions. The main literature sources used in the interpretation include Sys *et al.* (1993), Sys and Riquier (1980), FAO (1985), FAO (1996), FAO (1976b), FAO/Unesco (1974), and FAO/Unesco/ISRIC (1990).

18 In arid and hyperarid areas only Fluvisols, Gleysols and soils with phreatic phase have been considered for the assessment of irrigation suitability.

*Topography*

The dominant topographic factor governing the suitability of an area for gravity or sprinkler irrigation is the terrain slope. Other topographic factors, such as micro-relief, have partly been accounted for in the soil unit and soil phase suitability classifications. Permissible slopes for irrigation depend on type of irrigation systems and assumed level of inputs and management.

Gravity irrigation (basin, border, and furrow systems) is suitable for a large range of crops provided it is managed properly. It is used for terrain slopes up to 5 percent. For 'non-row crops' such as wheat, barley, pasture and forage legumes, slopes up to 10 percent can be used with special systems such as corrugations. At these steeper slopes irrigation efficiency is diminished due to poor uniformity of the water distribution, leading to irregular stands of crops. Therefore, slopes between 5 and 10 percent are classified as sub-optimal for all types of gravity irrigation.

**Table 11 Terrain-slope ratings for gravity irrigation**

**High Inputs**

| **Slope Gradient Classes** | **0-2 %** | **2-5%** | **5-8%** | **8-16%** | **16-30%** | **30-45%** | **> 45%** |
|---|---|---|---|---|---|---|---|
| Annuals 1 | S1 | S1 | S2/N | N | N | N | N |
| Annuals 2 | S1 | S1/S2 | S2/N | N | N | N | N |
| Wetland rice | S1 | S1/S2 | N | N | N | N | N |
| Sugarcane | S1 | S1/S2 | S2/N | N | N | N | N |
| Olive | S1 | S1/S2 | S2/N | N | N | N | N |
| Perennials | S1 | S1/S2 | S2/N | N | N | N | N |
| Pasture | S1 | S1 | S2/N | N | N | N | N |
| Forage legumes | S1 | S1 | S2/N | N | N | N | N |

**Intermediate Inputs**

| **Slope Gradient Classes** | **0-2 %** | **2-5%** | **5-8%** | **8-16%** | **16-30%** | **30-45%** | **> 45%** |
|---|---|---|---|---|---|---|---|
| Annuals 1 | S1 | S1 | S1/S2 | S2/N | N | N | N |
| Annuals 2 | S1 | S1/S2 | S2/N | N | N | N | N |
| Wetland rice | S1 | S1/S2 | N | N | N | N | N |
| Sugarcane | S1 | S1/S2 | S2/N | N | N | N | N |
| Olive | S1 | S1/S2 | S2/N | N | N | N | N |
| Perennials | S1 | S1/S2 | S2/N | N | N | N | N |
| Pasture | S1 | S1 | S1/S2 | S2/N | N | N | N |
| Forage legumes | S1 | S1 | S1/S2 | S2/N | N | N | N |

**Crop Groups**: Annuals 1: wheat, barley, rye;
Annuals 2: maize, sorghum, pearl millet, foxtail millet, white potato, sweet potato, phaseolus bean, chickpea, cowpea, soybean and groundnut, sunflower, cotton, sugar beet, rape;
Perennials: cassava, oil palm, banana, plantain.

Sprinkler irrigation systems include many types. They are generally more efficient than gravity systems but also much more expensive, and they require special management skills. Sprinklers can be used on somewhat steeper slopes than the gravity systems. However, some of the larger central pivot systems can only be used on flat or almost flat terrain. Small-scale systems are more suitable on sloping land. For perennial or well established pastures well adapted systems may be used on slopes up to 24 percent. For annual crops, serious erosion risk starts at about 10-12 percent slopes, depending on soil erodibility, ground cover, and management. Sprinkler irrigation is obviously not suitable for wetland crops.

Tables 11 and 12 present terrain-slope suitability ratings, respectively for gravity and sprinkler irrigation systems, for eight groups of crops at high and intermediate levels of inputs. The suitability rating classes are the same as for rain-fed conditions.

**Table 12 Terrain-slope ratings for sprinkler irrigation**

**High Inputs**

| Slope Gradient Classes | 0-2 % | 2-5% | 5-8% | 8-16% | 16-30% | 30-45% | > 45% |
|---|---|---|---|---|---|---|---|
| Annuals 1 | S1 | S1 | S1/S2 | S2/N | N | N | N |
| Annuals 2 | S1 | S1 | S1/S2 | S2/N | N | N | N |
| Wetland rice | N | N | N | N | N | N | N |
| Sugarcane | S1 | S1 | S1/S2 | S2/N | N | N | N |
| Olive | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| Perennials | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| Pasture | S1 | S1 | S1 | S1/S2 | S2/N | N | N |
| Forage legumes | S1 | S1 | S1/S2 | S2/N | N | N | N |

**Intermediate Inputs**

| Slope Gradient Classes | 0-2 % | 2-5% | 5-8% | 8-16% | 16-30% | 30-45% | > 45% |
|---|---|---|---|---|---|---|---|
| Annuals 1 | S1 | S1 | S1/S2 | S2/N | N | N | N |
| Annuals 2 | S1 | S1 | S1/S2 | S2/N | N | N | N |
| Wetland rice | N | N | N | N | N | N | N |
| Sugarcane | S1 | S1 | S1/S2 | S2/N | N | N | N |
| Olive | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| Perennials | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| Pasture | S1 | S1 | S1 | S1/S2 | S2/N | N | N |
| Forage legumes | S1 | S1 | S1/S2 | S2/N | N | N | N |

**Crop Groups**: Annuals 1: wheat, barley, rye;
Annuals 2: maize, sorghum, pearl millet, foxtail millet, white potato, sweet potato, phaseolus bean, chickpea, cowpea, soybean and groundnut, sunflower, cotton, sugar beet, rape;
Perennials: cassava, oil palm, banana, plantain.

### *Soil texture*

Soil texture provides a measure for permeability and to some extent, for water retention capacity. Soils with potentially high percolation losses and soils with low water retention capacity, e.g., Vitric Andosols, Arenosols, Podzols and all soils with coarse textures have been considered not suited for gravity irrigation. For medium and fine textured soils excessive percolation and low water-retention capacities are less relevant. However for Acrisols, Nitosols and Ferralsols the irrigation suitability ratings are slightly different as compared to rainfed conditions, because of their specific clay mineralogy, resulting in relatively low water-retention capacity and slightly higher percolation losses. The modifications related to texture/clay mineralogy are summarized in Table 13.

**Table 13 Soil texture/clay mineralogy limitations**

| Major Soil Unit | | Soil Unit | Suitability | |
|---|---|---|---|---|
| FAO '74 | FAO '90 | | Dryland Crops | Wetland Rice |
| Acrisols (A) | Acrisols (AC) | all units | S1/S2 | S2 |
| Ferralsols (F) | Ferralsols (FR) | all units | S1/S2 | S2 |
| Nitosols (N) | Nitisols (NT) | all units | S1/S2 | S2 |
| Podzols (P) | Podzols (PZ) | all units | N | N |
| Arenosols (Q) | Arenosols (AR) | all units | N | N |
| Andosols (T) | Andosols (AN) | Tv, ANz | N | N |
| n.a. | Alisols (AL) | all units | S1/S2 | S2 |
| n.a. | Plinthosols (PT) | all units | S1/S2 | S2 |

*Soil drainage*

Irrigation of dryland crops requires well drained soils to assure aeration and to avoid the danger of secondary salinization. Drainage conditions depend on depth and quality of groundwater. At present, this can not be assessed on regional and global scales due to lack of systematic data. Soil drainage quantification, however, is available for the soil units of the FAO '74 legend (FAO, 1995c). For wetland rice and dryland crops drainage requirements under irrigation are quite different as compared to rain-fed conditions. Therefore, the following modifications to rain-fed suitability ratings were adopted in GAEZ (see Table 14).

**Table 14 Soil drainage limitations**

| LUT | Soil Drainage Class | Suitability |
|---|---|---|
| Wetland Rice | P | S1 |
| | VP, I, MW, W | S2 |
| | SE, E | N |
| Dryland crops | W | S1 |
| | MW | S1/S2 |
| | I, P | S2 |
| | VP, SE, E | N |

**Drainage Classes:** VP very poor P poor I imperfectly
MW moderately well W well SE somewhat excessively E excessively

*Soil depth and soil stoniness*

Under irrigated conditions soil depth affects drainage, aeration and water retention properties. Deep soils favor drainage and are therefore optimal for irrigation of dryland crops. Soils with impermeable layers favor maintenance of flooding conditions for wetland rice. Shallow soils such as Rendzinas (Rendzic Leptosols) and Rankers (Umbric Leptosols) and soils with phases implying a reduction in soil depth have been reviewed and adjusted for irrigated conditions.

Surface stoniness affects soil workability. In addition, subsurface stoniness reduces water-holding capacity and increases infiltration rates. It is assumed that a level of more than 40 volume percent of coarse materials will markedly influence the water-balance in the soil profile (Sys and Riquier, 1980). To cater for these constraints specifically affecting irrigation suitability, the soil phase suitability ratings for petric (skeletic) and stony phases (rudic) in FAO legends have been adjusted from the rain-fed ratings. The soil phase ratings for irrigated crop production are presented in Appendix XI.

*Calcium carbonate*

Calcium carbonate in the form of free lime in the soil profile affects soil structure and interferes with infiltration and evapotranspiration processes. It influences both the soil moisture regime and availability of nutrients. This, however, applies equally to rain-fed and irrigated cropping. Therefore, no changes are required to the crop-specific limitations as established for rain-fed cropping.

*Gypsum*

Gypsum interferes with water absorption and availability. As consequence of the solubility of gypsum in water, so-called dissolution depressions can be formed as a result of the application of irrigation water to gypsiferous soils. This renders soils with high gypsum content unsuitable for irrigation. These gypsifereous soils and soil phases are listed below in Table 15.

**Table 15 Soil units with gypsum limitations**

| **Gypsiferous Soil Units** | | **Gypsiferous Soil Phases** | |
|---|---|---|---|
| FAO 1974 | FAO 1990 | FAO 1974 | FAO 1990 |
| Yy, Yl, Xy, Xl, Kl, Kk, Ck, Cl, and Bk | GY, GYk, GYl, GYh, KSy, RGy, SCy, SNy | Petrogypsic | Yermic |

*Salinity and alkalinity*

Irrigation in semi-arid and arid regions requires careful soil drainage (natural and/or artificial) to avoid irrigation-induced secondary salinization. It is assumed that, where so required, appropriate drainage systems are in place and that irrigation water is non-saline. In this case no changes are necessary to the crop-specific suitability ratings as used for rain-fed cropping.

Alkalinity, expressed as sodium saturation, influences the structure stability of soils, which in turn affects infiltration rates and aeration of soils. The alkalinity (sodicity) constraints are equally important for rain-fed and irrigated conditions. Therefore, the crop-specific soil unit and soil phase ratings evaluated for rain-fed conditions remain unchanged for irrigated cropping.

## 4.6 Fallow period requirements

In their natural state, many soils, in particular in the tropics, cannot be continuously cultivated without undergoing degradation. Such degradation is marked by a decrease in crop yields and a deterioration of soil structure, nutrient status and other physical, chemical and biological attributes. Under traditional low input farming systems, this deterioration is kept in check by alternating some years of cultivation with periods of fallow. The length of the necessary rest period is dependent on inputs applied, soil and climate conditions, and crops. Hence, the main reason for incorporating fallow into crop rotations is to enhance sustainability of production through maintenance of soil fertility.

Regeneration of nutrients and maintenance of soil fertility under low input cultivation is achieved through natural bush or grass fallow. At somewhat higher inputs to soils, soil fertility is maintained through fallow, which may include for a portion of time a grass, grass-legume ley or a green-manure crop. Factors affecting changes in soil organic matter are reviewed in Nye and Greenland (1960) and Kowal and Kassam (1978). They include temperature, rainfall, soil moisture and drainage, soil parent material, and cultivation practices. The fallow factors used in the present Global AEZ land potential are based on earlier work done in the context of FAO's regional assessments (Young and Wright, 1980) and the Kenya AEZ study (FAO/IIASA, 1991).

The fallow factors have been established by main crop groups and environmental conditions. The crop groups include cereals, legumes, roots and tubers, and a miscellaneous group consisting of long term annuals/perennials. Fallow requirements have been assumed to be negligible for olive and oil palm. The environmental frame consists of individual soil units, thermal regimes and moisture regimes. The thermal regimes are expressed in terms of annual mean temperatures of > 25°C, 20-25°C, 15-20°C and <15°C. The moisture regimes are made up of five broad LGP ranges:<90 days, 90-120 days, 120-180 days, 180-270 days, and > 270 days.

Appendix XII presents fallow-land requirements by thermal and moisture regimes imposed to maintain soil fertility. This factor is expressed as percentage of time during the fallow-cropping cycle the land must be under fallow. For Fluvisols and Gleysols fallow factors are lower because of their special moisture and fertility conditions.

At high levels of inputs and management fallow requirements are uniformly set at 10%. At intermediate level of inputs the fallow requirements are set at one third of the levels required under low level of inputs. In the present study the fallow requirement factors have been applied for the estimations of annually available arable land.

## 4.7 Multiple cropping zones for rain-fed crop production

In the GAEZ crop suitability analysis, the LUTs considered refer to single cropping of sole crops, i.e., each crop is presumed to occupy the land only once a year and in pure stand. Consequently, in areas where the growing periods are sufficiently long to allow more than one crop to be grown in the same year or season, single crop yields do not reflect the full potential of total time and space available per unit area of land for rain-fed production.

To assess the multiple cropping potential, a number of multiple cropping zones have been defined through matching both growth cycle and temperature requirements of individual suitable crops with time available for crop growth. For rain-fed conditions this period is approximated by the LGP, i.e., the number of days during which both temperature and moisture conditions permit crop growth.

For the definition of multiple cropping zones four types of crops are distinguished: thermophilic crops requiring warm temperatures, cryophilic crops performing best under cool and moderately cool conditions, hibernating crops, and wetland crops with specific water requirements. Furthermore, the crops are subdivided according to growth cycle length, namely of less or more than 120 days duration, respectively. According to the above criteria, the following nine zones were classified and mapped (see Plate 20):

**A.** *Zone of no cropping* (too cold or too dry for rain-fed crops)

**B.** *Zone of single cropping*

**C.** *Zone of limited double cropping* (relay cropping; single wetland rice may be possible)

**D.** *Zone of double cropping* (sequential cropping; wetland rice not possible)

**E.** *Zone of double cropping* (sequential cropping; one wetland rice crop possible)

**F.** *Zone of limited triple cropping* (partly relay cropping; no third crop possible in case of two wetland rice crops)

**G.** *Zone of triple cropping* (sequential cropping of three short-cycle crops; two wetland rice crops possible)

**H.** *Zone of triple rice cropping* (sequential cropping of three wetland rice crops possible)

Delineation of multiple cropping zones for rain-fed conditions is solely based on agro-climatic attributes calculated during AEZ analysis. The following attributes were used in the definition of cropping zones:

| | |
|---|---|
| LGP | length of growing period, i.e., number of days when temperature and soil moisture permit crop growth. |
| $LGP_{t=5}$ | number of days with mean daily temperatures above 5ºC. |
| $LGP_{t=10}$ | number of days with mean daily temperatures above 10ºC. |
| $TS_{t=0}$ | accumulated temperature (degree-days) on days when mean daily temperature ≥ 0ºC. |
| $TS_{t=10}$ | accumulated temperature (degree-days) on days when mean daily temperature ≥ 10ºC. |
| $TS\text{-}G_{t=5}$ | accumulated temperature during growing period when mean daily temperature ≥ 5ºC. |
| $TS\text{-}G_{t=10}$ | accumulated temperature during growing period when mean daily temperature ≥ 10ºC. |

Table 16 and 17 summarize the delineation criteria for multiple cropping zones under rain-fed conditions in respectively the tropics and the subtropics/temperate zones.

**Table 16 Delineation of multiple cropping zones under rain-fed conditions in the tropics**

| Zone | LGP | $LGP_{t=5}$ | $LGP_{t=10}$ | $TS_{t=0}$ | $TS_{t=10}$ | $TS\text{-}G_{t=5}$ | $TS\text{-}G_{t=10}$ |
|---|---|---|---|---|---|---|---|
| A[19] | – | – | – | – | – | – | – |
| B[20] | ≥ 45 | ≥120 | ≥90 | ≥1600 | ≥1000 | – | – |
| C[21] | ≥220 | ≥220 | ≥ | ≥5500 | | ≥ | ≥ |
| | ≥200 | ≥200 | ≥120 | ≥6400 | n.a. | ≥3200 | ≥2700 |
| | ≥180 | ≥200 | ≥ | ≥7200 | | ≥ | ≥ |
| D[22] | ≥270 | ≥270 | ≥ | ≥5500 | | ≥ | ≥ |
| | ≥240 | ≥240 | ≥165 | ≥6400 | n.a. | ≥4000 | ≥3200 |
| | ≥210 | ≥240 | ≥ | ≥7200 | | ≥ | ≥ |
| E | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| F | ≥300 | ≥300 | ≥240 | ≥7200 | ≥7000 | ≥5100 | ≥4800 |
| G | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| H | ≥360 | ≥360 | ≥360 | ≥7200 | ≥7000 | – | – |

**Table 17 Delineation of multiple cropping zones under rain-fed conditions in subtropics and temperate zones**

| Zone | LGP | $LGP_{t=5}$ | $LGP_{t=10}$ | $TS_{t=0}$ | $TS_{t=10}$ | $TS\text{-}G_{t=5}$ | $TS\text{-}G_{t=10}$ |
|---|---|---|---|---|---|---|---|
| A[19] | – | – | – | – | – | – | – |
| B[20] | ≥ 45 | ≥120 | ≥90 | ≥1600 | ≥1000 | – | – |
| C | ≥180 | ≥200 | ≥120 | ≥3600 | ≥3000 | ≥3200 | ≥2900 |
| D | ≥210 | ≥240 | ≥165 | ≥4500 | ≥3600 | ≥4000 | ≥3200 |
| E | ≥240 | ≥270 | ≥180 | ≥4800 | ≥4500 | ≥4300 | ≥4000 |
| F | ≥300 | ≥300 | ≥240 | ≥5400 | ≥5100 | ≥5100 | ≥4800 |
| G | ≥330 | ≥330 | ≥270 | ≥5700 | ≥5500 | – | – |
| H | ≥360 | ≥360 | ≥330 | ≥7200 | ≥7000 | – | – |

| | |
|---|---|
| 19) | Applies if conditions for zone B ('single cropping') are not met. |
| 20) | The program tests if at least one of the crop/LUTs is agro-climatically suitable in the respective grid-cell. |
| 21), 22) | Refers to, respectively, high-land, mid high-land, and lowland areas in the tropics. |

## 4.8 Review of results

### 4.8.1 Stepwise review of suitability analysis procedures

Crop suitability is a result of both agro-climatic and agro-edaphic evaluation. The combination of the agro-climatic suitabilities with the agro-edaphic suitabilities is based on the fact that the former results assume ideal soil and terrain conditions, while the latter evaluation assumes ideal agro-climates. In fact, the results of the agro-climatic suitabilities are successively modified, according to edaphic suitabilities, to provide overall crop suitability.

The calculation procedures have been grouped into five steps:

*(1)* Climate data analysis
*(2)* Crop-specific agro-climatic assessment and potential biomass calculation
*(3)* Application of agro-climatic constraints
*(4)* Edaphic assessments
*(5)* Various applications (e.g., calculation of land with cultivation potential)

**Step 1** calculates and organizes climate-related parameters for each grid-cell, i.e.,

- Altitude.
- Latitudinal climate
- Presence of cold break
- Continentality index
- Mean annual temperature
- Mean annual minimum temperature
- Mean annual maximum temperature
- Temperature profile: number of days in intervals of five degree centigrade steps from <-5ºC to > 30ºC separately for periods of increasing and decreasing temperatures
- Thermal growing periods: number of days >0ºC, >5ºC, >10ºC
- Begins and ends of thermal growing periods
- Accumulated temperature during thermal growing periods
- Mean temperature during thermal growing periods
- Aridity index (precipitation over reference evapotranspiration)
- Aridity index during growing period
- Total number of growing period days
- Number of growing period days when full crop water requirements of reference crop are met
- Total number of wet-days, i.e., growing period days with excess moisture
- Number of growing periods
- Begin and end of dormancy period
- Length of individual LGPs
- Number of days in each LGP when crop water requirements can be fully met.
- Number of days in each LGP with excess moisture
- Begin and end dates of each LGP
- Temperature profile during growing period
- Accumulated temperatures (above $0^{o}$C, $5^{o}$C, $10^{o}$C) during growing period
- Average temperature during growing period
- Multiple-cropping zones classification for rain-fed and irrigated conditions

Since all the above data is organized by grid-cell, maps of each item can be produced for spatial verification.

In **Step 2**, all the 154 LUTs (148 crop/LUTs and 6 grass/pasture legume LUTs) are “grown”. The LUTs are tested starting successively each day during the permissible window of time (separately determined for irrigated and rain-fed conditions). The highest obtained yield defines the optimal crop calendar of each LUT in each grid-cell. The CROPWAT methodology (FAO, 1992a) is used to run crop-specific water balances and to account for yield losses due to water deficits. Calculations are done seven times: once for irrigation conditions, and six times for rain-fed conditions assuming in the soil moisture balance calculations an available water-holding capacity (AWC) of respectively 150, 125, 100, 75, 50 and 15 mm/m. The following information is stored for each grid-cell after Step 2:

- Maximum attainable biomass and yield (determined by radiation and temperature)
- Estimated actual crop evapotranspiration (ETa)
- Accumulated crop water deficit during the growth cycle (i.e., ETo - ETa)
- Attainable water-limited biomass and yield

All these individual items can be reproduced in map form, for viewing and for spatial verification.

In **Step 3** specific multipliers are used to downgrade yields for what is defined in AEZ as agro-climatic constraints. This step is carried out separately to make the effect of the workability, pest and diseases, and other constraints transparent. The results of Step 3, agro-climatically attainable yields, are stored by crop/LUT for each grid-cell. The intermediate results of agro-climatic suitabilities, therefore, can be mapped for spatial verification.

**Step 4** performs the edaphic assessment and combines the agro-climatic results in accordance with the soil information. The FAO digital soil map of the World (DSMW), with a grid-cell size of 5 arc-minutes latitude/longitude, is used for the assessment, defining soil characteristics (soil type, soil texture and soil phase) and proportions of different soils in each mapping unit. For terrain-slope conditions, a slope distribution was derived from the 30 arc-second GTOPO30 digital elevation database (EROS Data Center, 1998). The slope characterization has been aggregated to the grid-cells of the DSMW in terms of seven classes, as used in SOTER (van Engelen and Ting-tiang, 1993): 0-2%, 2-5%, 5-8%, 8-16%, 16-30%, 30-45% and > 45%. Soil and slope rules are applied separately for rain-fed and irrigated conditions. As a result, for each 5-minute grid-cell and each crop/LUT an expected yield and suitability distribution (5 classes VS, S, MS, mS and NS) regarding rain-fed and irrigation conditions are obtained. Results are stored separately for dryland and naturally flooded soils (Fluvisols, and Gleysols with 0-2 % slopes). The results have been mapped of which several examples can be found in the Appendix XV. Suitability maps of the single-crop/LUTs have been intensively used for spatial verification.

**Step 5**. The databases created in steps 1 to 4 can and have been used to derive additional characterizations and aggregations, such as:

- Calculation of land with cultivation potential is involving an aggregation over individual crop/LUTs to estimate how much land is potentially suitable for crop cultivation. Examples of results were presented in this chapter and have proven useful for spatial verification purposes.

- Tabulation of results by ecosystem type: the USGS 1km land cover data set was aggregated to twelve major ecosystems and subsequently to 5-minute DSMW grid-cells. The resulting ecosystem distribution was matched with the assessed land with cultivation potential in each DSMW grid-cell, providing information about what suitable extents are under which current ecosystems. This information was useful to compare and verify, for example, the overlap between potential cultivable land and land shown as being currently in use for cropping.

- Quantification of climatic production risks by using historical time series of suitability results. For each crop/LUT and grid-cell this has resulted in information on average crop yield, number of crop failures, standard deviation of expected yields, ratio of average yield versus yield of average climate. In this way spatial distribution of climatic production risk can be mapped and verified.

As discussed above, the structure of the suitability analysis procedures allows step-wise review of results. As example of a verification sequence, a selection of intermediate results in map form for 120-days grain maize, grown under rain-fed conditions at high input level, are presented in Appendix XV:

| | |
|---|---|
| Plate 21 (Step 1) | Growing period days |
| Plate 22 (Step 2) | Maximum attainable potential biomass and yield (determined by radiation and temperature) |
| Plate 23 (Step 2) | Attainable (water limited) potential biomass and yield |
| Plate 24 (Step 3) | Agro-climatically attainable yield potentials (including the effect of agro-climatic constraints) |
| Plate 25 (Step 4) | Expected yields after application of edaphic constraints |
| Plate 26 (Step 5) | Maximum expected yields potentials across all 13 grain-maize types |

The results, obtained after completion of each of the above steps, have been used in the process of checking and validating the proper functioning of the various procedures. The intermediate and final results have been helpful for the verification against research data, crop statistics, expert knowledge, etc.

### 4.8.2 Confirmation of results

Various modes have been pursued for ‘ground-truthing’ and verifying results of the AEZ suitability analysis. Apart from consulting expert knowledge and agricultural research institutes, results have been systematically compared with research data and agricultural statistics. In particular the following activities have been conducted intensively by IIASA and FAO staff of ES and AG departments.

- Confirmation of estimated potential crop distribution and yields against quantitative and qualitative occurrence of these crops in national and sub-national agricultural statistics.

- Comparison of limits of AEZ potential crop distribution with limits to actual distribution of agricultural land (e.g., by comparison with spatial land use/land cover databases and crop distribution maps).

It should, however, be understood, that in the light of improved knowledge any part of the GAEZ suitability procedures and the model parameters will be scrutinized and may be subject to updating by FAO and IIASA. Also, the model and model parameters are expected to benefit refinement as result of follow-up applications.

# 5. RESULTS

In essence, the Global AEZ assessment has provided a comprehensive and spatially explicit database of crop production potential and related factors. The results are a valuable source of information and input to various global and regional applications. Examples of different types of results generated by Global AEZ are presented in the various sections of this chapter.

Section 5.1 provides data on occurrence and spatial distribution of climate, soil and terrain constraints to rain-fed crop production. Section 5.2 presents various results of the crop suitability analyses for rain-fed conditions and for rain-fed and/or irrigated conditions combined. Crop yields and sustainability of production are discussed in Section 5.3 in relation to differences between maximum attainable yields and long-term achievable yields. In Section 5.4 we present estimates of land with cultivation potential based on all cereal and non-cereal food and fiber crop/LUTs considered (i.e., from the list of 154 LUTs we excluded banana, oilpalm, olives, silage maize, alfalfa, grass legumes and grasses).

Section 5.5 highlights areas with high potential for irrigated crops vis-à-vis rain-fed crops. Furthermore, the production potential results are used in Section 5.6 to identify for individual grid-cells a 'best' cereal in terms of respectively agronomic suitability, food energy and gross value. Section 5.7 provides estimates of land productivity potential including multi-cropping. Section 5.8 deals with the comparison of estimated crop production potentials and land cover data. Finally, Section 5.9 discusses the sensitivity of regional crop production potential to climate change. Preliminary results of the suitability analysis for a number of temperature and rainfall sensitivity scenarios are presented.

All results discussed in the various sections of this chapter are available in digital formats; maps of respectively 5-minute and 30-minute latitude/longitude resolution, and tables (in form of spreadsheets) at different levels of aggregation, i.e., respectively at global, continental, regional and country levels.

## 5.1 Climate, soil and terrain constraints to rain-fed crop production

The classifications of soil and terrain constraints in Global AEZ for the application with FAO's Digital Soil Map of the World were briefly introduced in Section 3.3. Climate constraints are classified according to length of periods with cold temperatures and moisture limitations. Temperature constraints are related to the length of the temperature growing period ($LGP_{t=5}$), i.e., number of days with mean daily temperature above 5ºC. An $LGP_{t=5}$ of less than 120 days is considered a severe constraint, while an $LGP_{t=5}$ of less than 180 days is considered as posing moderate constraints to crop production. Hyper-arid and arid moisture regimes (LGP < 60 days) are considered severe constraints, and dry semi-arid moisture regimes (LGP 60-119 days) as moderate constraints.

On the basis of currently available soil, terrain and climatic data, the Global AEZ assessment estimates that some 10.5 billion hectares of land, i.e., almost four-fifth of the global land surface (excluding Antarctica), suffer rather severe constraints for rain-fed crop cultivation. An estimated 13 percent is too cold, 27 percent is too dry, 12 percent is too steep, and some 65 percent is constrained by poor soil conditions. Note, percentages do not sum up to 100, because several constraints coincide in some locations. Table 18 presents the regional distribution of different types of severe constraints mostly inhibiting rain-fed crop production.

Table 19 gives a more detailed account of various kinds of land constraints for rain-fed crop production. The analysis concludes that only 3.5 percent of the land surface (excluding Antarctica) can be regarded to be entirely free of constraining factors. Only for some sub-regions in Europe the share of essentially constraint-free conditions reaches 20 percent and more. Tables A1 to A22 in Appendix I present results aggregated by broad LGP classes separately for 22 major world regions. Plates 20 to 28 show the geographical distribution of climatic and soil/terrain constraints to rain-fed crop production.

**Table 18 Severe environmental constraints[23] for rain-fed crop production**

| Region | Total extents | Land with severe constraints for rain-fed cultivation of crops | | | | | |
|---|---|---|---|---|---|---|---|
| | | Total with constraints | | Too cold | Too dry | Too steep | Poor soils |
| | ($10^6$ ha) | ($10^6$ ha) | (%) | (%) | (%) | (%) | (%) |
| North America | 2138.5 | 1774.7 | 83.0 | 35.9 | 13.9 | 10.4 | 69.3 |
| Eastern Europe | 171.0 | 68.0 | 39.8 | 0.0 | 0.0 | 5.9 | 38.7 |
| Northern Europe | 172.5 | 135.5 | 78.5 | 18.0 | 0.0 | 9.9 | 77.8 |
| Southern Europe | 131.6 | 63.6 | 48.3 | 0.7 | 0.1 | 31.0 | 44.3 |
| Western Europe | 109.5 | 56.9 | 51.9 | 0.6 | 0.0 | 13.5 | 49.4 |
| Russian Federation | 1674.1 | 1412.5 | 84.4 | 44.6 | 2.5 | 11.9 | 82.8 |
| Caribbean | 23.4 | 15.7 | 67.0 | 0.0 | 0.0 | 15.8 | 65.8 |
| Central America | 248.4 | 184.8 | 74.4 | 0.0 | 31.5 | 26.3 | 59.7 |
| South America | 1777.6 | 1251.8 | 70.4 | 0.5 | 10.6 | 7.5 | 63.6 |
| Oceania | 793.5 | 698.7 | 88.1 | 0.0 | 61.6 | 1.8 | 62.4 |
| Polynesia | 56.1 | 32.4 | 57.8 | 0.8 | 0.8 | 24.9 | 48.8 |
| Eastern Africa | 639.5 | 404.7 | 63.3 | 0.0 | 18.5 | 10.2 | 53.5 |
| Middle Africa | 657.1 | 515.0 | 78.4 | 0.0 | 13.1 | 3.3 | 72.6 |
| Northern Africa | 794.1 | 728.2 | 91.7 | 0.0 | 77.4 | 5.2 | 62.7 |
| Southern Africa | 266.4 | 210.6 | 79.0 | 0.0 | 56.9 | 14.4 | 43.1 |
| Western Africa | 633.0 | 469.2 | 74.1 | 0.0 | 50.9 | 0.8 | 50.5 |
| Western Asia | 433.0 | 382.6 | 88.4 | 0.0 | 74.5 | 16.4 | 53.3 |
| Southeast. Asia | 444.5 | 271.8 | 61.2 | 0.0 | 0.0 | 21.7 | 57.4 |
| South Asia | 671.8 | 475.4 | 70.8 | 2.5 | 33.7 | 22.8 | 57.9 |
| East Asia | 1112.3 | 911.4 | 81.9 | 16.6 | 33.8 | 26.5 | 63.0 |
| Central Asia | 414.4 | 382.0 | 92.2 | 2.5 | 78.4 | 10.0 | 78.1 |
| Japan | 37.2 | 21.9 | 58.8 | 0.0 | 0.0 | 35.9 | 54.4 |
| **DEVELOPING** | 8171.5 | 6235.5 | 76.3 | 2.7 | 34.4 | 12.8 | 60.9 |
| **DEVELOPED** | 5228.0 | 4231.8 | 80.9 | 29.6 | 15.8 | 10.2 | 70.7 |
| **WORLD TOTAL** | 13399.5 | 10467.3 | 78.1 | 13.2 | 27.1 | 11.8 | 64.7 |

23 Extents of different constraint types are not additive as the occurrence of constraints may overlap.

**Table 19 Climate, soil and terrain constraints for rain-fed crop production - world totals**

| Constraints | | | LGP 0 days CC | LGP 1-60 CC | LGP 60-119 C | LGP 120-179 | LGP 180-269 | LGP 270-365 | LGP 365+ C | Totals ($10^6$ ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Temperature** | **$LGP_{t=5}$ > 180** | | 2366.0 | 987.8 | 1011.3 | 984.3 | 2202.0 | 2109.6 | 268.0 | 9929.0 | 74.1 |
| | **$LGP_{t=5}$ < 180** | **C** | 66.7 | 124.3 | 181.1 | 1331.2 | 0 | 0 | 0 | 1703.3 | 12.7 |
| | **$LGP_{t=5}$ < 120** | **CC** | 319.9 | 257.0 | 1190.3 | 0 | 0 | 0 | 0 | 1767.2 | 13.2 |
| **Terrain slopes** | **0 - 8%** | | 1723.8 | 759.8 | 1072.5 | 1165.8 | 1127.4 | 1235.2 | 160.8 | 7245.3 | 54.1 |
| | **8 - 16%** | **C** | 489.0 | 245.2 | 429.0 | 454.3 | 409.4 | 317.2 | 33.0 | 2377.1 | 17.7 |
| | **16 - 30%** | **C** | 354.6 | 196.0 | 480.4 | 419.5 | 395.6 | 313.6 | 42.0 | 2201.7 | 16.4 |
| | **> 30%** | **CC** | 185.2 | 168.2 | 400.7 | 276.0 | 269.6 | 243.6 | 32.2 | 1575.5 | 11.8 |
| **Soil depth** | **Deep** | | 1597.2 | 952.5 | 1584.8 | 1776.0 | 1833.7 | 1857.5 | 242.2 | 9843.9 | 73.5 |
| | **Medium** | **C** | 120.8 | 28.0 | 30.2 | 27.5 | 20.8 | 9.4 | 3.6 | 240.3 | 1.8 |
| | **Shallow** | **CC** | 421.0 | 225.3 | 654.3 | 449.4 | 294.2 | 206.2 | 20.5 | 2270.7 | 16.9 |
| **Soil fertility** | **High** | | 1264.6 | 632.0 | 742.0 | 601.0 | 598.9 | 310.5 | 20.3 | 4169.2 | 31.1 |
| | **Medium** | **C** | 182.9 | 133.7 | 314.3 | 611.4 | 809.8 | 827.7 | 125.4 | 3005.3 | 22.4 |
| | **Low** | **CC** | 691.4 | 440.1 | 1213.0 | 1040.5 | 740.0 | 934.8 | 120.6 | 5180.5 | 38.7 |
| **Soil drainage** | **Good** | | 2104.7 | 1130.7 | 1967.2 | 1971.0 | 1863.7 | 1787.1 | 232.8 | 11057.2 | 82.5 |
| | **Poor** | **CC** | 34.2 | 75.1 | 302.1 | 281.9 | 285.0 | 285.9 | 33.5 | 1297.7 | 9.7 |
| **Soil texture** | **Medium/fine** | | 1111.7 | 795.7 | 1596.7 | 1620.6 | 1597.0 | 1753.7 | 247.8 | 8723.2 | 65.1 |
| | **Sandy/stony** | **CC** | 307.6 | 135.0 | 244.7 | 179.5 | 124.6 | 73.5 | 5.9 | 1070.8 | 8.0 |
| | **Cracking clay** | **C** | 719.6 | 275.1 | 427.9 | 452.7 | 427.2 | 245.9 | 12.6 | 2561.0 | 19.1 |
| **Soil chemical constraints** | **None** | | 1906.2 | 957.9 | 2102.3 | 2160.4 | 2092.6 | 2039.9 | 263.9 | 11523.3 | 86.0 |
| | **S/S/G*** | **CC** | 232.7 | 247.9 | 167.0 | 92.4 | 56.1 | 33.2 | 2.4 | 831.7 | 6.2 |
| **Miscellaneous land units** | | **CC** | 613.6 | 163.4 | 113.4 | 62.7 | 53.3 | 36.5 | 1.7 | 1044.5 | 7.8 |
| **Total *without* constraints** | | | 0 | 0 | 0 | 134.6 | 226.4 | 108.4 | 0 | 469.4 | 3.5 |
| **Total with *moderate* constraints** | | **C** | 0 | 0 | 527.9 | 541.8 | 672.1 | 617.8 | 103.2 | 2462.8 | 18.4 |
| **Total with *severe* constraints** | | **CC** | 2752.6 | 1369.2 | 1854.7 | 1639.2 | 1303.5 | 1383.4 | 164.7 | 10467.3 | 78.1 |
| **Total** | **($10^6$ ha)** | | 2752570 | 1369.2 | 2382.7 | 2315.6 | 2202.0 | 2109.6 | 268.0 | 13399.5 | 100.0 |
| | **(%)** | | 20.5 | 10.2 | 17.8 | 17.3 | 16.4 | 15.7 | 2.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

## 5.2 Crop suitability

### 5.2.1 Rain-fed crops

A total of 24 crop species, four pasture types and one fodder crop, comprising together 154 crop/LUTs were assessed each at three defined levels of inputs and management. A full list of Land Utilization Types (LUTs) is shown in Table 8 at the beginning of Chapter 4. The results show, that for wheat some 6.9 percent of the total land area is suitable (VS+S+MS) for rain-fed cultivation at high level of inputs. In developed countries this is 12.8 percent and for developing countries only some 3 percent. For maize the situation is reversed. In developing countries 11.3 percent is assessed as suitable, while in developed countries the suitable area is only 3 percent. Globally, almost 1.1 thousand million ha (i.e., about 8 percent) is suitable for grain-maize. Results of crop suitability analysis have been summarized in tabular and map form. Tables 20 to 22 and Tables 23 to 25 present examples of results in terms of *gross*[24] extents of land with cultivation potential for rain-fed production of respectively wheat and grain maize under high, intermediate and low levels of inputs in 22 major world regions.

Plate 29 and 30 present suitability maps of rain-fed production at intermediate level of inputs for wheat and grain-maize. In these maps, the results for each 5 minute latitude/longitude grid-cell of the FAO DSMW are represented by a suitability index *SI*, which is reflecting the suitability make-up of a grid-cell in accordance with the definition of suitability classes in AEZ, namely as:

$$SI = VS*0.9 + S*0.7 + MS*0.5 + mS*0.3.$$

Plates 31 to 36 present rain-fed suitability maps at intermediate level of inputs of respectively cereals, roots and tubers, pulses, oil crops, sugar crops and cotton. The algorithm examines in each grid-cell all the crop types belonging to a particular crop group. Among these it determines the LUT that maximizes agronomic suitability. In Appendix I, Tables A23 to A28 and Tables A29 to A34, summarize *gross* extents of land with cultivation potential for the above crop groups under rain-fed conditions, by 22 major world regions, at respectively intermediate and high input levels.

For example, for rain-fed cereal food crops at intermediate input level, we estimate about 2.5 billion ha of gross extents of land to be potentially suitable (VS+S+MS). Of these, some 1.6 billion ha are assessed as very suitable or suitable (VS+S) for at least one cereal type. In other words, about 18.7 percent of the Earth's terrestrial surface is adjudged cultivation potential for cereal crops. As pointed out above, these estimates are termed 'gross' extents as they do not include specific allowances for other land uses. An interpretation of how much of these potentially suitable areas would actually be available for cereal production is more difficult to achieve. This will be discussed later on.

For other crop groups the estimates of gross extents with cultivation potential of respectively (VS+S+MS) and (VS+S) areas are as follows: roots and tubers 1.5 billion ha and 0.8 billion ha; pulses 1.5 billion ha and 0.7 billion ha; oil crops 2.0 billion ha and 1.1 billion ha; sugar crops 0.9 billion ha and 0.4 billion ha; and cotton 0.6 billion ha and 0.3 billion ha. The data tables in Appendix I, A23 to A34, show how the suitable extents are distributed over major world regions.

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24 The extents in these tabulations are termed 'gross' since we did not subtract land required for other uses, such as infrastructure and settlements, or legally protected areas. In reality, some 10% to 30% of potentially suitable areas may not be available for agriculture due to other competing uses.

**Table 20 Gross extents with cultivation potential for rain-fed wheat (1000ha) – high input level**

| REGION | NAME | TOTAL[25] | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | **2138498** | 52331 | 137648 | 83470 | 12.8 | 40671 | 14.7 | 1824378 | 85.3 |
| 21 | Eastern Europe | 170952 | 17473 | 42094 | 29381 | 52.0 | 22364 | 65.1 | 59640 | 34.9 |
| 22 | Northern Europe | 172524 | 3433 | 21550 | 13495 | 22.3 | 8758 | 27.4 | 125288 | 72.6 |
| 23 | Southern Europe | 131643 | 6391 | 8243 | 6001 | 15.7 | 2686 | 17.7 | 108322 | 82.3 |
| 24 | Western Europe | 109547 | 16781 | 20390 | 10157 | 43.2 | 7398 | 50.0 | 54821 | 50.0 |
| 25 | Russian Federation | 1674146 | 20758 | 54445 | 92570 | 10.0 | 50498 | 13.0 | 1455875 | 87.0 |
| | | **2258812** | **64836** | **146722** | **151604** | **16.1** | **91704** | **20.1** | **1803946** | **79.9** |
| 31 | Caribbean | 23397 | 0 | 0 | 8 | 0.0 | 213 | 0.9 | 23176 | 99.1 |
| 32 | Central America | 248353 | 1362 | 2169 | 1823 | 2.2 | 1030 | 2.6 | 241969 | 97.4 |
| | | **271750** | **1362** | **2169** | **1831** | **2.0** | **1243** | **2.4** | **265145** | **97.6** |
| 41 | South America | **1777573** | 25743 | 44235 | 40839 | 6.2 | 32686 | 8.1 | 1634070 | 91.9 |
| 51 | Oceania | 793540 | 4477 | 10139 | 12972 | 3.5 | 9692 | 4.7 | 756260 | 95.3 |
| 52 | Polynesia | 56118 | 0 | 0 | 0 | 0.0 | 186 | 0.3 | 55932 | 99.7 |
| | | **849658** | **4477** | **10139** | **12972** | **3.2** | **9878** | **4.4** | **812192** | **95.6** |
| 61 | Eastern Africa | 639474 | 5829 | 12108 | 11701 | 4.6 | 7675 | 5.8 | 602161 | 94.2 |
| 62 | Middle Africa | 657061 | 164 | 988 | 2733 | 0.6 | 1971 | 0.9 | 651205 | 99.1 |
| 63 | Northern Africa | 794112 | 274 | 1590 | 2047 | 0.5 | 1336 | 0.7 | 788865 | 99.3 |
| 64 | Southern Africa | 266428 | 354 | 949 | 1120 | 0.9 | 583 | 1.1 | 263422 | 98.9 |
| 65 | Western Africa | 632996 | 0 | 33 | 39 | 0.0 | 16 | 0.0 | 632908 | 100.0 |
| | | **2990071** | **6621** | **15668** | **17640** | **1.3** | **11581** | **1.7** | **2938561** | **98.3** |
| 71 | Western Asia | **432992** | 675 | 3435 | 6372 | 2.4 | 3371 | 3.2 | 419139 | 96.8 |
| 81 | Southeast. Asia | 444483 | 172 | 2653 | 4489 | 1.6 | 4131 | 2.6 | 433038 | 97.4 |
| 82 | South Asia | 671842 | 182 | 1646 | 4913 | 1.0 | 5134 | 1.8 | 659967 | 98.2 |
| 84 | East Asia | 1112296 | 2804 | 28441 | 31588 | 5.6 | 15690 | 7.1 | 1033773 | 92.9 |
| 85 | Central Asia | 414363 | 492 | 603 | 4205 | 1.3 | 2728 | 1.9 | 406335 | 98.1 |
| 86 | Japan | 37178 | 2111 | 2479 | 1855 | 17.3 | 819 | 19.5 | 29914 | 80.5 |
| | | **2680162** | **5761** | **35822** | **47050** | **3.3** | **28502** | **4.4** | **2563027** | **95.6** |
| | **DEVELOPING** | **8171488** | **38051** | **98850** | **111877** | **3.0** | **76750** | **4.0** | **7845960** | **96.0** |
| | **DEVELOPED** | **5228028** | **123755** | **296988** | **249901** | **12.8** | **142886** | **15.6** | **4414498** | **84.4** |
| | **WORLD TOTAL** | **13399516** | **161806** | **395838** | **361778** | **6.9** | **219636** | **8.5** | **12260458** | **91.5** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

25 Total extent derived from digital version of the Soil Map of the World (FAO, 1995c).

**Table 21 Gross extents with cultivation potential for rain-fed wheat (1000ha) – intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | **2138498** | 47600 | 133704 | 101895 | 13.2 | 77355 | 16.9 | 1777944 | 83.1 |
| 21 | Eastern Europe | 170952 | 22244 | 40029 | 35822 | 57.4 | 19662 | 68.9 | 53195 | 31.1 |
| 22 | Northern Europe | 172524 | 5385 | 13873 | 15049 | 19.9 | 10308 | 25.9 | 127909 | 74.1 |
| 23 | Southern Europe | 131643 | 7111 | 13171 | 15668 | 27.3 | 13130 | 37.3 | 82563 | 62.7 |
| 24 | Western Europe | 109547 | 19555 | 22273 | 14198 | 51.1 | 7672 | 58.1 | 45849 | 41.9 |
| 25 | Russian Federation | 1674146 | 20799 | 78123 | 74516 | 10.4 | 80400 | 15.2 | 1420308 | 84.8 |
| | | **2258812** | **75094** | **167469** | **155253** | **17.6** | **131172** | **23.4** | **1729824** | **76.6** |
| 31 | Caribbean | 23397 | 0 | 0 | 6 | 0.0 | 225 | 1.0 | 23166 | 99.0 |
| 32 | Central America | 248353 | 1350 | 3144 | 4690 | 3.7 | 5317 | 5.8 | 233852 | 94.2 |
| | | **271750** | **1350** | **3144** | **4696** | **3.4** | **5542** | **5.4** | **257018** | **94.6** |
| 41 | South America | **1777573** | 22693 | 43168 | 47497 | 6.4 | 43719 | 8.8 | 1620496 | 91.2 |
| 51 | Oceania | 793540 | 6374 | 13279 | 16484 | 4.6 | 17411 | 6.7 | 739992 | 93.3 |
| 52 | Polynesia | 56118 | 0 | 0 | 0 | 0.0 | 145 | 0.3 | 55973 | 99.7 |
| | | **849658** | **6374** | **13279** | **16484** | **4.3** | **17556** | **6.3** | **795965** | **93.7** |
| 61 | Eastern Africa | 639474 | 5367 | 17900 | 20789 | 6.9 | 19160 | 9.9 | 576258 | 90.1 |
| 62 | Middle Africa | 657061 | 732 | 2206 | 4495 | 1.1 | 5594 | 2.0 | 644034 | 98.0 |
| 63 | Northern Africa | 794112 | 614 | 2836 | 5544 | 1.1 | 5796 | 1.9 | 779322 | 98.1 |
| 64 | Southern Africa | 266428 | 575 | 2975 | 5628 | 3.4 | 5832 | 5.6 | 251418 | 94.4 |
| 65 | Western Africa | 632996 | 0 | 26 | 49 | 0.0 | 4 | 0.0 | 632917 | 100.0 |
| | | **2990071** | **7288** | **25943** | **36505** | **2.3** | **36386** | **3.5** | **2883949** | **96.5** |
| 71 | Western Asia | **432992** | 844 | 5286 | 12924 | 4.4 | 16346 | 8.2 | 397592 | 91.8 |
| 81 | Southeast. Asia | 444483 | 101 | 1803 | 4064 | 1.3 | 5056 | 2.5 | 433459 | 97.5 |
| 82 | South Asia | 671842 | 256 | 4722 | 7914 | 1.9 | 13031 | 3.9 | 645919 | 96.1 |
| 84 | East Asia | 1112296 | 2151 | 18804 | 31597 | 4.7 | 41963 | 8.5 | 1017781 | 91.5 |
| 85 | Central Asia | 414363 | 387 | 1339 | 6405 | 2.0 | 11815 | 4.8 | 394417 | 95.2 |
| 86 | Japan | 37178 | 1063 | 3277 | 3540 | 21.2 | 3182 | 29.8 | 26116 | 70.2 |
| | | **2680162** | **3958** | **29945** | **53520** | **3.3** | **75047** | **6.1** | **2517692** | **93.9** |
| | **DEVELOPING** | **8171488** | **35070** | **104209** | **151602** | **3.6** | **174003** | **5.7** | **7706604** | **94.3** |
| | **DEVELOPED** | **5228028** | **130131** | **317729** | **277172** | **13.9** | **229120** | **18.3** | **4273876** | **81.7** |
| | **WORLD TOTAL** | **13399516** | **165201** | **421938** | **428774** | **7.6** | **403123** | **10.6** | **11980480** | **89.4** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

**Table 22 Gross extents with cultivation potential for rain-fed wheat (1000ha) – low input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | **2138498** | **60770** | **112686** | **124511** | **13.9** | **109473** | **19.1** | **1731059** | **80.9** |
| 21 | Eastern Europe | 170952 | 28710 | 42177 | 33112 | 60.8 | 9197 | 66.2 | 57759 | 33.8 |
| 22 | Northern Europe | 172524 | 3159 | 13160 | 15739 | 18.6 | 8800 | 23.7 | 131664 | 76.3 |
| 23 | Southern Europe | 131643 | 9148 | 15839 | 16648 | 31.6 | 12760 | 41.3 | 77246 | 58.7 |
| 24 | Western Europe | 109547 | 19638 | 21832 | 9859 | 46.9 | 4981 | 51.4 | 53237 | 48.6 |
| 25 | Russian Federation | 1674146 | 13419 | 73623 | 100906 | 11.2 | 65140 | 15.1 | 1421061 | 84.9 |
| | | **2258812** | **74074** | **166631** | **176264** | **18.5** | **100878** | **22.9** | **1740967** | **77.1** |
| 31 | Caribbean | 23397 | 0 | 0 | 2 | 0.0 | 191 | 0.8 | 23204 | 99.2 |
| 32 | Central America | 248353 | 1547 | 3794 | 5293 | 4.3 | 6662 | 7 | 231058 | 93.0 |
| | | **271750** | **1547** | **3794** | **5295** | **3.9** | **6853** | **6.4** | **254262** | **93.6** |
| 41 | South America | **1777573** | **18134** | **37699** | **43776** | **5.6** | **45928** | **8.2** | **1632033** | **91.8** |
| 51 | Oceania | 793540 | 6270 | 14456 | 16584 | 4.7 | 19715 | 7.2 | 736516 | 92.8 |
| 52 | Polynesia | 56118 | 0 | 0 | 0 | 0.0 | 199 | 0.4 | 55918 | 99.6 |
| | | **849658** | **6270** | **14456** | **16584** | **4.4** | **19914** | **6.7** | **792434** | **93.3** |
| 61 | Eastern Africa | 639474 | 3844 | 17258 | 25759 | 7.3 | 27332 | 11.6 | 565278 | 88.4 |
| 62 | Middle Africa | 657061 | 396 | 1966 | 5686 | 1.2 | 9336 | 2.6 | 639677 | 97.4 |
| 63 | Northern Africa | 794112 | 1166 | 4278 | 6291 | 1.5 | 5593 | 2.2 | 776784 | 97.8 |
| 64 | Southern Africa | 266428 | 1650 | 3639 | 5532 | 4.1 | 6667 | 6.6 | 248938 | 93.4 |
| 65 | Western Africa | 632996 | 0 | 0 | 2 | 0.0 | 39 | 0 | 632955 | 100.0 |
| | | **2990071** | **7056** | **27141** | **43270** | **2.6** | **48967** | **4.2** | **2863632** | **95.8** |
| 71 | Western Asia | **432992** | **2312** | **8075** | **17245** | **6.4** | **13080** | **9.4** | **392281** | **90.6** |
| 81 | Southeast. Asia | 444483 | 0 | 115 | 1427 | 0.3 | 6080 | 1.7 | 436865 | 98.3 |
| 82 | South Asia | 671842 | 395 | 3507 | 9467 | 2.0 | 18260 | 4.7 | 640213 | 95.3 |
| 84 | East Asia | 1112296 | 3614 | 24195 | 36366 | 5.8 | 49504 | 10.2 | 998618 | 89.8 |
| 85 | Central Asia | 414363 | 882 | 1774 | 8429 | 2.7 | 21972 | 8 | 381308 | 92.0 |
| 86 | Japan | 37178 | 419 | 2647 | 4201 | 19.5 | 4105 | 30.6 | 25806 | 69.4 |
| | | **2680162** | **5310** | **32238** | **59890** | **3.6** | **99921** | **7.4** | **2482810** | **92.6** |
| | **DEVELOPING** | **8171488** | **33940** | **106300** | **165275** | **3.7** | **210843** | **6.3** | **7655130** | **93.7** |
| | **DEVELOPED** | **5228028** | **141533** | **296420** | **321560** | **14.5** | **234171** | **19** | **4234348** | **81.0** |
| | **WORLD TOTAL** | **13399516** | **175473** | **402720** | **486835** | **7.9** | **445014** | **11.3** | **11889478** | **88.7** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

**Table 23 Gross extents with cultivation potential for rain-fed grain maize (1000ha) – high input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | **2138498** | 20380 | 53051 | 29468 | 4.8 | 5979 | 5.1 | 2029620 | 94.9 |
| 21 | Eastern Europe | 170952 | 40 | 3380 | 1425 | 2.8 | 279 | 3.0 | 165828 | 97.0 |
| 22 | Northern Europe | 172524 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 172524 | 100.0 |
| 23 | Southern Europe | 131643 | 643 | 1737 | 602 | 2.3 | 128 | 2.4 | 128533 | 97.6 |
| 24 | Western Europe | 109547 | 34 | 1805 | 910 | 2.5 | 118 | 2.6 | 106680 | 97.4 |
| 25 | Russian Federation | 1674146 | 0 | 3161 | 534 | 0.2 | 41 | 0.2 | 1670410 | 99.8 |
| | | **2258812** | **717** | **10083** | **3471** | **0.6** | **566** | **0.7** | **2243975** | **99.3** |
| 31 | Caribbean | 23397 | 218 | 1393 | 1583 | 13.7 | 4397 | 32.4 | 15806 | 67.6 |
| 32 | Central America | 248353 | 4353 | 4650 | 5432 | 5.8 | 14787 | 11.8 | 219131 | 88.2 |
| | | **271750** | **4571** | **6043** | **7015** | **6.5** | **19184** | **13.5** | **234937** | **86.5** |
| 41 | South America | **1777573** | 22219 | 76786 | 88849 | 10.6 | 182745 | 20.8 | 1406974 | 79.2 |
| 51 | Oceania | 793540 | 6460 | 14189 | 14896 | 4.5 | 6062 | 5.2 | 751933 | 94.8 |
| 52 | Polynesia | 56118 | 61 | 125 | 310 | 0.9 | 4654 | 9.2 | 50968 | 90.8 |
| | | **849658** | **6521** | **14314** | **15206** | **4.2** | **10716** | **5.5** | **802901** | **94.5** |
| 61 | Eastern Africa | 639474 | 45758 | 62008 | 51930 | 25.0 | 36171 | 30.6 | 443607 | 69.4 |
| 62 | Middle Africa | 657061 | 30562 | 30649 | 38740 | 15.2 | 88715 | 28.7 | 468395 | 71.3 |
| 63 | Northern Africa | 794112 | 33542 | 16335 | 13668 | 8.0 | 8372 | 9.1 | 722195 | 90.9 |
| 64 | Southern Africa | 266428 | 250 | 1827 | 2183 | 1.6 | 2395 | 2.5 | 259773 | 97.5 |
| 65 | Western Africa | 632996 | 26731 | 38694 | 35718 | 16.0 | 39964 | 22.3 | 491889 | 77.7 |
| | | **2990071** | **136843** | **149513** | **142239** | **14.3** | **175617** | **20.2** | **2385859** | **79.8** |
| 71 | Western Asia | **432992** | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 432992 | 100.0 |
| 81 | Southeast. Asia | 444483 | 368 | 14520 | 22382 | 8.4 | 45180 | 18.5 | 362033 | 81.5 |
| 82 | South Asia | 671842 | 38479 | 77713 | 47724 | 24.4 | 22115 | 27.7 | 485811 | 72.3 |
| 84 | East Asia | 1112296 | 22030 | 33885 | 29043 | 7.6 | 14427 | 8.9 | 1012911 | 91.1 |
| 85 | Central Asia | 414363 | 57 | 78 | 140 | 0.1 | 143 | 0.1 | 413945 | 99.9 |
| 86 | Japan | 37178 | 1483 | 2009 | 1485 | 13.4 | 770 | 15.5 | 31431 | 84.5 |
| | | **2680162** | **62417** | **128205** | **100774** | **10.9** | **82635** | **14.0** | **2306131** | **86.0** |
| | **DEVELOPING** | **8171488** | **224628** | **358663** | **337702** | **11.3** | **464065** | **16.9** | **6786430** | **83.1** |
| | **DEVELOPED** | **5228028** | **29040** | **79332** | **49320** | **3.0** | **13377** | **3.3** | **5056959** | **96.7** |
| | **WORLD TOTAL** | **13399516** | **253668** | **437995** | **387022** | **8.1** | **477442** | **11.6** | **11843389** | **88.4** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

**Table 24 Gross extents with cultivation potential for rain-fed grain maize (1000ha) – intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | **2138498** | 7703 | 64953 | 97671 | 8.0 | 47489 | 10.2 | 1920682 | 89.8 |
| 21 | Eastern Europe | 170952 | 473 | 6797 | 17546 | 14.5 | 11764 | 21.4 | 134372 | 78.6 |
| 22 | Northern Europe | 172524 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 172524 | 100.0 |
| 23 | Southern Europe | 131643 | 964 | 2414 | 3907 | 5.5 | 2918 | 7.8 | 121440 | 92.2 |
| 24 | Western Europe | 109547 | 33 | 1813 | 6632 | 7.7 | 4493 | 11.8 | 96576 | 88.2 |
| 25 | Russian Federation | 1674146 | 161 | 1046 | 13167 | 0.9 | 10451 | 1.5 | 1649321 | 98.5 |
| | | **2258812** | **1631** | **12070** | **41252** | **2.4** | **29626** | **3.7** | **2174233** | **96.3** |
| 31 | Caribbean | 23397 | 165 | 932 | 1234 | 10.0 | 2938 | 22.5 | 18128 | 77.5 |
| 32 | Central America | 248353 | 2726 | 4893 | 6671 | 5.8 | 9488 | 9.6 | 224575 | 90.4 |
| | | **271750** | **2891** | **5825** | **7905** | **6.1** | **12426** | **10.7** | **242703** | **89.3** |
| 41 | South America | **1777573** | 11462 | 64017 | 93019 | 9.5 | 103056 | 15.3 | 1506019 | 84.7 |
| 51 | Oceania | 793540 | 6137 | 11424 | 14728 | 4.1 | 19353 | 6.5 | 741898 | 93.5 |
| 52 | Polynesia | 56118 | 48 | 134 | 236 | 0.7 | 532 | 1.7 | 55168 | 98.3 |
| | | **849658** | **6185** | **11558** | **14964** | **3.8** | **19885** | **6.2** | **797066** | **93.8** |
| 61 | Eastern Africa | 639474 | 25876 | 58708 | 64929 | 23.4 | 48920 | 31.0 | 441041 | 69.0 |
| 62 | Middle Africa | 657061 | 10855 | 22754 | 38137 | 10.9 | 49902 | 18.5 | 535413 | 81.5 |
| 63 | Northern Africa | 794112 | 13561 | 15685 | 12670 | 5.3 | 13990 | 7.0 | 738206 | 93.0 |
| 64 | Southern Africa | 266428 | 414 | 3148 | 5777 | 3.5 | 9070 | 6.9 | 248019 | 93.1 |
| 65 | Western Africa | 632996 | 7292 | 40844 | 36548 | 13.4 | 33740 | 18.7 | 514572 | 81.3 |
| | | **2990071** | **57998** | **141139** | **158061** | **11.9** | **155622** | **17.2** | **2477251** | **82.8** |
| 71 | Western Asia | **432992** | 402 | 271 | 560 | 0.3 | 516 | 0.4 | 431243 | 99.6 |
| 81 | Southeast. Asia | 444483 | 224 | 3377 | 11555 | 3.4 | 18687 | 7.6 | 410640 | 92.4 |
| 82 | South Asia | 671842 | 23185 | 58039 | 41812 | 18.3 | 31632 | 23.0 | 517174 | 77.0 |
| 84 | East Asia | 1112296 | 4717 | 17721 | 26779 | 4.4 | 29469 | 7.1 | 1033610 | 92.9 |
| 85 | Central Asia | 414363 | 174 | 398 | 1079 | 0.4 | 3069 | 1.1 | 409643 | 98.9 |
| 86 | Japan | 37178 | 489 | 1809 | 2374 | 12.6 | 2343 | 18.9 | 30163 | 81.1 |
| | | **2680162** | **28789** | **81344** | **83599** | **7.2** | **85200** | **10.4** | **2401230** | **89.6** |
| | **DEVELOPING** | **8171488** | **101101** | **290921** | **341006** | **9.0** | **355009** | **13.3** | **7083451** | **86.7** |
| | **DEVELOPED** | **5228028** | **15960** | **90256** | **156025** | **5.0** | **98811** | **6.9** | **4866976** | **93.1** |
| | **WORLD TOTAL** | **13399516** | **117061** | **381177** | **497031** | **7.4** | **453820** | **10.8** | **11950427** | **89.2** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

**Table 25 Gross extents with cultivation potential for rain-fed grain maize (1000ha) – low input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | **2138498** | **18822** | **75827** | **94673** | **8.9** | **51424** | **11.3** | **1897753** | **88.7** |
| 21 | Eastern Europe | 170952 | 694 | 11335 | 22397 | 20.1 | 21022 | 32.4 | 115504 | 67.6 |
| 22 | Northern Europe | 172524 | 0 | 0 | 0 | 0.0 | 5 | 0.0 | 172520 | 100.0 |
| 23 | Southern Europe | 131643 | 979 | 2132 | 4950 | 6.1 | 3114 | 8.5 | 120468 | 91.5 |
| 24 | Western Europe | 109547 | 22 | 513 | 7878 | 7.7 | 10387 | 17.2 | 90750 | 82.8 |
| 25 | Russian Federation | 1674146 | 241 | 12055 | 22805 | 2.1 | 19790 | 3.3 | 1619259 | 96.7 |
| | | **2258812** | **1936** | **26035** | **58030** | **3.8** | **54318** | **6.2** | **2118501** | **93.8** |
| 31 | Caribbean | 23397 | 209 | 1121 | 2820 | 17.7 | 3029 | 30.7 | 16216 | 69.3 |
| 32 | Central America | 248353 | 2070 | 4170 | 9570 | 6.4 | 12948 | 11.6 | 219596 | 88.4 |
| | | **271750** | **2279** | **5291** | **12390** | **7.3** | **15977** | **13.2** | **235812** | **86.8** |
| 41 | South America | **1777573** | **10710** | **62598** | **103040** | **9.9** | **249851** | **24.0** | **1351374** | **76.0** |
| 51 | Oceania | 793540 | 2694 | 8262 | 14295 | 3.2 | 17343 | 5.4 | 750946 | 94.6 |
| 52 | Polynesia | 56118 | 13 | 85 | 246 | 0.6 | 979 | 2.4 | 54796 | 97.6 |
| | | **849658** | **2707** | **8347** | **14541** | **3.0** | **18322** | **5.2** | **805742** | **94.8** |
| 61 | Eastern Africa | 639474 | 18588 | 55718 | 65820 | 21.9 | 60338 | 31.3 | 439009 | 68.7 |
| 62 | Middle Africa | 657061 | 3899 | 23166 | 41987 | 10.5 | 93674 | 24.8 | 494337 | 75.2 |
| 63 | Northern Africa | 794112 | 4383 | 16817 | 17033 | 4.8 | 10845 | 6.2 | 745033 | 93.8 |
| 64 | Southern Africa | 266428 | 347 | 2760 | 5179 | 3.1 | 7782 | 6.0 | 250361 | 94.0 |
| 65 | Western Africa | 632996 | 3152 | 30807 | 43490 | 12.2 | 54044 | 20.8 | 501504 | 79.2 |
| | | **2990071** | **30369** | **129268** | **173509** | **11.1** | **226683** | **18.7** | **2430244** | **81.3** |
| 71 | Western Asia | **432992** | **330** | **201** | **476** | **0.2** | **407** | **0.3** | **431577** | **99.7** |
| 81 | Southeast. Asia | 444483 | 118 | 2733 | 13576 | 3.7 | 24256 | 9.2 | 403803 | 90.8 |
| 82 | South Asia | 671842 | 12752 | 37209 | 50044 | 14.9 | 45063 | 21.6 | 526771 | 78.4 |
| 84 | East Asia | 1112296 | 6871 | 18681 | 26915 | 4.7 | 32843 | 7.7 | 1026986 | 92.3 |
| 85 | Central Asia | 414363 | 25 | 248 | 722 | 0.2 | 1579 | 0.6 | 411789 | 99.4 |
| 86 | Japan | 37178 | 188 | 781 | 2513 | 9.4 | 2846 | 17.0 | 30850 | 83.0 |
| | | **2680162** | **19954** | **59652** | **93770** | **6.5** | **106587** | **10.4** | **2400199** | **89.6** |
| | **DEVELOPING** | **8171488** | **63467** | **256314** | **380918** | **8.6** | **597638** | **15.9** | **6873152** | **84.1** |
| | **DEVELOPED** | **5228028** | **23640** | **110905** | **169511** | **5.8** | **125931** | **8.2** | **4798050** | **91.8** |
| | **WORLD TOTAL** | **13399516** | **87107** | **367219** | **550429** | **7.5** | **723569** | **12.9** | **11671202** | **87.1** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

### 5.2.2 Rain-fed and/or irrigated crops

The Global AEZ model allows to assess potential crop suitability for the combination of rain-fed and irrigated crop cultivation. The results have been used to highlight regions where the availability of irrigation facilities would result in substantial increases of potential production and areas with cultivation potential. For the assessment of irrigated land productivity potentials, it has been assumed that (i) water resources of good quality are available, and (ii) irrigation infrastructure is in place. In other words, the assessment identifies areas where climate, soils and terrain permit irrigated crop cultivation but does not undertake a quantification of water availability within a watershed. However, suitability in hyper-arid (LGP = 0 days) and arid regions (LGP < 60 days) was limited to specific soil conditions, such as Fluvisols and Gleysols in flat terrain conditions.

Table 26 shows the estimated percentage of the Earth's terrestrial surface that is considered suitable for the six crop groups, under respectively rain-fed conditions and for rain-fed plus irrigation conditions. For intermediate level of inputs the estimates include very suitable, suitable and moderately suitable areas (VS+S+MS). At high level of input, very suitable and suitable extents (VS+S) are accounted for. The results for intermediate level of inputs indicate that irrigation could increase the extents of land with cultivation potential for staple food crops (cereals, roots and tubers, pulses, oil crops) by some 6 to 11 percent. Larger relative improvements from irrigation would result for sugar crops (about 35 %) and cotton (about 20 %). The potential contribution from irrigation becomes more pronounced when looking at the prime suitability classes, i.e., VS and S, as is done for high level of inputs. For the four staple food crop groups the increases in VS+S extents range from 13 to 31 percent, for sugar crops the respective area nearly doubles (about 93%), and for cotton 46 percent more land is assessed as very suitable or suitable.

**Table 26 Percentage of global land surface potentially suitable for crop production**

| | Rain-fed cultivation potential | | Rain-fed and/or irrigated cultivation potential | |
|---|---|---|---|---|
| | High input (% VS+S) | Intermediate input (% VS+S+MS) | High input (% VS+S) | Intermediate input (% VS+S+MS) |
| Cereals | 14.9 | 18.7 | 16.8 | 19.8 |
| Roots & Tubers | 8.5 | 11.3 | 10.9 | 12.6 |
| Pulses | 7.8 | 11.2 | 10.1 | 12.2 |
| Oil crops | 11.2 | 15.2 | 14.6 | 16.5 |
| Sugar crops | 4.0 | 6.7 | 7.7 | 9.1 |
| Cotton | 3.3 | 4.3 | 4.8 | 5.2 |

The extents with cultivation potential for rain-fed and/or irrigated wheat, grain-maize and wetland rice at high and intermediate levels of input are given in Tables 27 to 32, respectively. Plates 37, 38 and 39 present, for the same crops under rain-fed and/or irrigated conditions, suitability maps at high input level. The results for wheat and grain-maize suggest gains of quite comparable magnitude. For both crops about 1 billion ha, i.e. about 7.5 percent of the global land surface, are assessed as very suitable, suitable or moderately suitable at intermediate levels of inputs. Extents very suitable and suitable (VS+S) under rain-fed conditions are larger for grain-maize than for wheat. For both crops, consideration of irrigation increases the extents of VS+S land by just over 40 percent, whereas the VS+S+MS areas increase only by about 12 percent. In other words, the results suggest that irrigation is more important in providing stable water supply in areas of climatic variability rather than for bringing land in hyper-arid and arid regions into cultivation. For wheat the VS+S estimates under rain-fed and rain-fed plus irrigated conditions are respectively 558 and 804 million ha; for grain-maize we obtained 692 and 975 million ha.

**Table 27 Gross extents with cultivation potential for rain-fed and/or irrigated wheat (1000 ha) – high input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 100067 | 128872 | 72821 | 14.1 | 37161 | 15.8 | 1799577 | 84.2 |
| 21 | Eastern Europe | 170952 | 27247 | 38780 | 26327 | 54.0 | 20219 | 65.9 | 58379 | 34.1 |
| 22 | Northern Europe | 172524 | 6196 | 18974 | 13309 | 22.3 | 8758 | 27.4 | 125287 | 72.6 |
| 23 | Southern Europe | 131643 | 9703 | 7723 | 4781 | 16.9 | 2387 | 18.7 | 107049 | 81.3 |
| 24 | Western Europe | 109547 | 22357 | 16963 | 8670 | 43.8 | 7353 | 50.5 | 54204 | 49.5 |
| 25 | Russian Federation | 1674146 | 37331 | 74496 | 79540 | 11.4 | 44913 | 14.1 | 1437866 | 85.9 |
| | | **2258812** | **102834** | **156936** | **132627** | **17.4** | **83630** | **21.1** | **1782785** | **78.9** |
| 31 | Caribbean | 23397 | 0 | 0 | 8 | 0.0 | 213 | 0.9 | 23176 | 99.1 |
| 32 | Central America | 248353 | 1528 | 3556 | 2011 | 2.9 | 1026 | 3.3 | 240232 | 96.7 |
| | | **271750** | **1528** | **3556** | **2019** | **2.6** | **1239** | **3.1** | **263408** | **96.9** |
| 41 | South America | 1777573 | 36391 | 48334 | 39119 | 7.0 | 31547 | 8.7 | 1622182 | 91.3 |
| 51 | Oceania | 793540 | 20243 | 23584 | 13043 | 7.2 | 8094 | 8.2 | 728576 | 91.8 |
| 52 | Polynesia | 56118 | 0 | 0 | 0 | 0.0 | 186 | 0.3 | 55932 | 99.7 |
| | | **849658** | **20243** | **23584** | **13043** | **6.7** | **8280** | **7.7** | **784508** | **92.3** |
| 61 | Eastern Africa | 639474 | 7729 | 22084 | 16253 | 7.2 | 7649 | 8.4 | 585759 | 91.6 |
| 62 | Middle Africa | 657061 | 1130 | 4714 | 4819 | 1.6 | 1971 | 1.9 | 644427 | 98.1 |
| 63 | Northern Africa | 794112 | 3801 | 12412 | 3957 | 2.5 | 1197 | 2.7 | 772745 | 97.3 |
| 64 | Southern Africa | 266428 | 1204 | 5767 | 2157 | 3.4 | 572 | 3.6 | 256728 | 96.4 |
| 65 | Western Africa | 632996 | 409 | 2050 | 264 | 0.4 | 16 | 0.4 | 630257 | 99.6 |
| | | **2990071** | **14273** | **47027** | **27450** | **3.0** | **11405** | **3.3** | **2889916** | **96.7** |
| 71 | Western Asia | 432992 | 3160 | 7003 | 6255 | 3.8 | 3114 | 4.5 | 413460 | 95.5 |
| 81 | Southeast. Asia | 444483 | 174 | 3028 | 4671 | 1.8 | 4128 | 2.7 | 432482 | 97.3 |
| 82 | South Asia | 671842 | 824 | 30932 | 15201 | 7.0 | 4782 | 7.7 | 620103 | 92.3 |
| 84 | East Asia | 1112296 | 9375 | 47163 | 37153 | 8.4 | 15540 | 9.8 | 1003065 | 90.2 |
| 85 | Central Asia | 414363 | 6463 | 7325 | 5152 | 4.6 | 2436 | 5.2 | 392987 | 94.8 |
| 86 | Japan | 37178 | 2111 | 2479 | 1855 | 17.3 | 819 | 19.5 | 29914 | 80.5 |
| | | **2680162** | **18947** | **90927** | **64032** | **6.5** | **27705** | **7.5** | **2478551** | **92.5** |
| | **DEVELOPING** | **8171488** | **72188** | **194368** | **137020** | **4.9** | **74377** | **5.8** | **7693535** | **94.2** |
| | **DEVELOPED** | **5228028** | **225255** | **311871** | **220346** | **14.5** | **129704** | **17.0** | **4340852** | **83.0** |
| | **WORLD TOTAL** | **13399516** | **297443** | **506239** | **357366** | **8.7** | **204081** | **10.2** | **12034387** | **89.8** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

**Table 28 Gross extents with cultivation potential for rain-fed and/or irrigated wheat (1000 ha) – intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 61151 | 137905 | 96644 | 13.8 | 69768 | 17.1 | 1773030 | 82.9 |
| 21 | Eastern Europe | 170952 | 25400 | 40653 | 34243 | 58.7 | 17948 | 69.2 | 52708 | 30.8 |
| 22 | Northern Europe | 172524 | 5814 | 13567 | 14937 | 19.9 | 10297 | 25.9 | 127909 | 74.1 |
| 23 | Southern Europe | 131643 | 9106 | 12977 | 14917 | 28.1 | 12550 | 37.6 | 82093 | 62.4 |
| 24 | Western Europe | 109547 | 20916 | 21858 | 13422 | 51.3 | 7589 | 58.2 | 45762 | 41.8 |
| 25 | Russian Federation | 1674146 | 29864 | 88777 | 69468 | 11.2 | 67624 | 15.3 | 1418413 | 84.7 |
| | | **2258812** | **91100** | **177832** | **146987** | **18.4** | **116008** | **23.5** | **1726885** | **76.5** |
| 31 | Caribbean | 23397 | 0 | 0 | 6 | 0.0 | 225 | 1.0 | 23166 | 99.0 |
| 32 | Central America | 248353 | 1466 | 3862 | 4775 | 4.1 | 5126 | 6.1 | 233124 | 93.9 |
| | | **271750** | **1466** | **3862** | **4781** | **3.7** | **5351** | **5.7** | **256290** | **94.3** |
| 41 | South America | 1777573 | 29689 | 43534 | 46412 | 6.7 | 42861 | 9.1 | 1615077 | 90.9 |
| 51 | Oceania | 793540 | 17938 | 24076 | 16460 | 7.4 | 12951 | 9.0 | 722115 | 91.0 |
| 52 | Polynesia | 56118 | 0 | 0 | 0 | 0.0 | 145 | 0.3 | 55973 | 99.7 |
| | | **849658** | **17938** | **24076** | **16460** | **6.9** | **13096** | **8.4** | **778088** | **91.6** |
| 61 | Eastern Africa | 639474 | 5893 | 20659 | 22956 | 7.7 | 18731 | 10.7 | 571235 | 89.3 |
| 62 | Middle Africa | 657061 | 761 | 2826 | 5006 | 1.3 | 5573 | 2.2 | 642895 | 97.8 |
| 63 | Northern Africa | 794112 | 2417 | 8082 | 6278 | 2.1 | 5278 | 2.8 | 772057 | 97.2 |
| 64 | Southern Africa | 266428 | 769 | 3880 | 6199 | 4.1 | 5596 | 6.2 | 249984 | 93.8 |
| 65 | Western Africa | 632996 | 194 | 863 | 337 | 0.2 | 4 | 0.2 | 631598 | 99.8 |
| | | **2990071** | **10034** | **36310** | **40776** | **2.9** | **35182** | **4.1** | **2867769** | **95.9** |
| 71 | Western Asia | 432992 | 2416 | 7321 | 12757 | 5.2 | 15608 | 8.8 | 394890 | 91.2 |
| 81 | Southeast. Asia | 444483 | 101 | 1852 | 4075 | 1.4 | 5037 | 2.5 | 433418 | 97.5 |
| 82 | South Asia | 671842 | 532 | 19466 | 16905 | 5.5 | 11454 | 7.2 | 623485 | 92.8 |
| 84 | East Asia | 1112296 | 4888 | 25166 | 32974 | 5.7 | 41024 | 9.4 | 1008244 | 90.6 |
| 85 | Central Asia | 414363 | 1721 | 5391 | 6511 | 3.3 | 8708 | 5.4 | 392032 | 94.6 |
| 86 | Japan | 37178 | 1063 | 3277 | 3544 | 21.2 | 3177 | 29.8 | 26117 | 70.2 |
| | | **2680162** | **8305** | **55152** | **64009** | **4.8** | **69400** | **7.3** | **2483296** | **92.7** |
| | **DEVELOPING** | **8171488** | **50847** | **142902** | **165191** | **4.4** | **165370** | **6.4** | **7647178** | **93.6** |
| | **DEVELOPED** | **5228028** | **171252** | **343090** | **263635** | **14.9** | **201904** | **18.7** | **4248147** | **81.3** |
| | **WORLD TOTAL** | **13399516** | **222099** | **485992** | **428826** | **8.5** | **367274** | **11.2** | **11895325** | **88.8** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

**Table 29 Gross extents with cultivation potential for rain-fed and/or irrigated grain maize (1000 ha) – high input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 64649 | 69840 | 32994 | 7.8 | 5835 | 8.1 | 1965180 | 91.9 |
| 21 | Eastern Europe | 170952 | 1536 | 8789 | 4174 | 8.5 | 279 | 8.6 | 156174 | 91.4 |
| 22 | Northern Europe | 172524 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 172524 | 100.0 |
| 23 | Southern Europe | 131643 | 3549 | 5567 | 1448 | 8.0 | 128 | 8.1 | 120951 | 91.9 |
| 24 | Western Europe | 109547 | 258 | 3707 | 1813 | 5.3 | 118 | 5.4 | 103651 | 94.6 |
| 25 | Russian Federation | 1674146 | 1901 | 8634 | 3508 | 0.8 | 41 | 0.8 | 1660062 | 99.2 |
| | | **2258812** | **7244** | **26697** | **10943** | **2.0** | **566** | **2.0** | **2213362** | **98.0** |
| 31 | Caribbean | 23397 | 303 | 1320 | 1583 | 13.7 | 4397 | 32.5 | 15794 | 67.5 |
| 32 | Central America | 248353 | 6145 | 5977 | 5424 | 7.1 | 14496 | 12.9 | 216311 | 87.1 |
| | | **271750** | **6448** | **7297** | **7007** | **7.6** | **18893** | **14.6** | **232105** | **85.4** |
| 41 | South America | 1777573 | 49196 | 79763 | 81547 | 11.8 | 179889 | 22.0 | 1387178 | 78.0 |
| 51 | Oceania | 793540 | 35944 | 25688 | 12995 | 9.4 | 5313 | 10.1 | 713600 | 89.9 |
| 52 | Polynesia | 56118 | 61 | 125 | 310 | 0.9 | 4654 | 9.2 | 50968 | 90.8 |
| | | **849658** | **36005** | **25813** | **13305** | **8.8** | **9967** | **10.0** | **764568** | **90.0** |
| 61 | Eastern Africa | 639474 | 57952 | 66747 | 50899 | 27.5 | 34938 | 32.9 | 428938 | 67.1 |
| 62 | Middle Africa | 657061 | 33144 | 31324 | 37025 | 15.4 | 88254 | 28.9 | 467314 | 71.1 |
| 63 | Northern Africa | 794112 | 52980 | 21476 | 11687 | 10.8 | 7841 | 11.8 | 700128 | 88.2 |
| 64 | Southern Africa | 266428 | 5468 | 2415 | 1872 | 3.7 | 2374 | 4.6 | 254299 | 95.4 |
| 65 | Western Africa | 632996 | 33267 | 42409 | 34241 | 17.4 | 39038 | 23.5 | 484041 | 76.5 |
| | | **2990071** | **182811** | **164371** | **135724** | **16.2** | **172445** | **21.9** | **2334720** | **78.1** |
| 71 | Western Asia | 432992 | 7068 | 3645 | 521 | 2.6 | 0 | 2.6 | 421758 | 97.4 |
| 81 | Southeast. Asia | 444483 | 370 | 14593 | 22496 | 8.4 | 45001 | 18.6 | 362023 | 81.4 |
| 82 | South Asia | 671842 | 53676 | 83930 | 40740 | 26.5 | 20820 | 29.6 | 472676 | 70.4 |
| 84 | East Asia | 1112296 | 32837 | 42849 | 28701 | 9.4 | 13700 | 10.6 | 994209 | 89.4 |
| 85 | Central Asia | 414363 | 6059 | 6547 | 1599 | 3.4 | 143 | 3.5 | 400015 | 96.5 |
| 86 | Japan | 37178 | 1483 | 2009 | 1485 | 13.4 | 770 | 15.5 | 31431 | 84.5 |
| | | **2680162** | **94425** | **149928** | **95021** | **12.7** | **80434** | **15.7** | **2260354** | **84.3** |
| | **DEVELOPING** | **8171488** | **338526** | **403120** | **318645** | **13.0** | **455545** | **18.6** | **6655652** | **81.4** |
| | **DEVELOPED** | **5228028** | **109320** | **124234** | **58417** | **5.6** | **12484** | **5.8** | **4923573** | **94.2** |
| | **WORLD TOTAL** | **13399516** | **447846** | **527354** | **377062** | **10.1** | **468029** | **13.6** | **11579225** | **86.4** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

**Table 30 Gross extents with cultivation potential for rain-fed and/or irrigated grain maize (1000 ha) – intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 24283 | 70870 | 88488 | 8.6 | 44706 | 10.7 | 1910151 | 89.3 |
| 21 | Eastern Europe | 170952 | 1044 | 8762 | 18374 | 16.5 | 11659 | 23.3 | 131113 | 76.7 |
| 22 | Northern Europe | 172524 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 172524 | 100.0 |
| 23 | Southern Europe | 131643 | 2995 | 4470 | 3836 | 8.6 | 2773 | 10.7 | 117569 | 89.3 |
| 24 | Western Europe | 109547 | 166 | 2646 | 7063 | 9.0 | 4447 | 13.1 | 95225 | 86.9 |
| 25 | Russian Federation | 1674146 | 689 | 4521 | 15338 | 1.2 | 10198 | 1.8 | 1643400 | 98.2 |
| | | **2258812** | **4894** | **20399** | **44611** | **3.1** | **29077** | **4.4** | **2159831** | **95.6** |
| 31 | Caribbean | 23397 | 168 | 942 | 1233 | 10.0 | 2927 | 22.5 | 18127 | 77.5 |
| 32 | Central America | 248353 | 3667 | 5453 | 6692 | 6.4 | 9263 | 10.1 | 223278 | 89.9 |
| | | **271750** | **3835** | **6395** | **7925** | **6.7** | **12190** | **11.2** | **241405** | **88.8** |
| 41 | South America | 1777573 | 28072 | 67946 | 85370 | 10.2 | 99031 | 15.8 | 1497154 | 84.2 |
| 51 | Oceania | 793540 | 26613 | 24134 | 14372 | 8.2 | 9079 | 9.4 | 719342 | 90.6 |
| 52 | Polynesia | 56118 | 48 | 134 | 237 | 0.7 | 532 | 1.7 | 55167 | 98.3 |
| | | **849658** | **26661** | **24268** | **14609** | **7.7** | **9611** | **8.8** | **774509** | **91.2** |
| 61 | Eastern Africa | 639474 | 30525 | 62919 | 64143 | 24.6 | 46997 | 32.0 | 434890 | 68.0 |
| 62 | Middle Africa | 657061 | 11383 | 24184 | 37665 | 11.1 | 48828 | 18.6 | 535001 | 81.4 |
| 63 | Northern Africa | 794112 | 22141 | 18009 | 11772 | 6.5 | 12643 | 8.1 | 729547 | 91.9 |
| 64 | Southern Africa | 266428 | 1289 | 3739 | 5535 | 4.0 | 8639 | 7.2 | 247226 | 92.8 |
| 65 | Western Africa | 632996 | 9143 | 42698 | 35998 | 13.9 | 32553 | 19.0 | 512604 | 81.0 |
| | | **2990071** | **74481** | **151549** | **155113** | **12.7** | **149660** | **17.8** | **2459268** | **82.2** |
| 71 | Western Asia | 432992 | 4080 | 2331 | 841 | 1.7 | 310 | 1.7 | 425430 | 98.3 |
| 81 | Southeast. Asia | 444483 | 226 | 3417 | 11649 | 3.4 | 18559 | 7.6 | 410632 | 92.4 |
| 82 | South Asia | 671842 | 31145 | 64137 | 39388 | 20.0 | 25107 | 23.8 | 512065 | 76.2 |
| 84 | East Asia | 1112296 | 9053 | 20434 | 26363 | 5.0 | 28569 | 7.6 | 1027877 | 92.4 |
| 85 | Central Asia | 414363 | 1944 | 2641 | 1714 | 1.5 | 2091 | 2.0 | 405973 | 98.0 |
| 86 | Japan | 37178 | 489 | 1837 | 2410 | 12.7 | 2308 | 18.9 | 30134 | 81.1 |
| | | **2680162** | **42857** | **92466** | **81524** | **8.1** | **76634** | **11.0** | **2386681** | **89.0** |
| | **DEVELOPING** | **8171488** | **152884** | **318984** | **328600** | **9.8** | **336049** | **13.9** | **7034971** | **86.1** |
| | **DEVELOPED** | **5228028** | **56279** | **117240** | **149881** | **6.2** | **85170** | **7.8** | **4819458** | **92.2** |
| | **WORLD TOTAL** | **13399516** | **209163** | **436224** | **478481** | **8.4** | **421219** | **11.5** | **11854429** | **88.5** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

**Table 31 Gross extents with cultivation potential for rain-fed and/or irrigated wetland rice (1000 ha) – high input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 49213 | 36349 | 13253 | 4.6 | 4025 | 4.8 | 2035658 | 95.2 |
| 21 | Eastern Europe | 170952 | 2447 | 2335 | 1110 | 3.4 | 0 | 3.4 | 165060 | 96.6 |
| 22 | Northern Europe | 172524 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 172524 | 100.0 |
| 23 | Southern Europe | 131643 | 5549 | 2401 | 347 | 6.3 | 31 | 6.3 | 123315 | 93.7 |
| 24 | Western Europe | 109547 | 487 | 235 | 12 | 0.7 | 0 | 0.7 | 108813 | 99.3 |
| 25 | Russian Federation | 1674146 | 1390 | 3681 | 2794 | 0.5 | 519 | 0.5 | 1665762 | 99.5 |
| | | **2258812** | **9873** | **8652** | **4263** | **1.0** | **550** | **1.0** | **2235474** | **99.0** |
| 31 | Caribbean | 23397 | 2492 | 2442 | 869 | 24.8 | 264 | 25.9 | 17330 | 74.1 |
| 32 | Central America | 248353 | 6121 | 11241 | 6578 | 9.6 | 1695 | 10.3 | 222718 | 89.7 |
| | | **271750** | **8613** | **13683** | **7447** | **10.9** | **1959** | **11.7** | **240048** | **88.3** |
| 41 | South America | 1777573 | 100709 | 165906 | 152004 | 23.6 | 110693 | 29.8 | 1248261 | 70.2 |
| 51 | Oceania | 793540 | 21014 | 28150 | 11408 | 7.6 | 1160 | 7.8 | 731808 | 92.2 |
| 52 | Polynesia | 56118 | 784 | 1370 | 2504 | 8.3 | 4364 | 16.1 | 47096 | 83.9 |
| | | **849658** | **21798** | **29520** | **13912** | **7.7** | **5524** | **8.3** | **778904** | **91.7** |
| 61 | Eastern Africa | 639474 | 25422 | 24580 | 16267 | 10.4 | 13416 | 12.5 | 559789 | 87.5 |
| 62 | Middle Africa | 657061 | 22105 | 55684 | 63054 | 21.4 | 29923 | 26.0 | 486295 | 74.0 |
| 63 | Northern Africa | 794112 | 17704 | 26423 | 10946 | 6.9 | 5863 | 7.7 | 733176 | 92.3 |
| 64 | Southern Africa | 266428 | 5265 | 1287 | 75 | 2.5 | 11 | 2.5 | 259790 | 97.5 |
| 65 | Western Africa | 632996 | 11425 | 27987 | 23430 | 9.9 | 13619 | 12.1 | 556535 | 87.9 |
| | | **2990071** | **81921** | **135961** | **113772** | **11.1** | **62832** | **13.2** | **2595585** | **86.8** |
| 71 | Western Asia | 432992 | 6715 | 2596 | 119 | 2.2 | 0 | 2.2 | 423562 | 97.8 |
| 81 | Southeast. Asia | 444483 | 17974 | 33851 | 23284 | 16.9 | 18775 | 21.1 | 350599 | 78.9 |
| 82 | South Asia | 671842 | 18575 | 54136 | 21681 | 14.0 | 10133 | 15.6 | 567317 | 84.4 |
| 84 | East Asia | 1112296 | 20625 | 25594 | 13242 | 5.3 | 2162 | 5.5 | 1050673 | 94.5 |
| 85 | Central Asia | 414363 | 4919 | 3405 | 470 | 2.1 | 16 | 2.1 | 405553 | 97.9 |
| 86 | Japan | 37178 | 1104 | 1404 | 382 | 7.8 | 89 | 8.0 | 34199 | 92.0 |
| | | **2680162** | **63197** | **118390** | **59059** | **9.0** | **31175** | **10.1** | **2408341** | **89.9** |
| | **DEVELOPING** | **8171488** | **260835** | **436502** | **334523** | **12.6** | **210934** | **15.2** | **6928694** | **84.8** |
| | **DEVELOPED** | **5228028** | **81204** | **74555** | **29306** | **3.5** | **5824** | **3.7** | **5037139** | **96.3** |
| | **WORLD TOTAL** | **13399516** | **342039** | **511057** | **363829** | **9.1** | **216758** | **10.7** | **11965833** | **89.3** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

**Table 32 Gross extents with cultivation potential for rain-fed and/or irrigated wetland rice (1000 ha) – intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 34066 | 28807 | 20725 | 3.9 | 8535 | 4.3 | 2046365 | 95.7 |
| 21 | Eastern Europe | 170952 | 1296 | 2246 | 1399 | 2.9 | 103 | 3.0 | 165908 | 97.0 |
| 22 | Northern Europe | 172524 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 172524 | 100.0 |
| 23 | Southern Europe | 131643 | 4016 | 2560 | 623 | 5.5 | 378 | 5.8 | 124066 | 94.2 |
| 24 | Western Europe | 109547 | 390 | 224 | 35 | 0.6 | 22 | 0.6 | 108876 | 99.4 |
| 25 | Russian Federation | 1674146 | 589 | 2970 | 3170 | 0.4 | 1183 | 0.5 | 1666234 | 99.5 |
| | | **2258812** | **6291** | **8000** | **5227** | **0.9** | **1686** | **0.9** | **2237608** | **99.1** |
| 31 | Caribbean | 23397 | 1486 | 2506 | 1223 | 22.3 | 540 | 24.6 | 17642 | 75.4 |
| 32 | Central America | 248353 | 4239 | 9450 | 7547 | 8.6 | 3667 | 10.0 | 223450 | 90.0 |
| | | 271750 | **5725** | **11956** | **8770** | **9.7** | **4207** | **11.3** | **241092** | **88.7** |
| 41 | South America | 1777573 | 54547 | 155415 | 146042 | 20.0 | 106592 | 26.0 | 1314977 | 74.0 |
| 51 | Oceania | 793540 | 13887 | 29848 | 15627 | 7.5 | 2172 | 7.8 | 732006 | 92.2 |
| 52 | Polynesia | 56118 | 53 | 1139 | 615 | 3.2 | 2884 | 8.4 | 51427 | 91.6 |
| | | **849658** | **13940** | **30987** | **16242** | **7.2** | **5056** | **7.8** | **783433** | **92.2** |
| 61 | Eastern Africa | 639474 | 15848 | 19264 | 22173 | 9.0 | 23015 | 12.6 | 559174 | 87.4 |
| 62 | Middle Africa | 657061 | 10475 | 41309 | 58018 | 16.7 | 29627 | 21.2 | 517632 | 78.8 |
| 63 | Northern Africa | 794112 | 8969 | 14165 | 14035 | 4.7 | 6732 | 5.5 | 750211 | 94.5 |
| 64 | Southern Africa | 266428 | 2793 | 1275 | 352 | 1.7 | 22 | 1.7 | 261986 | 98.3 |
| 65 | Western Africa | 632996 | 5565 | 24866 | 28277 | 9.3 | 20862 | 12.6 | 553426 | 87.4 |
| | | **2990071** | **43650** | **100879** | **122855** | **8.9** | **80258** | **11.6** | **2642429** | **88.4** |
| 71 | Western Asia | 432992 | 3570 | 1695 | 312 | 1.3 | 32 | 1.3 | 427383 | 98.7 |
| 81 | Southeast. Asia | 444483 | 5616 | 22563 | 25617 | 12.1 | 17596 | 16.1 | 373091 | 83.9 |
| 82 | South Asia | 671842 | 7852 | 41195 | 29124 | 11.6 | 15871 | 14.0 | 577800 | 86.0 |
| 84 | East Asia | 1112296 | 11245 | 24818 | 18378 | 4.9 | 5608 | 5.4 | 1052247 | 94.6 |
| 85 | Central Asia | 414363 | 2308 | 1687 | 740 | 1.1 | 102 | 1.2 | 409526 | 98.8 |
| 86 | Japan | 37178 | 567 | 1653 | 854 | 8.3 | 159 | 8.7 | 33945 | 91.3 |
| | | **2680162** | **27588** | **91916** | **74713** | **7.2** | **39336** | **8.7** | **2446609** | **91.3** |
| | **DEVELOPING** | **8171488** | **134566** | **361347** | **352453** | **10.4** | **233150** | **13.2** | **7089972** | **86.8** |
| | **DEVELOPED** | **5228028** | **54811** | **68308** | **42433** | **3.2** | **12552** | **3.4** | **5049924** | **96.6** |
| | **WORLD TOTAL** | **13399516** | **189377** | **429655** | **394886** | **7.6** | **245702** | **9.4** | **12139896** | **90.6** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

Areas suitable for major crop groups are displayed in Appendix XV where Plates 40 to 45 present suitability maps for high level of inputs of respectively cereals, roots and tubers, pulses, oil crops, cotton, and sugar crops. Regional results are provided in Tables A35 to A40 and Tables A41 to A46 in Appendix I, which summarize gross extents of land with cultivation potential for these crop groups at respectively intermediate and high input levels.

### 5.2.3 Hyper-arid and arid land with cultivation potential under irrigation

Globally, some 3.6 billion hectares, i.e., about 27 percent of the Earth's land surface, are too dry for rain-fed agriculture (see Table 18 at beginning of this Chapter). As working hypothesis we have only considered for irrigation those soils in hyper-arid (LGP = 0 days) and arid (LGP < 60 days) zones that indicate possible availability of surface or groundwater resources. These soils are Fluvisols, which by definition are regularly flooded, and Gleysols, which indicate regular occurrence of high groundwater tables.

**Table 33 Gross extents of potentially irrigable land in hyper-arid and arid zones very suitable and suitable (VS+S) for cereals**

| Region | Irrigated land in 1994-96 | (A): Total VS+S rainfed & irrigated potential | Hyper-arid zone (LGP = 0 days) VS+S irrigable land (high input) | | Arid zone (LGP = 1-60 days) VS+S irrigable land (high input) | | Hyper-arid and arid zones total VS+S irrigable land (high input) | |
|---|---|---|---|---|---|---|---|---|
| | (1000 ha) | (1000 ha) | (1000 ha) | % of (A) | (1000 ha) | % of (A) | (1000 ha) | % of (A) |
| North America | 22120 | 256624 | 1152 | 0.4 | 1293 | 0.5 | 2445 | 1.0 |
| Eastern Europe | 7444 | 70075 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Northern Europe | 913 | 28100 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Southern Europe | 8742 | 18101 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Western Europe | 2686 | 39925 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Russian Federation | 5209 | 126075 | 0 | 0.0 | 1553 | 1.2 | 1553 | 1.2 |
| | **24994** | 282276 | 0 | 0.0 | 1553 | 0.6 | 1553 | 0.6 |
| Caribbean | 1359 | 7853 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Central America | 6668 | 32190 | 623 | 1.9 | 565 | 1.8 | 1188 | 3.7 |
| | **8027** | 40043 | 623 | 1.6 | 565 | 1.4 | 1188 | 3.0 |
| South America | 9785 | 540013 | 3936 | 0.7 | 1372 | 0.3 | 5308 | 1.0 |
| Oceania | 2788 | 91284 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Polynesia | 3 | 3398 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | **2791** | 94682 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Eastern Africa | 2073 | 169740 | 2327 | 1.4 | 2497 | 1.5 | 4824 | 2.8 |
| Middle Africa | 141 | 221798 | 159 | 0.1 | 117 | 0.1 | 276 | 0.1 |
| Northern Africa | 7866 | 92650 | 15087 | 16.3 | 1746 | 1.9 | 16833 | 18.2 |
| Southern Africa | 1349 | 11575 | 194 | 1.7 | 715 | 6.2 | 909 | 7.9 |
| Western Africa | 773 | 143867 | 3530 | 2.5 | 1907 | 1.3 | 5437 | 3.8 |
| | **12203** | 639630 | 21297 | 3.3 | 6982 | 1.1 | 28279 | 4.4 |
| Western Asia | 11506 | 15062 | 6315 | 41.9 | 703 | 4.7 | 7018 | 46.6 |
| Southeast. Asia | 15286 | 88588 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| South Asia | 85667 | 177531 | 3582 | 2.0 | 1580 | 0.9 | 5162 | 2.9 |
| East Asia | 52814 | 99422 | 4450 | 4.5 | 652 | 0.7 | 5102 | 5.1 |
| Central Asia | 12142 | 16417 | 0 | 0.0 | 8494 | 51.7 | 8494 | 51.7 |
| Japan | 2744 | 5286 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| | **168653** | 387244 | 8032 | 2.1 | 10726 | 2.8 | 18758 | 4.8 |
| **DEVELOPING** | **207432** | 1620104 | 40203 | 2.5 | 20348 | 1.3 | 60551 | 3.7 |
| **DEVELOPED** | **47437** | 635470 | 1152 | 0.2 | 2846 | 0.4 | 3998 | 0.6 |
| **WORLD TOTAL** | **254869** | 2255574 | 41355 | 1.8 | 23194 | 1.0 | 64549 | 2.9 |

Assuming availability of water resources, nearly 65 million hectares, i.e., only about 1.8 percent of these dry zones, were assessed as potentially very suitable and suitable (VS+S) for cereal crops under irrigation. About 40 percent of this land, potentially suitable under irrigation, is located throughout Africa. Table 33 presents by major world region the estimated extents of irrigable land in hyper-arid (with a moisture growing period of zero days, LGP 0) and arid (with a moisture growing period of less than sixty days, LGP 1-59) zones potentially very suitable and suitable for cultivation of cereal crops. In comparison, FAO reports that about 255 million ha were irrigated globally in 1994-96. Note, however, that these irrigated lands were distributed among various climatic zones, not only hyper-arid and arid regions.

## 5.3 Crop yields

Maximum[26] agro-climatically attainable yield ranges were calculated for respectively tropics, sub-tropics and temperate/boreal zones. Table 34 presents potential yields for irrigated production at high and intermediate levels of inputs. Table 35 lists yield ranges for rain-fed conditions at high, intermediate and low levels of inputs. The maximum attainable yields for rain-fed conditions represent averages of simulated year-by-year yields attainable during the period 1960 to 1996. The yields are presented in ranges indicating the maximum attainable yields of the least and most productive cultivars for each of the 24 crop species in respectively tropics, subtropics and temperate/boreal zones.

With balanced fertilizer applications and proper pest and disease management (which is best possible at high level of inputs), only limited fallow will be required to maintain soil fertility and to keep pest and disease outbreaks in check. At low level of inputs, assuming virtually no application of chemical and only limited organic fertilizer, and very limited or no application of biocides, there is need for considerable fallow periods in the crop rotations to restore soil nutrient status and to break pest and disease cycles (see Appendix XII). The expected long-term yields as estimated by the Global AEZ procedures assume that proper crop/fallow cycles are respected. The yields attained on the long-term are well below the estimated maximum attainable yields when accounting for fallow period requirements.

Table 36 compares maximum attainable yields and long-term sustainable yields for the best crop among wheat, rice and grain-maize, averaged over all very suitable, suitable and moderately suitable land (VS+S+MS). The calculations assume the best suitable cereal to be chosen and aggregates yields for different major world regions and levels of inputs (see Section 4.4.4 for a discussion of fallow period requirements and cultivation factors in Global AEZ). On average, long-term sustainable yields are 10, 20, and 55 percent lower than maximum attainable yields, respectively at high, intermediate and low levels of inputs.

[26] To obtain representative results for a global study, the 99-percentile of non-zero yields (i.e., the yield level equalled or exceeded by just one percent of yields) over all grid-cells in the respective climatic zones has been chosen to represent maximum attainable yield potentials.

**Table 34 Maximum attainable crop yield ranges (t/ha) for high and intermediate level inputs in tropical, subtropical and temperate environments under irrigated conditions**

| Crop | High Input Yields (t/ha) | | | Intermediate Input Yields (t/ha) | | |
|---|---|---|---|---|---|---|
| | Tropics | Subtropics | Temperate | Tropics | Subtropics | Temperate |
| Wheat (hibernating) | n.a. | 6.6 – 14.2 | 7.4 – 13.5 | n.a. | 4.6 – 10.2 | 5.2 – 9.7 |
| Wheat (non-hibernating) | 5.3 – 11.1 | 5.4 – 9.9 | 5.3 – 8.5 | 3.3 – 7.4 | 3.4 – 6.9 | 3.3 – 5.7 |
| Rice (wetland) | 7.9 – 12.2 | 8.7 – 12.7 | 8.2 – 10.9 | 6.1 – 9.5 | 6.5 – 9.9 | 6.3 – 8.7 |
| Rice (dryland) | 4.8 – 6.8 | n.a. | n.a. | 3.1 – 4.6 | n.a. | n.a. |
| Maize (grain) | 6.0 – 15.6 | 8.5 – 17.1 | 8.0 – 15.7 | 3.5 – 10.5 | 5.3 – 12.2 | 4.9 – 11.3 |
| Maize (silage) | n.a. | 17.0 – 26.0 | 15.9 – 24.0 | n.a. | 13.0 – 20.9 | 12.1 – 19.2 |
| Barley (hibernating) | n.a. | 6.6 – 14.2 | 7.4 – 13.5 | n.a. | 4.6 – 10.2 | 5.2 – 9.7 |
| Barley (non-hibernating) | 4.7 – 9.9 | 5.2 – 9.2 | 3.9 – 7.6 | 2.9 – 6.7 | 2.9 – 6.4 | 2.8 – 5.1 |
| Sorghum | 3.4 – 12.1 | 7.8 – 13.0 | 5.9 – 10.3 | 2.2 – 7.5 | 4.6 – 8.1 | 3.4 – 6.4 |
| Pearl millet | 4.2 – 5.8 | n.a | n.a | 2.5 – 3.7 | n.a. | n.a. |
| Foxtail millet | n.a. | 5.2 – 10.0 | 5.0 – 9.3 | n.a | 3.6 – 7.2 | 3.5 – 6.7 |
| Rye (hibernating) | n.a. | 4.2 – 8.3 | 4.6 – 7.9 | n.a | 2.9 – 5.9 | 3.3 – 5.7 |
| Rye (non-hibernating) | n.a. | 3.5 – 6.6 | 3.4 – 6.3 | n.a | 2.1 – 4.1 | 2.0 – 3.9 |
| White potato | 7.4 – 15.8 | 8.1 – 16.5 | 7.8 – 15.2 | 4.9 – 10.6 | 5.4 – 11.1 | 5.2 – 10.2 |
| Sweet potato | 7.5 – 15.4 | 7.5 – 15.9 | n.a | 5.0 – 10.6 | 5.0 – 10.9 | n.a. |
| Cassava | 16.6 | n.a | n.a | 11.0 | n.a. | n.a. |
| Phaseolus bean | 3.4 –5.5 | 3.1 – 5.6 | 3.0 – 4.8 | 2.2 – 3.7 | 2.0 – 3.7 | 1.9 – 3.2 |
| Chickpea | 3.2 – 4.7 | 3.5 – 6.1 | n.a | 2.0 – 3.1 | 2.2 – 4.1 | n.a. |
| Cowpea | 2.9 – 4.7 | n.a. | n.a. | 1.9 – 3.1 | n.a. | n.a. |
| Soybean | 3.1 – 4.8 | 4.6 – 5.5 | 4.3 – 5.1 | 2.0 – 3.2 | 3.0 – 3.6 | 2.8 – 3.4 |
| Rape | 4.5 – 5.6 | 4.5 – 6.0 | 4.7 – 5.7 | 2.6 – 3.5 | 2.9 – 3.8 | 2.8 – 3.6 |
| Groundnut | 3.1 – 4.7 | 3.2 – 4.9 | 3.1 – 4.6 | 2.0 – 3.1 | 2.0 – 3.3 | 2.0 – 3.0 |
| Sunflower | 5.6 – 6.7 | 4.9 – 6.1 | 4.7 – 5.8 | 3.9 – 4.8 | 3.4 – 4.4 | 3.3 – 4.1 |
| Oil palm | 8.7 | 6.4 | n.a. | 6.0 | 4.4 | n.a. |
| Olive | n.a. | 6.7 | 5.4 | n.a. | 4.1 | 3.3 |
| Cotton | 1.1 – 1.6 | 1.2 – 1.6 | 1.2 –1.5 | 0.7 – 1.0 | 0.8 – 1.0 | 0.7 – 0.9 |
| Sugarcane | 21.0 | 20.1 | n.a, | 16.5 | 15.8 | n.a. |
| Sugar beet | n.a. | 7.1 – 9.3 | 6.7 – 8.6 | n.a. | 4.8 – 6.7 | 4.6 – 6.2 |
| Banana/Plantain | 11.5 | 11.5 | n.a. | 8.4 | 8.4 | n.a. |
| Alfalfa | n.a. | 26.7 | 21.5 | n.a | 16.9 | 13.6 |

**Table 35 Average of year 1960-1996 simulated maximum attainable crop yield ranges (t/ha) for high, intermediate and low level inputs in tropical, subtropical and temperate environments under rain-fed conditions**

| Crop | High Input Yields (t/ha) | | | Intermediate Input Yields (t/ha) | | | Low Input Yields (t/ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tropics | Subtropics | Temperate | Tropics | Subtropics | Temperate | Tropics | Subtropics | Temperate |
| Wheat (hibernating) | n.a. | 4.2 – 11.8 | 5.9 – 12.1 | n.a. | 2.9 - 8.4 | 4.1 - 8.7 | n.a. | 1.6 – 4.3 | 2.4 – 4.9 |
| Wheat (non-hibernating) | 4.5 – 8.5 | 4.6 – 8.0 | 4.6 – 7.7 | 2.8 – 5.7 | 2.9 – 5.4 | 2.9 – 5.2 | 1.2 – 2.7 | 1.3 – 3.0 | 1.5 – 2.7 |
| Rice (wetland) | 6.2 – 9.9 | 6.2 – 9.2 | 6.4 – 8.6 | 4.8 – 7.7 | 4.8 – 7.3 | 4.9 – 6.9 | 2.9 – 5.0 | 2.9 – 4.7 | 3.2 – 4.9 |
| Rice (dryland) | 3.5 – 5.5 | n.a. | n.a. | 2.3 – 3.7 | n.a. | n.a. | 1.2 – 1.9 | n.a. | n.a. |
| Maize (grain) | 4.6 – 12.5 | 6.3 – 12.3 | 6.1 – 12.1 | 2.7 – 8.5 | 4.0 – 8.9 | 3.8 – 8.7 | 1.1 – 5.1 | 1.8 – 5.8 | 1.8 – 5.3 |
| Maize (silage) | n.a. | 12.6 – 19.2 | 12.4 – 18.8 | n.a. | 9.7 – 15.2 | 9.4 – 15.1 | n.a. | 6.9 – 12.0 | 6.7 – 11.1 |
| Barley (hibernating) | n.a. | 4.2 – 11.8 | 5.9 – 12.1 | n.a. | 2.3 – 8.4 | 4.1 – 8.7 | n.a. | 1.6 – 4.3 | 2.4 – 4.9 |
| Barley (non-hibernating) | 4.1 – 7.7 | 3.0 – 7.3 | 3.5 – 6.8 | 2.5 – 5.2 | 2.2 – 5.1 | 2.5 – 4.6 | 1.1 – 2.7 | 1.1 – 2.8 | 1.3 – 2.5 |
| Sorghum | 2.6 – 9.7 | 5.8 – 8.7 | 3.6 – 6.3 | 1.7 – 6.1 | 3.4 – 5.5 | 2.1 – 3.9 | 0.9 – 2.6 | 1.5 – 2.4 | 0.9 – 2.0 |
| Pearl millet | 2.7 – 4.7 | n.a | n.a | 1.6 – 3.0 | n.a. | n.a. | 0.9 – 1.6 | n.a. | n.a. |
| Foxtail millet | n.a. | 3.7 – 7.0 | 4.1 – 6.8 | n.a | 2.6 – 5.0 | 2.5 – 4.9 | n.a | 1.5 – 2.8 | 1.4 – 2.7 |
| Rye (hibernating) | n.a. | 2.6 – 7.0 | 3.7 – 7.2 | n.a | 1.9 – 5.0 | 2.6 – 5.2 | n.a | 1.0 – 2.5 | 1.5 – 3.0 |
| Rye (non-hibernating) | n.a. | 2.8 – 5.9 | 3.0 – 5.7 | n.a | 1.6 – 3.7 | 1.8 – 3.6 | n.a | 0.6 – 1.4 | 0.8 – 1.6 |
| White potato | 5.8 – 11.8 | 5.4 – 11.6 | 6.4 – 10.3 | 3.8 – 8.0 | 3.6 – 7.8 | 4.3 – 6.9 | 2.1 – 4.0 | 1.9 – 4.1 | 2.3 – 3.7 |
| Sweet potato | 5.2 – 11.8 | 5.3 – 11.0 | n.a | 3.5 – 8.1 | 3.5 – 7.6 | n.a. | 1.7 – 4.6 | 1.6 – 4.1 | n.a. |
| Cassava | 15.5 | n.a | n.a | 10.2 | n.a. | n.a. | 4.1 | n.a | n.a |
| Phaseolus bean | 2.8 – 4.2 | 2.4 – 4.0 | 2.5 – 3.7 | 1.8 – 2.8 | 1.5 – 2.6 | 1.6 – 2.4 | 0.9 – 1.3 | 0.8 – 1.2 | 0.8 – 1.2 |
| Chickpea | 1.9 – 3.1 | 1.9 – 2.9 | n.a | 1.2– 2.2 | 1.6 – 2.4 | n.a. | 0.6 – 1.0 | 0.8 – 1.0 | n.a. |
| Cowpea | 2.5 – 3.8 | n.a. | n.a. | 1.6 – 2.5 | n.a. | n.a. | 0.7 – 1.2 | n.a | n.a |
| Soybean | 2.7 – 3.8 | 3.4 - 4.2 | 3.4 – 3.8 | 1.7 – 2.5 | 2.2 – 2.8 | 2.2 – 2.6 | 0.8 – 1.2 | 1.0 – 1.2 | 0.9 – 1.1 |
| Rape | 3.7 – 4.4 | 2.6 – 4.5 | 3.9 – 4.4 | 2.2 – 2.8 | 1.6 – 2.8 | 2.3 – 3.0 | 0.9 – 1.3 | 0.7– 1.1 | 1.0 – 1.3 |
| Groundnut | 2.7 – 3.8 | 2.6 - 3.5 | 1.8 – 2.6 | 1.7 – 2.5 | 1.7 – 2.4 | 1.1 – 1.9 | 0.8 - 1.2 | 0.8 – 1.2 | 0.5 – 0.9 |
| Sunflower | 4.1 – 4.9 | 3.4 – 4.0 | 3.7 – 3.9 | 2.9 – 3.5 | 2.3 – 2.9 | 2.6 – 2.7 | 1.6 – 2.1 | 1.4 – 1.7 | 1.5 – 1.6 |
| Oil palm | 7.5 | 3.7 | n.a. | 5.2 | 2.6 | n.a. | 2.8 | 1.5 | n.a |
| Olive | n.a. | 5.9 | 4.6 | n.a. | 3.6 | 2.8 | n.a. | 1.7 | 1.2 |
| Cotton | 0.9 – 1.2 | 0.9 – 1.2 | 0.5 – 0.6 | 0.6 – 0.8 | 0.6 – 0.7 | 0.4 – 0.5 | .16 - .28 | .15 –.22 | .12 – .16 |
| Sugarcane | 17.1 | 16.0 | n.a, | 13.4 | 12.6 | n.a. | 9.4 | 8.5 | n.a. |
| Sugar beet | n.a. | 5.0 – 6.3 | 5.4 – 6.0 | n.a. | 3.9 – 4.7 | 3.8 – 4.6 | n.a. | 2.2 – 3.6 | 2.3 – 2.7 |
| Banana/Plantain | 9.7 | 9.0 | n.a. | 6.8 | 6.6 | n.a. | 3.2 | 3.3 | n.a. |
| Alfalfa | n.a. | 23.8 | 19.9 | n.a | 15.1 | 12.6 | n.a. | 7.4 | 6.2 |

*Notes:* The yields given in Tables 34 and 35 represent yields attained during the cultivation phase of cultivation-fallow cycles. In low and intermediate input agriculture, fallow and/or crop rotations are needed to maintain the soil nutrient balance and to break pest and disease cycles. The required intensity of fallow depends on crop rotations implemented, on soil characteristics such as soil nutrient availability and nutrient retention capacity, on climatic conditions and on management and agricultural inputs applied. As a rule of thumb for low level input/management conditions, fallow period requirements may vary between 30–90% of the cultivation-fallow cycle. For intermediate level input/management conditions, fallow requirements may vary between 10–30% (see also Table 36).

**Table 36 Maximum attainable and long-term sustainable[27] yields for rain-fed wheat, rice, or grain-maize averaged over all VS+S+MS land, by region and level of inputs**

| Region | Low inputs | | Intermediate inputs | | High inputs | |
|---|---|---|---|---|---|---|
| | Short-term attainable (kg/ha) | Long-term sustainable (kg/ha) | Short-term attainable (kg/ha) | Long-term sustainable (kg/ha) | Short-term attainable (kg/ha) | Long-term sustainable (kg/ha) |
| North America | 836 | 357 | 3558 | 2800 | 5784 | 5227 |
| Eastern Europe | 1142 | 407 | 4193 | 3326 | 6469 | 5862 |
| Northern Europe | 925 | 359 | 3732 | 2940 | 5795 | 5228 |
| Southern Europe | 927 | 338 | 3606 | 2844 | 6339 | 5715 |
| Western Europe | 1058 | 347 | 4335 | 3361 | 7031 | 6362 |
| Russian Federation | 739 | 348 | 2943 | 2467 | 4363 | 3966 |
| Caribbean | 1390 | 639 | 4091 | 3360 | 5884 | 5301 |
| Central America | 1076 | 534 | 3630 | 2999 | 5952 | 5378 |
| South America | 1154 | 595 | 3645 | 3009 | 5609 | 5079 |
| Oceania | 718 | 335 | 3187 | 2566 | 5334 | 4816 |
| Polynesia | 1360 | 843 | 3805 | 3263 | 5378 | 4968 |
| Eastern Africa | 1025 | 388 | 3822 | 3027 | 6914 | 6233 |
| Middle Africa | 1167 | 557 | 3765 | 3067 | 6197 | 5590 |
| Northern Africa | 1033 | 427 | 4145 | 3338 | 7506 | 6794 |
| Southern Africa | 812 | 396 | 3052 | 2513 | 4727 | 4278 |
| Western Africa | 984 | 406 | 3791 | 3020 | 6739 | 6086 |
| Western Asia | 843 | 370 | 3075 | 2525 | 4483 | 4074 |
| Southeast. Asia | 1341 | 696 | 3694 | 3080 | 5641 | 5120 |
| South Asia | 1093 | 474 | 4077 | 3274 | 6755 | 6087 |
| East Asia | 982 | 471 | 3386 | 2760 | 5837 | 5259 |
| Central Asia | 708 | 417 | 2957 | 2507 | 3646 | 3331 |
| Japan | 987 | 371 | 3844 | 3018 | 7259 | 6533 |
| **DEVELOPING** | 1089 | 511 | 3728 | 3033 | 6157 | 5564 |
| **DEVELOPED** | 869 | 358 | 3539 | 2825 | 5613 | 5079 |
| **WORLD TOTAL** | 998 | 448 | 3658 | 2955 | 5983 | 5409 |

## 5.4 Land with cultivation potential

Various ways are available for estimating the extent of land with cultivation potential for rain-fed crops. Any quantification depends on a variety of assumptions: the range of crop types considered, the definition of what minimum level of output qualifies as acceptable, the social acceptance of land-cover conversions (in particular forests), and the assumptions on what land constraints may be alleviated with modern inputs and investment. The results presented in this section are based on the following calculation procedures for each 5-minute grid-cell of the DSMW:

(1) *Determine all land very suitable and suitable at high level of inputs for the crops offering the largest total extent;*

(2) *Of the balance of land after* (1), *determine all land very suitable, suitable or moderately suitable at intermediate level of inputs for the crops offering the largest extent;*

(3) *Of the balance of land after* (1) and (2), *determine all suitable land (i.e. very suitable, suitable, moderately suitable or marginally suitable) at low level of inputs for the crops offering the largest extent.*

[27] Long-term sustainable yields are calculated by applying a fallow period requirement factor dependent on climatic conditions, soil type, crop, and level of inputs/management (see Section 4.4.4).

The total extents obtained in this way for each grid-cell, referred to as *mixed* level of inputs, were calculated for rain-fed and rain-fed plus irrigated conditions. The results have been aggregated to various levels (e.g., climatic zones, country, and region).

Table 37 lists *gross* extents of land with cultivation potential for rain-fed conditions in comparison to levels of cultivated land use in 1994-96. Note that the extents in this table are termed 'gross' since no land was subtracted as is required for non-agricultural uses, such as infrastructure and settlements, nor legally protected areas. In reality, some 10 to 30 percent of gross suitable areas may not be available for cultivation even with full exploitation of suitable potentials for cropping.

**Table 37 Extents of land in use for crop cultivation (1994-96)[28] and gross extents of land with potential for rain-fed cultivation (VS+S+MS)**

| REGION | TOTAL LAND (1000 ha) | Land in use for crop cultivation (FAOSTAT 1994-96) | | VS+S+MS Land with rain-fed cultivation potential (mixed inputs) | | Balance | |
|---|---|---|---|---|---|---|---|
| | | (1000 ha) | (%) | (1000 ha) | (%) | (1000 ha) | (%) |
| North America | 2138498 | 225278 | 10.5 | 405499 | 19.0 | 180221 | 8.4 |
| Eastern Europe | 170952 | 81716 | 47.8 | 125883 | 73.6 | 44167 | 25.8 |
| Northern Europe | 172524 | 21556 | 12.5 | 44572 | 25.8 | 23016 | 13.3 |
| Southern Europe | 131643 | 45632 | 34.7 | 59291 | 45.0 | 13659 | 10.4 |
| Western Europe | 109547 | 35143 | 32.1 | 66309 | 60.5 | 31166 | 28.5 |
| Russian Federation | 1674146 | 130055 | 7.8 | 238658 | 14.3 | 108603 | 6.5 |
| Caribbean | 23397 | 7601 | 32.5 | 11728 | 50.1 | 4127 | 17.6 |
| Central America | 248353 | 35937 | 14.5 | 57487 | 23.1 | 21550 | 8.7 |
| South America | 1777573 | 114787 | 6.5 | 925299 | 52.1 | 810512 | 45.6 |
| Oceania | 793540 | 51782 | 6.5 | 120652 | 15.2 | 68870 | 8.7 |
| Polynesia | 56118 | 1379 | 2.5 | 17860 | 31.8 | 16481 | 29.4 |
| Eastern Africa | 639474 | 45975 | 7.2 | 276735 | 43.3 | 230760 | 36.1 |
| Middle Africa | 657061 | 24772 | 3.8 | 364076 | 55.4 | 339304 | 51.6 |
| Northern Africa | 794112 | 44134 | 5.6 | 108814 | 13.7 | 64680 | 8.1 |
| Southern Africa | 266428 | 17437 | 6.5 | 34118 | 12.8 | 16681 | 6.3 |
| Western Africa | 632996 | 65384 | 10.3 | 195132 | 30.8 | 129748 | 20.5 |
| Western Asia | 432992 | 46075 | 10.6 | 36441 | 8.4 | -9634 | -2.2 |
| Southeast. Asia | 444483 | 89578 | 20.2 | 167490 | 37.7 | 77912 | 17.5 |
| South Asia | 671842 | 231647 | 34.5 | 216846 | 32.3 | -14801 | -2.2 |
| East Asia | 1112296 | 139727 | 12.6 | 151479 | 13.6 | 11752 | 1.1 |
| Central Asia | 414363 | 45197 | 10.9 | 16323 | 3.9 | -28874 | -7.0 |
| Japan | 37178 | 4379 | 11.8 | 10592 | 28.5 | 6213 | 16.7 |
| **DEVELOPING** | **8171488** | **909630** | **11.1** | **2579828** | **31.6** | **1670198** | **20.4** |
| **DEVELOPED** | **5228028** | **465486** | **8.9** | **1071456** | **20.5** | **605970** | **11.6** |
| **WORLD TOTAL** | **13399516** | **1375116** | **10.3** | **3651284** | **27.2** | **2276168** | **17.0** |

When considering all crop types modeled in Global AEZ (excluding silage maize, forage legumes and grasses) and mixing all three input levels, we conclude that a little more than one-quarter of the Earth's land surface (excluding Antarctica) can be regarded as suitable for crop cultivation. In developed regions about one-fifth comprises of land with rain-fed cultivation potential. In developing regions it amounts to about 30 percent. This estimate of land with cultivation potential (of course, also because of being 'gross' rather than 'net' available areas) is more than twice the area that was actually in use for cultivation during 1994-96 (according to FAOSTAT). Despite this optimistic aggregate picture, Table 37 indicates several regions where the rain-fed cultivation potential has already been exceeded or is nearly fully exhausted. Further details, in terms of suitability by input level, are shown

[28] Source: FAOSTAT, Rome.

in Table 39. Plate 46 (in Appendix XV) shows a map of areas with rain-fed cultivation potential.

By looking at all crop types, without consideration of the demand for different products, we may well over-estimate the *useful* extents of land with cultivation potential. Therefore, Table 38 was compiled by restricting the considered crop types to the three major cereals, namely wheat, rice, and grain-maize. Under these assumptions, an estimate of about 2.4 thousand million ha of land with rain-fed cultivation potential (VS+S+MS) was obtained. Of these, 1.5 thousand million ha were found in less developed countries and 0.9 thousand million ha in developed regions.

**Table 38 Extents of land in use for crop cultivation (1994-96) and gross extents of land with potential for rain-fed wheat, grain-maize, or rice cultivation (VS+S+MS)**

| REGION | TOTAL LAND (1000 ha) | Land in use for crop cultivation (FAOSTAT 1994-96) | | Land suitable for rain-fed cereals (VS+S+MS) (mixed inputs) | | Balance | |
|---|---|---|---|---|---|---|---|
| | | (1000 ha) | (%) | (1000 ha) | (%) | (1000 ha) | (%) |
| North America | 2138498 | 225278 | 10.5 | 347237 | 16.2 | 121959 | 5.7 |
| Eastern Europe | 170952 | 81716 | 47.8 | 114214 | 66.8 | 32498 | 19.0 |
| Northern Europe | 172524 | 21556 | 12.5 | 39558 | 22.9 | 18002 | 10.4 |
| Southern Europe | 131643 | 45632 | 34.7 | 45283 | 34.4 | -349 | -0.3 |
| Western Europe | 109547 | 35143 | 32.1 | 61457 | 56.1 | 26314 | 24.0 |
| Russian Federation | 1674146 | 130055 | 7.8 | 214588 | 12.8 | 84533 | 5.0 |
| Caribbean | 23397 | 7601 | 32.5 | 7490 | 32.0 | -111 | -0.5 |
| Central America | 248353 | 35937 | 14.5 | 40017 | 16.1 | 4080 | 1.6 |
| South America | 1777573 | 114787 | 6.5 | 532101 | 29.9 | 417314 | 23.5 |
| Oceania | 793540 | 51782 | 6.5 | 71009 | 8.9 | 19227 | 2.4 |
| Polynesia | 56118 | 1379 | 2.5 | 2903 | 5.2 | 1524 | 2.7 |
| Eastern Africa | 639474 | 45975 | 7.2 | 198963 | 31.1 | 152988 | 23.9 |
| Middle Africa | 657061 | 24772 | 3.8 | 184683 | 28.1 | 159911 | 24.3 |
| Northern Africa | 794112 | 44134 | 5.6 | 74969 | 9.4 | 30835 | 3.9 |
| Southern Africa | 266428 | 17437 | 6.5 | 16196 | 6.1 | -1241 | -0.5 |
| Western Africa | 632996 | 65384 | 10.3 | 126083 | 19.9 | 60699 | 9.6 |
| Western Asia | 432992 | 46075 | 10.6 | 29520 | 6.8 | -16555 | -3.8 |
| Southeast. Asia | 444483 | 89578 | 20.2 | 75461 | 17.0 | -14117 | -3.2 |
| South Asia | 671842 | 231647 | 34.5 | 168461 | 25.1 | -63186 | -9.4 |
| East Asia | 1112296 | 139727 | 12.6 | 118169 | 10.6 | -21558 | -1.9 |
| Central Asia | 414363 | 45197 | 10.9 | 12286 | 3.0 | -32911 | -7.9 |
| Japan | 37178 | 4379 | 11.8 | 9999 | 26.9 | 5620 | 15.1 |
| **DEVELOPING** | **8171488** | **909630** | **11.1** | **1587302** | **19.4** | **677672** | **8.3** |
| **DEVELOPED** | **5228028** | **465486** | **8.9** | **903345** | **17.3** | **437859** | **8.4** |
| **WORLD TOTAL** | **13399516** | **1375116** | **10.3** | **2490647** | **18.6** | **1115531** | **8.3** |

To take yet another look at the Global AEZ crop suitability results, in Table 40 we present per capita land currently (i.e., average of 1994-96) in use for cultivation and per capita *net*[29] rain-fed land with cultivation potential for populations in 1995 and projected populations in 2050. In the calculations the population projections of the United Nations medium variant

[29] Net rain-fed land with cultivation potential excludes land requirements for infrastructure and settlement. In order to estimate land requirements for housing and infrastructure, we used a gridded population dataset of the year 1995, available from the World Data Center for Human Interaction in the Environment at the Center for International Earth Science Information Network (CIESIN, 2000). The data provides population counts and population density (people per square kilometer) for grid-cells of 5 minutes latitude/longitude. Housing and infrastructure requirements population density. They amount to 0.1 ha per person in areas with very low population density, and are estimated at 0.05 ha per person when population density is 35 persons per square kilometer, and they decline monotonously to 0.01 ha per person when the density reaches 3000 persons per square kilometer.

were used (United Nations, 1998). With very few exceptions (notably Australia, Russia, and North America), most regions were characterized by a use of arable land per person in the mid-1990s of some 0.1 to 0.4 ha; the world average in 1995 being about 0.25 ha/person for a world population of almost 5.7 billion people. The results suggest a considerable availability of resources suitable for agricultural uses. However, we do not hesitate to state that such increased use of cultivated land is neither likely (because of improvements in input use and technology leading to higher average per hectare output, and because of competition with other non-agricultural uses) nor desirable (because of obvious implications for bio-diversity and the carbon cycle).

**Table 39 Gross extents with rain-fed cultivation potential (1000 ha) - maximizing technology mix[30]**

| | Region | Total | VS+S+MS Land with | | High input level | | Intermediate input level | | | Low input level | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | land | cultivation potential | | VS | S | VS | S | MS | VS | S | MS | mS | NS |
| | | (1000 ha) | (1000 ha) | (%) | (1000 ha) | (1000 ha) | (1000 ha) | (1000 ha) | (1000 ha) | (1000 ha) | (1000 ha) | (1000 ha) | (1000 ha) | (1000 ha) |
| 11 | North America | 2138498 | 405499 | 19.0 | 91673 | 142981 | 3095 | 42713 | 77317 | 1 | 1266 | 46453 | 108847 | 1624153 |
| 21 | Eastern Europe | 170952 | 125883 | 73.6 | 21941 | 41914 | 1166 | 14713 | 34372 | 0 | 534 | 11243 | 9871 | 35202 |
| 22 | Northern Europe | 172524 | 44572 | 25.8 | 7700 | 20947 | 625 | 3684 | 9693 | 0 | 60 | 1863 | 6313 | 121640 |
| 23 | Southern Europe | 131643 | 59291 | 45.0 | 7922 | 10879 | 536 | 11935 | 18978 | 33 | 1875 | 7133 | 9605 | 62745 |
| 24 | Western Europe | 109547 | 66309 | 60.5 | 16421 | 21130 | 1340 | 11586 | 12522 | 0 | 101 | 3209 | 4556 | 38684 |
| 25 | Russian Federation | 1674146 | 238658 | 14.3 | 30416 | 72538 | 2658 | 36100 | 61572 | 0 | 1157 | 34217 | 50578 | 1384914 |
| | | **2258812** | **534713** | **23.7** | **84400** | **167408** | **6325** | **78018** | **137137** | **33** | **3727** | **57665** | **80923** | **1643185** |
| 31 | Caribbean | 23397 | 11728 | 50.1 | 5883 | 3302 | 0 | 973 | 1313 | 0 | 62 | 195 | 879 | 10779 |
| 32 | Central America | 248353 | 57487 | 23.1 | 24891 | 13867 | 0 | 4888 | 9509 | 0 | 136 | 4196 | 11403 | 179461 |
| | | **271750** | **69215** | **25.5** | **30774** | **17169** | **0** | **5861** | **10822** | **0** | **198** | **4391** | **12282** | **190240** |
| 41 | South America | 1777573 | 925299 | 52.1 | 393937 | 386480 | 973 | 23981 | 102205 | 0 | 1324 | 16399 | 68235 | 784038 |
| 51 | Oceania | 793540 | 120652 | 15.2 | 32240 | 35109 | 163 | 9131 | 32066 | 0 | 380 | 11563 | 34741 | 638148 |
| 52 | Polynesia | 56118 | 17860 | 31.8 | 9877 | 6586 | 0 | 286 | 1019 | 0 | 0 | 92 | 1796 | 36461 |
| | | **849658** | **138512** | **16.3** | **42117** | **41695** | **163** | **9417** | **33085** | **0** | **380** | **11655** | **36537** | **674609** |
| 61 | Eastern Africa | 639474 | 276735 | 43.3 | 108320 | 92498 | 870 | 14592 | 47494 | 0 | 252 | 12709 | 39256 | 323485 |
| 62 | Middle Africa | 657061 | 364076 | 55.4 | 172064 | 135663 | 6 | 4311 | 48421 | 0 | 1 | 3610 | 38016 | 254969 |
| 63 | Northern Africa | 794112 | 108814 | 13.7 | 48246 | 26394 | 724 | 7803 | 18647 | 11 | 1450 | 5539 | 14055 | 671242 |
| 64 | Southern Africa | 266428 | 34118 | 12.8 | 2484 | 4694 | 516 | 7061 | 13602 | 22 | 748 | 4991 | 13050 | 219256 |
| 65 | Western Africa | 632996 | 195132 | 30.8 | 92246 | 70109 | 208 | 6019 | 24977 | 0 | 11 | 1562 | 13957 | 423904 |
| | | **2990071** | **978875** | **32.7** | **423360** | **329358** | **2324** | **39786** | **153141** | **33** | **2462** | **28411** | **118334** | **1892856** |
| 71 | Western Asia | 432992 | 36441 | 8.4 | 1881 | 5023 | 281 | 4671 | 15498 | 1 | 972 | 8114 | 11661 | 384888 |
| 81 | Southeast. Asia | 444483 | 167490 | 37.7 | 96359 | 58401 | 24 | 1495 | 9860 | 0 | 0 | 1351 | 13580 | 263420 |
| 82 | South Asia | 671842 | 216846 | 32.3 | 116544 | 73409 | 184 | 4490 | 15965 | 4 | 324 | 5926 | 23338 | 431656 |
| 84 | East Asia | 1112296 | 151479 | 13.6 | 49793 | 45264 | 190 | 13573 | 34490 | 0 | 364 | 7805 | 34134 | 926682 |
| 85 | Central Asia | 414363 | 16323 | 3.9 | 503 | 782 | 337 | 1315 | 7840 | 0 | 223 | 5323 | 26669 | 371374 |
| 86 | Japan | 37178 | 10592 | 28.5 | 3039 | 2586 | 0 | 1649 | 2966 | 0 | 2 | 350 | 2564 | 24023 |
| | | **2680162** | **562730** | **21.0** | **266238** | **180442** | **735** | **22522** | **71121** | **4** | **913** | **20755** | **100285** | **2017155** |
| | **DEVELOPING** | **8171488** | **2579828** | **31.6** | **1123028** | **922472** | **4313** | **95458** | **350840** | **38** | **5867** | **77812** | **310029** | **5281615** |
| | **DEVELOPED** | **5228028** | **1071456** | **20.5** | **211352** | **348084** | **9583** | **131511** | **249486** | **34** | **5375** | **116031** | **227075** | **3929509** |
| | **WORLD TOTAL** | **13399516** | **3651284** | **27.2** | **1334380** | **1270556** | **13896** | **226969** | **600326** | **72** | **11242** | **193843** | **537104** | **9211124** |

VS = very suitable, S = suitable, MS = moderately suitable, mS = marginally suitable, NS = not suitable.

30 For the definition of *maximizing technology mix*, see text at beginning of Section 5.4.

**Table 40** **Per capita land in use for cultivation and net rain-fed cultivation potential for cereals, populations of 1995 and projected populations in 2050**

| Region | | Population[31] | | Total land | Land in use for cultivation 1994-96 | | Rain-fed VS+S+MS net potential land (mixed input) | | Rain-fed VS+S net potential land (high input) | | Per capita land use (ha/pers.) | Per capita VS+S+MS land (mixed input) | | Per capita VS+S land (high input) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Name | 1995 | 2050 | (1000 ha) | (1000 ha) | % | (1000 ha) | % | (1000 ha) | % | 1994-96 | 1995 | 2050 | 1995 | 2050 |
| 11 | North America | 296575 | 391692 | 2138498 | 225278 | 10.5 | 364949 | 17.1 | 211189 | 9.9 | 0.8 | 1.2 | 0.9 | 0.7 | 0.5 |
| 21 | Eastern Europe | 162047 | 130639 | 170952 | 81716 | 47.8 | 113295 | 66.3 | 57470 | 33.6 | 0.5 | 0.7 | 0.9 | 0.4 | 0.4 |
| 22 | Northern Europe | 93373 | 90384 | 172524 | 21556 | 12.5 | 40115 | 23.3 | 25782 | 14.9 | 0.2 | 0.4 | 0.4 | 0.3 | 0.3 |
| 23 | Southern Europe | 143352 | 114496 | 131643 | 45632 | 34.7 | 53362 | 40.5 | 16921 | 12.9 | 0.3 | 0.4 | 0.5 | 0.1 | 0.1 |
| 24 | Western Europe | 181377 | 170571 | 109547 | 35143 | 32.1 | 59678 | 54.5 | 33796 | 30.9 | 0.2 | 0.3 | 0.3 | 0.2 | 0.2 |
| 25 | Russian Federation | 148460 | 121256 | 1674146 | 130055 | 7.8 | 214792 | 12.8 | 92659 | 5.5 | 0.9 | 1.5 | 1.8 | 0.6 | 0.8 |
| | | **728609** | **627346** | **2258812** | **314102** | **13.9** | **481242** | **21.3** | **226627** | **10.0** | **0.4** | **0.7** | **0.8** | **0.3** | **0.4** |
| 31 | Caribbean | 35559 | 51518 | 23397 | 7601 | 32.5 | 10555 | 45.1 | 8267 | 35.3 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 |
| 32 | Central America | 123473 | 222502 | 248353 | 35937 | 14.5 | 51738 | 20.8 | 34882 | 14.0 | 0.3 | 0.4 | 0.2 | 0.3 | 0.2 |
| | | **159032** | **274020** | **271750** | **43538** | **16.0** | **62294** | **22.9** | **43149** | **15.9** | **0.3** | **0.4** | **0.2** | **0.3** | **0.2** |
| 41 | South America | 317477 | 534383 | 1777573 | 114787 | 6.5 | 832769 | 46.8 | 702375 | 39.5 | 0.4 | 2.5 | 1.6 | 2.2 | 1.3 |
| 51 | Oceania | 21423 | 31009 | 793540 | 51782 | 6.5 | 108587 | 13.7 | 60614 | 7.6 | 2.4 | 4.9 | 3.5 | 2.8 | 2.0 |
| 52 | Polynesia | 6890 | 14563 | 56118 | 1379 | 2.5 | 16074 | 28.6 | 14817 | 26.4 | 0.2 | 2.2 | 1.1 | 2.2 | 1.0 |
| | | **28313** | **45572** | **849658** | **53161** | **6.3** | **124661** | **14.7** | **75431** | **8.9** | **1.9** | **4.2** | **2.7** | **2.7** | **1.7** |
| 61 | Eastern Africa | 219470 | 593048 | 639474 | 45975 | 7.2 | 249062 | 38.9 | 180736 | 28.3 | 0.2 | 1.1 | 0.4 | 0.8 | 0.3 |
| 62 | Middle Africa | 83271 | 274631 | 657061 | 24772 | 3.8 | 327668 | 49.9 | 276954 | 42.2 | 0.3 | 3.6 | 1.2 | 3.3 | 1.0 |
| 63 | Northern Africa | 157830 | 303173 | 794112 | 44134 | 5.6 | 97933 | 12.3 | 67176 | 8.5 | 0.3 | 0.6 | 0.3 | 0.4 | 0.2 |
| 64 | Southern Africa | 47335 | 65537 | 266428 | 17437 | 6.5 | 30706 | 11.5 | 6460 | 2.4 | 0.4 | 0.7 | 0.5 | 0.1 | 0.1 |
| 65 | Western Africa | 209380 | 526301 | 632996 | 65384 | 10.3 | 175619 | 27.7 | 146120 | 23.1 | 0.3 | 0.8 | 0.3 | 0.7 | 0.3 |
| | | **717286** | **1762690** | **2990071** | **197703** | **6.6** | **880988** | **29.5** | **677446** | **22.7** | **0.3** | **1.2** | **0.5** | **0.9** | **0.4** |
| 71 | Western Asia | 149917 | 357461 | 432992 | 46075 | 10.6 | 32797 | 7.6 | 6214 | 1.4 | 0.3 | 0.2 | 0.1 | 0.0 | 0.0 |
| 81 | Southeast. Asia | 481106 | 784197 | 444483 | 89578 | 20.2 | 150741 | 33.9 | 139284 | 31.3 | 0.2 | 0.3 | 0.2 | 0.3 | 0.2 |
| 82 | South Asia | 1312671 | 2343713 | 671842 | 231647 | 34.5 | 195161 | 29.0 | 170958 | 25.4 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| 84 | East Asia | 1295816 | 1570837 | 1112296 | 139727 | 12.6 | 136331 | 12.3 | 85551 | 7.7 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 85 | Central Asia | 70555 | 104770 | 414363 | 45197 | 10.9 | 14691 | 3.5 | 1157 | 0.3 | 0.6 | 0.2 | 0.1 | 0.0 | 0.0 |
| 86 | Japan | 125068 | 104921 | 37178 | 4379 | 11.8 | 9533 | 25.6 | 5063 | 13.6 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 |
| | | **3285216** | **4908438** | **2680162** | **510528** | **19.0** | **506457** | **18.9** | **402012** | **15.0** | **0.2** | **0.1** | **0.1** | **0.1** | **0.1** |
| | **DEVELOPING** | **4510750** | **7746634** | **8171488** | **909630** | **11.1** | **2321845** | **28.4** | **1840950** | **22.5** | **0.2** | **0.5** | **0.3** | **0.4** | **0.2** |
| | **DEVELOPED** | **1171675** | **1154968** | **5228028** | **465486** | **8.9** | **964310** | **18.4** | **503492** | **9.6** | **0.4** | **0.8** | **0.8** | **0.4** | **0.4** |
| | **WORLD** | **5682425** | **8901602** | **13399516** | **1375116** | **10.3** | **3286156** | **24.5** | **2344442** | **17.5** | **0.2** | **0.6** | **0.4** | **0.4** | **0.3** |

31 Source: Projected data for 2050 from UN medium variant (Unites Nations, 1998).

## 5.5 Where irrigation matters

The results from Global AEZ have been examined to highlight areas where irrigation can make a significant contribution to land productivity. After processing each land unit of the land resources inventory, individual 5-minute latitude/longitude grid-cells were marked according to the potential impact that the application of irrigation has on suitable extents and production of cereals. The grid-cell results were aggregated according to impact classes by regions and countries, using an algorithm proceeding in six steps, as follows:

**Algorithm:**

For each land unit within each 5-minute latitude/longitude grid-cell in the land resources inventory, the algorithm proceeds in 5 steps:

Step 1: Determine the crop (or multiple crop combination) which maximizes expected food grain output under rain-fed conditions;

Step 2: Determine the crop (or multiple crop combination) which maximizes expected food grain output under irrigation conditions;

Step 3: Determine the fraction of land in each 5 minute latitude/longitude grid-cell that is assessed as very suitable or suitable under irrigation (economically viable for irrigation). Test whether the irrigable share exceeds a specified minimum threshold *SHmin*;

Step 4: Combine rain-fed and irrigated production so as to maximize total output in each grid-cell;

Step 5: Determine the ratio of potential cereal output under rain-fed and/or irrigation conditions to cereal potential under rain-fed conditions only, and

Step 6: Aggregate results by country and region into 6 irrigation impact classes according to the following scheme:

1: Areas where rain-fed cereal crops can be cultivated but irrigation is impossible or the irrigable share in a grid-cell is below the specified threshold *SHmin*;

2: The irrigable share in a grid-cell exceeds the minimum threshold *SHmin*; irrigation increases potential cereal output of the respective grid-cell by less than 20 percent above rain-fed levels;

3: As for 2, but contribution of irrigation to grid-cell production potential is 20 - 50 percent;

4: As for 2, but contribution of irrigation to grid-cell production potential is 50 - 100 percent;

5: As for 2, but contribution of irrigation to grid-cell production potential is > 100 percent and

6: No rain-fed production possible and no or too little suitability under irrigation.

By definition, there is no or little contribution from irrigation to the production potential in areas grouped in impact classes 1, 2, and 6. On the other hand, the potential contribution from irrigation is particularly great in impact classes 4 and 5. Both the impact of irrigation on suitable extents and cereal production potential were quantified. Results were compiled for different levels of minimum threshold *SHmin*, namely of 1%, 5%, 10% and 25%. Summaries are available in form of tables and maps.

The analysis provides interesting insights regarding the potential role of irrigation in the various regions:

- Full exploitation of potential irrigable land increases the global gross extent of suitable land (VS+S+MS) for cereals by 6 to 9 percent[32] for the world as a whole over and above the land potentially suitable under rain-fed conditions (see Table 41). Regional results vary substantially, namely between 3 percent (for South America) and 69 percent (for Western Asia).
- The impact of irrigation is more pronounced on potential production than on potential area. The cereal production potential increases by 30 to 40 percent (see Table 41). The

32 Depends on assumptions regarding minimum size of irrigable land tracts considered for irrigation (*SHmin*).

regions with the largest relative increase are Oceania, Northern and Southern Africa, Central and Western Asia.

**Table 41 Potential impact of irrigation on global cereal suitability and production**

| Irrigation threshold *SHmin* | Land with suitability for irrigation: | | Contribution of irrigation to: | |
|---|---|---|---|---|
| | Share in total suitable land (percent) | Share of impact classes 4 and 5 in total irrigable land | Total suitable land (percent) | Potential production (percent) |
| 1 percent | 34.6 | 52.1 | 8.8 | 41.7 |
| 5 percent | 33.2 | 53.3 | 8.4 | 40.0 |
| 10 percent | 31.2 | 54.9 | 7.8 | 37.4 |
| 25 percent | 24.6 | 59.9 | 5.8 | 29.2 |

**Table 42 Rain-fed share in total area suitable for cereals, by impact class**

| **NAME** | **SHARE IN TOTAL SUITABLE AREA** | **SHARE IN IRRIGATION IMPACT CLASS** | | | | |
|---|---|---|---|---|---|---|
| | | **Class1 Rain-fed** | **Class 2 0-20 %** | **Class 3 20-50 %** | **Class 4 50-100 %** | **Class 5 >100 %** |
| North America | 90 | 100 | 99 | 96 | 92 | 43 |
| Eastern Europe | 97 | 100 | 100 | 96 | 80 | 22 |
| Northern Europe | 97 | 100 | 99 | 87 | 63 | -- |
| Southern Europe | 93 | 100 | 99 | 97 | 91 | 61 |
| Western Europe | 98 | 100 | 99 | 95 | 95 | 31 |
| Russian Fed. | 89 | 100 | 99 | 93 | 85 | 14 |
| | 93 | 100 | 99 | 94 | 86 | 20 |
| Caribbean | 96 | 100 | 100 | 96 | 94 | 88 |
| Central America | 91 | 100 | 99 | 96 | 90 | 54 |
| | 92 | 100 | 99 | 96 | 91 | 58 |
| South America | 96 | 100 | 99 | 96 | 93 | 73 |
| Oceania | 67 | 100 | 99 | 99 | 96 | 47 |
| Polynesia | 100 | 100 | 100 | 98 | 100 | 100 |
| | 69 | 100 | 99 | 99 | 96 | 47 |
| Eastern Africa | 95 | 100 | 100 | 99 | 97 | 51 |
| Middle Africa | 98 | 100 | 99 | 95 | 96 | 93 |
| Northern Africa | 79 | 100 | 100 | 95 | 94 | 30 |
| Southern Africa | 77 | 100 | 100 | 99 | 98 | 39 |
| Western Africa | 95 | 100 | 99 | 96 | 95 | 62 |
| | 94 | 100 | 99 | 97 | 96 | 50 |
| Western Asia | 56 | 100 | 100 | 99 | 99 | 15 |
| Southeast. Asia | 97 | 100 | 100 | 95 | 85 | 62 |
| South Asia | 94 | 100 | 100 | 99 | 98 | 74 |
| East Asia | 89 | 100 | 99 | 97 | 96 | 57 |
| Central Asia | 31 | 100 | 99 | 98 | 95 | 14 |
| Japan | 97 | 100 | 95 | 80 | 64 | -- |
| | 91 | 100 | 99 | 97 | 96 | 59 |
| **DEVELOPING** | 94 | 100 | 99 | 97 | 95 | 57 |
| **DEVELOPED** | 89 | 100 | 99 | 95 | 91 | 40 |
| **WORLD TOTAL** | 92 | 100 | 99 | 96 | 94 | 51 |

- In about 17 percent of gross suitable areas for rain-fed and/or irrigation conditions the share of supplementary or full irrigation would increase potential output by more than 50 percent above rain-fed levels. In another 11 percent of these suitable areas, potential output would benefit from irrigation between 20 to 50 percent.
- Overall, application of irrigation has a slightly higher impact in the developed countries than in developing countries, for both increases in extents of arable areas (13 and 7

percent, respectively) and potential output (47 and 38 percent, respectively for developed and developing regions)[33].

**Table 43 Rain-fed share in total potential cereals production, by impact class**

| REGION | SHARE IN TOTAL PRODUCT-ION | SHARE IN IRRIGATION IMPACT CLASS | | | | |
|---|---|---|---|---|---|---|
| | | Class1 Rain-fed | Class 2 0-20 % | Class 3 20-50 % | Class 4 50-100 % | Class 5 >100 % |
| North America | 74 | 100 | 92 | 76 | 58 | 18 |
| Eastern Europe | 88 | 100 | 93 | 74 | 46 | 8 |
| Northern Europe | 92 | 100 | 92 | 77 | 65 | -- |
| Southern Europe | 73 | 100 | 93 | 76 | 53 | 19 |
| Western Europe | 91 | 100 | 93 | 75 | 59 | 11 |
| Russian Fed. | 78 | 100 | 93 | 72 | 46 | 5 |
| | 84 | 100 | 93 | 74 | 48 | 9 |
| Caribbean | 70 | 100 | 88 | 73 | 58 | 38 |
| Central America | 69 | 100 | 89 | 75 | 58 | 24 |
| | 69 | 100 | 89 | 74 | 58 | 26 |
| South America | 80 | 100 | 92 | 77 | 59 | 28 |
| Oceania | 28 | 100 | 91 | 74 | 57 | 14 |
| Polynesia | 97 | 100 | 95 | 78 | 65 | 37 |
| | 31 | 100 | 92 | 74 | 57 | 14 |
| Eastern Africa | 72 | 100 | 88 | 75 | 59 | 16 |
| Middle Africa | 83 | 100 | 89 | 75 | 60 | 37 |
| Northern Africa | 47 | 100 | 88 | 74 | 59 | 9 |
| Southern Africa | 35 | 100 | 87 | 73 | 54 | 12 |
| Western Africa | 73 | 100 | 90 | 76 | 60 | 20 |
| | 70 | 100 | 89 | 75 | 59 | 15 |
| Western Asia | 21 | 100 | 89 | 73 | 56 | 3 |
| Southeast. Asia | 87 | 100 | 92 | 75 | 61 | 47 |
| South Asia | 62 | 100 | 91 | 75 | 59 | 28 |
| East Asia | 76 | 100 | 95 | 75 | 59 | 20 |
| Central Asia | 13 | 100 | 94 | 69 | 48 | 4 |
| Japan | 96 | 100 | 94 | 78 | 64 | -- |
| | 70 | 100 | 93 | 75 | 59 | 23 |
| **DEVELOPING** | 73 | 100 | 91 | 76 | 59 | 21 |
| **DEVELOPED** | 68 | 100 | 92 | 75 | 56 | 14 |
| **WORLD TOTAL** | 71 | 100 | 92 | 75 | 59 | 19 |

The geographical distribution of irrigation impact classes for areas suitable for cereal production is shown in Plate 47.

## 5.6 Best cereal

Another interesting application with results of AEZ concerns the comparison of agronomic suitability among cereals[34] and selection of the cereal type with the highest overall suitability for individual land units of each 5' grid-cell. It is very well possible, for instance, that a certain land unit is very suitable for pearl millet and only moderately suitable for grain maize. Pearl millet would be the crop that is best agronomically suited to that particular environment, while the grain yield of the moderately suitable maize could exceed the yield of the millet. Therefore, also a comparison is presented in terms of food production, using nutritive values and conversion rates as weights. A third option is to compare yields and

33 Calculated taking inverse of relevant entries in column 2 of Table 42 and 43, respectively.

34 Cereals in Global AEZ include: wheat, barley, rye, rice, maize, sorghum, foxtail millet and pearl millet.

production in value terms. Weighting factors for crop selection by output value and nutritive content are the following:

**Value and nutritive weighting factors of cereals used for determining 'best' crop**

| | Unit Value ($/ton) | Calorie content (kcal/100 g) | Protein content (g/kg) | Food conversion rate (%) | Food energy weight | Nutritive weight |
|---|---|---|---|---|---|---|
| WHEAT | 161 | 334 | 122 | 78 | 261 | 299 |
| RICE | 263 | 360 | 67 | 67 | 241 | 259 |
| MAIZE | 142 | 356 | 95 | 92 | 328 | 362 |
| BARLEY | 138 | 337 | 75 | 82 | 276 | 301 |
| SORGHUM | 126 | 343 | 101 | 95 | 326 | 364 |
| RYE | 124 | 319 | 110 | 80 | 255 | 290 |
| MILLET | 125 | 340 | 97 | 95 | 323 | 360 |

Plate 48 in Appendix XV presents a map showing the 'best' cereal in terms of agronomic suitability, Plate 49 shows a map of the 'best' cereal in terms of food energy, and Plate 50 displays the 'best' cereal according to output value, using average 1994-98 world export unit values for comparison.

When selecting among cereal crops on the basis of expected value of output, then wheat, rice and grain maize each dominate in around 30 percent of the total suitable areas. The remaining cereals (barley, rye, sorghum, foxtail millet and pearl millet) together would be chosen in merely 6 percent of the area. In terms of production, grain maize provides the largest share of some 40 percent, followed by wheat and rice, each contributing 28 percent (see Table 44).

The picture changes somewhat when nutritive factors are used for weighting crop production prior to selecting a 'best' crop. In this case, grain-maize takes a somewhat larger share of 42 percent in total suitable area while the share of rice is decreased in comparison to a selection based on price rather than nutrition (from 30 to 22 percent). Results for wheat/barley remain nearly the same. These differences in area distribution are also reflected in the resulting output pattern. Grain-maize accounts for 49 percent of total output when selecting among cereals according to nutritive content, rice contributes 20 percent, wheat and barley together account for 25 percent, and close to 7 percent go to sorghum, rye and millet (see Table 45.).

**Table 44 Distribution of "best" crops when using as selection criterion the crop output value per land unit**

| REGION | GROSS SUIT-ABLE AREA (VS+S+MS) $10^6$ ha | SHARE IN SUITABLE AREA (PERCENT) | | | | POTENTIAL USABLE PRODUCTION $10^6$ tons | SHARE IN POTENTIAL PRODUCTION (PERCENT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | WHEAT, BARLEY | RICE | MAIZE | OTHER CEREALS | | WHEAT, BARLEY | RICE | MAIZE | OTHER CEREALS |
| North America | 280.3 | 81.6 | 0.5 | 17.5 | 0.4 | 847.8 | 79.0 | 0.3 | 20.5 | 0.2 |
| Eastern Europe | 89.0 | 100.0 | 0.0 | 0.0 | 0.0 | 296.1 | 100.0 | 0.0 | 0.0 | 0.0 |
| Northern Europe | 35.9 | 99.7 | 0.0 | 0.0 | 0.3 | 110.6 | 99.9 | 0.0 | 0.0 | 0.1 |
| Southern Europe | 21.1 | 99.3 | 0.4 | 0.1 | 0.2 | 68.1 | 99.5 | 0.3 | 0.1 | 0.1 |
| Western Europe | 47.5 | 99.8 | 0.0 | 0.2 | 0.0 | 171.5 | 99.9 | 0.0 | 0.1 | 0.0 |
| Russian Fed. | 168.9 | 99.7 | 0.0 | 0.1 | 0.2 | 378.4 | 99.7 | 0.0 | 0.2 | 0.1 |
| | 362.5 | 99.8 | 0.0 | 0.1 | 0.1 | 1024.9 | 99.8 | 0.0 | 0.1 | 0.1 |
| Caribbean | 6.6 | 0.0 | 76.2 | 23.8 | 0.0 | 19.2 | 0.0 | 74.3 | 25.6 | 0.0 |
| Central America | 32.6 | 9.4 | 56.4 | 27.9 | 6.3 | 96.9 | 6.8 | 54.8 | 34.7 | 3.8 |
| | 39.2 | 7.8 | 59.7 | 27.2 | 5.2 | 116.1 | 5.6 | 58.0 | 33.2 | 3.1 |
| South America | 527.0 | 7.7 | 64.8 | 24.7 | 2.7 | 1505.3 | 6.2 | 62.1 | 29.6 | 2.1 |
| Oceania | 67.4 | 37.1 | 2.7 | 42.7 | 17.5 | 177.7 | 29.7 | 2.4 | 54.7 | 13.1 |
| Polynesia | 5.0 | 0.0 | 93.3 | 6.5 | 0.2 | 13.5 | 0.0 | 92.2 | 7.7 | 0.1 |
| | 72.3 | 34.6 | 8.9 | 40.2 | 16.3 | 191.2 | 27.6 | 8.7 | 51.4 | 12.2 |
| Eastern Africa | 189.4 | 4.4 | 13.0 | 74.2 | 8.4 | 630.9 | 2.3 | 11.2 | 82.2 | 4.3 |
| Middle Africa | 200.2 | 0.3 | 58.2 | 37.7 | 3.8 | 612.2 | 0.1 | 51.9 | 45.7 | 2.2 |
| Northern Africa | 76.5 | 5.6 | 8.6 | 70.4 | 15.4 | 269.9 | 2.8 | 7.1 | 82.4 | 7.7 |
| Southern Africa | 8.7 | 9.8 | 0.0 | 55.7 | 34.5 | 19.1 | 6.8 | 0.0 | 69.1 | 24.1 |
| Western Africa | 143.8 | 0.0 | 26.4 | 56.0 | 17.7 | 453.3 | 0.0 | 22.7 | 67.4 | 9.9 |
| | 618.6 | 2.3 | 30.0 | 57.4 | 10.3 | 1985.5 | 1.2 | 25.7 | 67.5 | 5.6 |
| Western Asia | 10.5 | 100.0 | 0.0 | 0.0 | 0.0 | 24.2 | 100.0 | 0.0 | 0.0 | 0.0 |
| Southeast. Asia | 87.2 | 2.5 | 85.4 | 11.8 | 0.3 | 244.4 | 1.0 | 86.2 | 12.5 | 0.2 |
| South Asia | 184.8 | 0.8 | 15.9 | 68.3 | 14.9 | 613.3 | 0.5 | 14.5 | 73.8 | 11.3 |
| East Asia | 113.0 | 10.8 | 21.0 | 51.0 | 17.2 | 298.9 | 9.9 | 21.8 | 59.6 | 8.6 |
| Central Asia | 6.0 | 98.9 | 1.1 | 0.0 | 0.0 | 10.7 | 98.7 | 1.3 | 0.0 | 0.0 |
| Japan | 6.6 | 60.7 | 36.5 | 2.8 | 0.0 | 22.4 | 65.3 | 32.1 | 2.5 | 0.0 |
| | 397.6 | 6.5 | 32.7 | 48.9 | 11.9 | 1189.8 | 5.1 | 31.3 | 55.6 | 8.0 |
| **DEVELOPING** | 1591.3 | 5.6 | 42.9 | 43.4 | 8.0 | 4811.9 | 4.0 | 39.3 | 51.7 | 5.0 |
| **DEVELOPED** | 716.7 | 86.4 | 0.8 | 10.9 | 1.9 | 2072.7 | 84.9 | 0.7 | 13.1 | 1.2 |
| **WORLD TOTAL** | 2308.0 | 30.7 | 29.8 | 33.3 | 6.1 | 6884.7 | 28.4 | 27.7 | 40.1 | 3.9 |

**Table 45 Distribution of "best" crops when using nutritive values as weights in crop selection**

| REGION | GROSS SUIT-ABLE AREA (VS+S+MS) $10^6$ ha | SHARE IN SUITABLE AREA (PERCENT) | | | | POTENTIAL USABLE PRODUCTION $10^6$ tons | SHARE IN POTENTIAL PRODUCTION (PERCENT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | WHEAT, BARLEY | RICE | MAIZE | OTHER CEREALS | | WHEAT, BARLEY | RICE | MAIZE | OTHER CEREALS |
| North America | 278.2 | 66.1 | 0.3 | 31.5 | 2.1 | 839.3 | 64.1 | 0.2 | 34.5 | 1.2 |
| Eastern Europe | 89.0 | 99.5 | 0.0 | 0.5 | 0.0 | 296.0 | 99.4 | 0.0 | 0.6 | 0.0 |
| Northern Europe | 36.0 | 99.2 | 0.0 | 0.0 | 0.8 | 110.8 | 99.7 | 0.0 | 0.0 | 0.3 |
| Southern Europe | 21.2 | 89.3 | 0.0 | 10.5 | 0.2 | 68.0 | 86.8 | 0.0 | 13.2 | 0.1 |
| Western Europe | 47.6 | 99.6 | 0.0 | 0.3 | 0.1 | 171.7 | 99.7 | 0.0 | 0.3 | 0.1 |
| Russian Fed. | 171.1 | 97.8 | 0.0 | 1.8 | 0.3 | 380.0 | 97.9 | 0.0 | 1.9 | 0.2 |
| | 364.9 | 98.1 | 0.0 | 1.6 | 0.3 | 1026.4 | 98.1 | 0.0 | 1.8 | 0.1 |
| Caribbean | 5.7 | 0.0 | 44.6 | 55.3 | 0.0 | 17.9 | 0.0 | 42.0 | 57.9 | 0.0 |
| Central America | 30.3 | 7.3 | 42.3 | 42.6 | 7.9 | 93.7 | 4.8 | 41.3 | 49.0 | 4.9 |
| | 36.0 | 6.1 | 42.7 | 44.6 | 6.7 | 111.6 | 4.0 | 41.4 | 50.5 | 4.1 |
| South America | 515.2 | 4.2 | 58.0 | 32.6 | 5.2 | 1493.1 | 3.0 | 55.4 | 37.3 | 4.2 |
| Oceania | 66.9 | 33.7 | 0.4 | 39.7 | 26.2 | 179.5 | 26.3 | 0.3 | 51.5 | 21.9 |
| Polynesia | 4.7 | 0.0 | 92.0 | 6.9 | 1.2 | 13.0 | 0.0 | 90.8 | 7.8 | 1.4 |
| | 71.5 | 31.5 | 6.4 | 37.5 | 24.6 | 192.4 | 24.6 | 6.4 | 48.5 | 20.5 |
| Eastern Africa | 188.5 | 3.2 | 3.7 | 79.6 | 13.6 | 650.7 | 1.6 | 3.2 | 86.7 | 8.5 |
| Middle Africa | 195.8 | 0.2 | 47.0 | 46.7 | 6.1 | 618.2 | 0.1 | 40.4 | 55.3 | 4.2 |
| Northern Africa | 77.1 | 5.7 | 1.4 | 73.9 | 19.0 | 277.2 | 2.8 | 1.2 | 85.6 | 10.4 |
| Southern Africa | 8.8 | 6.9 | 0.0 | 43.7 | 49.4 | 19.5 | 4.7 | 0.0 | 55.1 | 40.3 |
| Western Africa | 140.2 | 0.0 | 15.2 | 62.8 | 22.0 | 456.0 | 0.0 | 13.3 | 73.4 | 13.4 |
| | 610.3 | 1.9 | 19.9 | 63.9 | 14.3 | 2021.6 | 1.0 | 16.5 | 73.7 | 8.8 |
| Western Asia | 10.5 | 100.0 | 0.0 | 0.0 | 0.0 | 24.1 | 100.0 | 0.0 | 0.0 | 0.0 |
| Southeast. Asia | 81.9 | 2.4 | 55.1 | 42.0 | 0.6 | 240.3 | 0.9 | 53.0 | 45.7 | 0.4 |
| South Asia | 185.1 | 0.7 | 5.2 | 71.9 | 22.2 | 638.5 | 0.4 | 5.0 | 77.6 | 17.0 |
| East Asia | 112.2 | 2.9 | 1.2 | 72.2 | 23.7 | 314.0 | 2.4 | 1.2 | 83.1 | 13.4 |
| Central Asia | 5.9 | 94.6 | 0.8 | 4.6 | 0.0 | 10.6 | 90.6 | 1.0 | 8.4 | 0.0 |
| Japan | 6.5 | 32.7 | 1.9 | 65.3 | 0.0 | 24.5 | 32.4 | 1.3 | 66.2 | 0.0 |
| | 391.7 | 3.6 | 14.4 | 64.6 | 17.4 | 1227.9 | 2.4 | 13.3 | 71.9 | 12.4 |
| **DEVELOPING** | 1561.9 | 3.7 | 31.7 | 52.7 | 11.8 | 4866.7 | 2.4 | 28.4 | 61.0 | 8.2 |
| **DEVELOPED** | 716.5 | 79.1 | 0.2 | 17.4 | 3.4 | 2069.7 | 77.3 | 0.1 | 20.1 | 2.5 |
| **WORLD TOTAL** | 2278.4 | 27.4 | 21.8 | 41.6 | 9.2 | 6936.4 | 24.7 | 20.0 | 48.8 | 6.5 |

## 5.7 Multiple cropping land productivity

A multiple cropping zones classification (see Section 4.7) is used to determine feasible crop combinations (sequential cropping patterns) in each 5-minute latitude/longitude grid-cell of the land resources inventory.

In our calculations, only those crops qualify which are individually suitable and which can be combined within the available growing period (LGP for rain-fed conditions, or $LGP_{t=5}$ for irrigated conditions). Dryland crops are allowed to overlap partly (relay cropping with less than 30% overlap). Zones where relay cropping is required for double or triple cropping are referred to as ‘limited’ double (C) or ‘limited’ triple cropping (F) zones. It is assumed that relay cropping is not applicable to wetland-wetland or wetland-dryland crop combinations. An example of results of an assessment of land production potential of cereals by multiple cropping zones is presented in Table 46. This table is complemented by Plates 53 and 54, which present maps showing the global distribution of the land production potential of cereals, under rain-fed and rain-fed plus irrigated conditions.

The selection of an optimal cereal crop combination can be described as the task of matching the requirements of the suitable crop types with the characteristics of a particular grid-cell in such a way that a maximum grain production can be achieved. The AEZ algorithm uses a scheme of eight generic crop groups, based on a distinction of crop growth cycle length and thermal requirements, to determine feasible (within-year) sequential multi-cropping patterns. Each crop LUT belongs to one of these eight groups.

In the case of a single-cropping zone the selection of the best grain is easy. The algorithm compares the grid-cell characteristics with the requirements of all cereal LUTs. Among those grains that fit, the algorithm selects the one producing the highest potential production. In the case of multi-cropping the selection is more difficult. The algorithm cannot practically test all possible combinations of the 83 available crop types - this would multiply the time needed for the calculations. Instead, only those crops are tested as a second or third grain, that have the highest yield in each of the eight generic groups. The rules for constructing cropping patterns have been designed to make sure that the algorithm uses typical crop sequences in cultivation cycles. For instance, in the typical double-cropping areas around Shanghai, the algorithm would select a long-cycle rice or maize crop as the most productive summer crop, and winter wheat or barley (depending on which is more productive) as the winter crop, provided the combination of both grains fits within the LGP of the particular grid-cell. In a triple-cropping zone either three short-cycle crops or two long-cycle crops are permitted.

The results in Table 46 are shown as percentage distributions over eight multiple cropping zones, both for suitable land (VS+S+MS) and attainable production from these areas. According to our estimation from an example calculation for cereals, 46 percent of the land globally suitable for rain-fed cereals falls in zone B (i.e., single cropping) providing 42 percent of the cereal production potential. Some 39 percent of the suitable area could produce two crops per year (zones C, D, E) contributing 38 percent of the global cereal production potential. The remaining 15 percent of suitable areas could support three crops per annum (zones F, G, H) and produce almost 20 percent of the global cereal production potential.

**Table 46** **Gross area and production potential for cereals at intermediate input level, by multiple cropping zones and major world region**

| Region | Total land area ($10^6$ ha) | Land with cultivation potential VS+S+MS ($10^6$ ha) | Multiple cropping production ($10^6$ tons) | Zone A Area (%) | Zone A Prod. (%) | Zone B Area (%) | Zone B Prod. (%) | Zone C Area (%) | Zone C Prod. (%) | Zone D Area (%) | Zone D Prod. (%) | Zone E Area (%) | Zone E Prod. (%) | Zone F Area (%) | Zone F Prod. (%) | Zone G Area (%) | Zone G Prod. (%) | Zone H Area (%) | Zone H Prod. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Share of total suitable area and multiple cropping production potential for cereals at intermediate input level | | | | | | | | | | | | | | | | | |
| North America | 2138.5 | 296.7 | 1266.3 | 0.0 | 0.0 | 37.9 | 26.1 | 18.8 | 19.0 | 13.7 | 14.5 | 10.1 | 12.5 | 6.2 | 8.3 | 11.3 | 16.5 | 1.9 | 3.2 |
| Eastern Europe | 171.0 | 105.0 | 433.0 | 0.0 | 0.0 | 95.0 | 94.8 | 5.0 | 5.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Northern Europe | 172.5 | 36.2 | 133.7 | 0.0 | 0.0 | 100.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Southern Europe | 131.6 | 36.2 | 132.4 | 0.0 | 0.0 | 73.2 | 67.9 | 23.1 | 27.5 | 3.7 | 4.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Western Europe | 109.5 | 57.0 | 247.8 | 0.0 | 0.0 | 97.4 | 97.6 | 2.5 | 2.2 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Russian Federation | 1674.1 | 187.7 | 547.1 | 0.0 | 0.0 | 98.8 | 98.2 | 1.1 | 1.6 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Caribbean | 23.4 | 8.8 | 26.8 | 0.0 | 0.0 | 0.2 | 0.1 | 0.6 | 0.9 | 70.7 | 68.6 | 0.0 | 0.0 | 22.1 | 20.5 | 0.0 | 0.0 | 6.4 | 8.5 |
| Central America | 248.4 | 38.8 | 126.7 | 0.0 | 0.0 | 39.5 | 32.9 | 8.3 | 10.0 | 32.6 | 34.8 | 0.0 | 0.0 | 16.6 | 17.3 | 0.0 | 0.0 | 3.0 | 4.7 |
| South America | 1777.8 | 558.4 | 2055.0 | 0.0 | 0.0 | 9.7 | 7.5 | 7.0 | 6.5 | 46.1 | 38.5 | 2.0 | 2.7 | 17.6 | 16.8 | 5.9 | 10.8 | 11.7 | 16.7 |
| Oceania | 793.5 | 84.0 | 246.0 | 0.0 | 0.0 | 78.3 | 68.3 | 7.0 | 7.7 | 4.8 | 6.5 | 4.5 | 6.7 | 2.1 | 3.9 | 3.3 | 6.8 | 0.0 | 0.0 |
| Polynesia | 56.1 | 2.7 | 9.2 | 0.0 | 0.0 | 0.0 | 0.0 | 6.2 | 7.1 | 56.4 | 55.2 | 0.0 | 0.0 | 13.1 | 13.1 | 0.0 | 0.0 | 24.3 | 23.9 |
| Eastern Africa | 639.5 | 209.4 | 734.2 | 0.0 | 0.0 | 49.1 | 49.3 | 27.1 | 29.8 | 21.4 | 18.8 | 0.0 | 0.0 | 1.6 | 1.0 | 0.0 | 0.0 | 0.9 | 0.8 |
| Middle Africa | 657.1 | 213.9 | 623.0 | 0.0 | 0.0 | 20.9 | 24.9 | 9.9 | 12.7 | 46.7 | 42.0 | 0.0 | 0.0 | 16.0 | 13.2 | 0.0 | 0.0 | 6.6 | 6.7 |
| Northern Africa | 794.1 | 69.3 | 235.8 | 0.1 | 0.1 | 62.2 | 60.5 | 18.5 | 24.3 | 19.3 | 14.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Southern Africa | 266.4 | 23.9 | 60.3 | 0.0 | 0.1 | 74.6 | 65.1 | 17.4 | 19.6 | 3.4 | 4.9 | 2.2 | 4.5 | 0.9 | 1.4 | 1.1 | 3.1 | 0.3 | 1.2 |
| Western Africa | 633.0 | 161.4 | 484.6 | 0.0 | 0.0 | 46.6 | 48.7 | 13.6 | 18.0 | 32.0 | 27.0 | 0.0 | 0.0 | 7.7 | 6.1 | 0.0 | 0.0 | 0.1 | 0.1 |
| Western Asia | 433.0 | 22.1 | 65.1 | 0.0 | 0.0 | 98.2 | 97.8 | 1.8 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Southeast. Asia | 444.5 | 73.4 | 233.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 2.1 | 81.7 | 77.9 | 0.9 | 1.1 | 6.7 | 6.7 | 0.0 | 0.1 | 8.9 | 11.5 |
| South Asia | 671.8 | 158.6 | 605.4 | 0.0 | 0.0 | 73.3 | 70.6 | 13.1 | 15.2 | 10.0 | 9.3 | 2.4 | 3.1 | 0.6 | 0.6 | 0.3 | 0.4 | 0.4 | 0.5 |
| East Asia | 1112.3 | 93.8 | 366.5 | 0.0 | 0.0 | 45.5 | 28.6 | 11.8 | 9.6 | 6.2 | 5.7 | 12.7 | 19.8 | 12.2 | 17.2 | 8.3 | 13.5 | 3.3 | 5.5 |
| Central Asia | 414.4 | 10.1 | 28.7 | 4.2 | 4.0 | 91.3 | 89.6 | 2.5 | 4.0 | 1.8 | 2.3 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Japan | 37.2 | 8.1 | 34.0 | 0.0 | 0.0 | 51.2 | 47.2 | 17.7 | 17.7 | 21.7 | 24.7 | 9.4 | 10.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| **DEVELOPING** | **8171.5** | **1644.6** | **5654.3** | **0.0** | **0.0** | **33.0** | **31.0** | **11.7** | **13.0** | **34.7** | **29.8** | **1.7** | **2.7** | **10.6** | **10.2** | **2.5** | **4.9** | **5.7** | **8.0** |
| **DEVELOPED** | **5228.0** | **810.9** | **3039.7** | **0.0** | **0.0** | **72.2** | **63.4** | **9.9** | **11.1** | **5.9** | **7.1** | **4.2** | **5.9** | **2.5** | **3.8** | **4.5** | **7.4** | **0.7** | **1.3** |
| **WORLD TOTAL** | **13399.5** | **2455.4** | **8694.0** | **0.0** | **0.0** | **46.0** | **42.3** | **11.1** | **12.4** | **25.2** | **21.9** | **2.5** | **3.8** | **7.9** | **7.9** | **3.2** | **5.8** | **4.1** | **5.7** |

**A.** *Zone of no cropping* (on average, too cold or too dry for rain-fed crops)
**B.** *Zone of single cropping*
**C.** *Zone of limited double cropping* (relay cropping; single wetland rice may be possible)
**D.** *Zone of double cropping* (sequential cropping; wetland rice not possible)
**E.** *Zone of double cropping* (sequential cropping; one wetland rice crop possible)
**F.** *Zone of limited triple cropping* (partly relay cropping; no third crop possible in case of two wetland rice crops)
**G.** *Zone of triple cropping* (sequential cropping of three short-cycle crops; two wetland rice crops possible)
**H.** *Zone of triple rice cropping* (sequential cropping of three wetland rice crops possible)

## 5.8 Current land cover

Presently some 1.5 billion hectares of land is used for agriculture (average over years 1994-96 according to FAOSTAT). Comparison of potentially arable land with presently used land requires that within the potential arable land non-agricultural land uses are accounted for. Land needed for infrastructure and human settlement along with land set aside for, e.g. forest ecosystems in natural reserves, must be excluded, or at least must be accounted for separately.

**Table 47 Distribution of aggregate land cover classes by world region**

| Region | Aggregate land cover classes* (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (i) | (ii) | (iii) | (iv) | (v) | (vi) | (vii) | (viii) | (ix) | (x) | (xi) | (xii) |
| North America | 6.3 | 11.1 | 26.3 | 7.6 | 4.0 | 2.6 | 1.0 | 8.5 | 6.8 | 25.2 | 0.4 | 0.1 |
| Eastern Europe | 0.5 | 2.1 | 9.9 | 32.2 | 51.6 | 0.1 | 0.0 | 0.0 | 2.1 | 0.0 | 1.4 | 0.0 |
| Northern Europe | 1.5 | 10.8 | 41.3 | 12.6 | 14.4 | 0.1 | 0.7 | 0.4 | 11.2 | 6.2 | 0.8 | 0.0 |
| Southern Europe | 0.6 | 14.1 | 19.8 | 21.8 | 35.6 | 0.6 | 0.0 | 2.9 | 4.0 | 0.3 | 0.3 | 0.0 |
| Western Europe | 0.6 | 6.2 | 13.5 | 6.0 | 68.8 | 0.2 | 0.1 | 0.2 | 2.5 | 0.7 | 1.3 | 0.0 |
| Russian Federation | 4.0 | 24.6 | 38.3 | 5.8 | 8.7 | 0.3 | 3.4 | 0.4 | 3.6 | 10.6 | 0.2 | 0.0 |
| Caribbean | 8.8 | 12.8 | 26.3 | 0.6 | 32.3 | 0.0 | 6.6 | 0.3 | 11.6 | 0.1 | 0.4 | 0.0 |
| Central America | 14.3 | 15.6 | 29.8 | 7.2 | 12.1 | 0.8 | 0.1 | 17.5 | 2.6 | 0.0 | 0.1 | 0.0 |
| South America | 13.3 | 15.4 | 39.2 | 14.8 | 3.4 | 2.9 | 0.3 | 5.6 | 2.9 | 2.0 | 0.1 | 0.0 |
| Oceania | 27.0 | 33.5 | 4.8 | 0.0 | 6.4 | 0.0 | 0.0 | 26.1 | 2.1 | 0.0 | 0.1 | 0.0 |
| Polynesia | 14.7 | 5.0 | 59.9 | 5.2 | 3.1 | 1.0 | 0.0 | 0.0 | 8.3 | 0.0 | 0.0 | 2.8 |
| Eastern Africa | 25.8 | 23.5 | 5.1 | 10.5 | 15.4 | 0.0 | 0.0 | 15.9 | 3.7 | 0.0 | 0.0 | 0.0 |
| Middle Africa | 15.5 | 31.7 | 29.3 | 4.8 | 5.2 | 0.0 | 0.1 | 11.6 | 1.9 | 0.0 | 0.0 | 0.0 |
| Northern Africa | 9.7 | 8.3 | 0.6 | 1.4 | 0.9 | 0.2 | 0.3 | 78.1 | 0.4 | 0.0 | 0.0 | 0.0 |
| Southern Africa | 38.4 | 0.6 | 1.6 | 17.8 | 7.2 | 0.0 | 0.1 | 33.9 | 0.3 | 0.0 | 0.1 | 0.0 |
| Western Africa | 25.4 | 16.3 | 2.1 | 6.1 | 2.3 | 0.1 | 0.5 | 46.0 | 1.2 | 0.0 | 0.0 | 0.0 |
| Western Asia | 5.2 | 0.5 | 1.8 | 6.5 | 5.8 | 0.3 | 0.0 | 78.5 | 1.2 | 0.1 | 0.1 | 0.0 |
| Southeast. Asia | 3.8 | 3.0 | 51.3 | 10.7 | 9.1 | 17.6 | 0.0 | 0.1 | 4.0 | 0.0 | 0.2 | 0.0 |
| South Asia | 7.3 | 4.5 | 5.9 | 8.1 | 21.1 | 12.0 | 0.1 | 37.8 | 1.5 | 1.5 | 0.1 | 0.0 |
| East Asia | 25.1 | 6.9 | 10.0 | 8.2 | 6.7 | 9.6 | 0.0 | 30.9 | 1.8 | 0.8 | 0.1 | 0.0 |
| Central Asia | 33.2 | 1.7 | 2.2 | 14.3 | 9.0 | 2.1 | 0.0 | 32.1 | 3.7 | 1.4 | 0.2 | 0.0 |
| Japan | 3.9 | 12.5 | 55.5 | 7.7 | 2.9 | 8.4 | 1.1 | 0.3 | 6.5 | 0.0 | 1.2 | 0.0 |
| **DEVELOPING** | 17.1 | 11.9 | 17.8 | 9.3 | 7.2 | 4.1 | 0.2 | 29.3 | 2.2 | 0.7 | 0.1 | 0.0 |
| **DEVELOPED** | 8.1 | 18.5 | 26.6 | 7.1 | 9.9 | 1.3 | 1.6 | 7.7 | 4.9 | 13.9 | 0.4 | 0.0 |
| **WORLD TOTAL** | 13.6 | 14.5 | 21.2 | 8.5 | 8.3 | 3.0 | 0.7 | 20.9 | 3.3 | 5.9 | 0.2 | 0.0 |

***** *(i) Grassland*
*(ii) Woodland*
*(iii) Forest*
*(iv) Mosaics including cropland*
*(v) Cropland 1*
*(vi) Cropland 2*
*(vii) Wetland*
*(viii) Desert and barren land*
*(ix) Water (coastal fringes)*
*(x) Ice, cold desert*
*(xi) Urban*
*(xii) Undefined*

In the Global AEZ assessment we have used an aggregate ecosystems data set derived from a Global Land Cover Characteristics (GLCC) Database[35] with 30 arc-seconds latitude/longitude resolution (EROS Data Center, 2000). The GLCC database provides interpretations of 1-km AVHRR data (obtained during April 1992 through March 1993) according to various legends. We applied the Olson Global Ecosystem classification (Olson, 1994). This classification distinguishes about 100 ecosystem classes (not all classes are present in the data set), which were aggregated into broad ecosystem classes (see Plate 55)

[35] The data set was compiled from remotely-sensed multi-temporal AVHRR data of 1992/93 by the US Geological Survey (USGS) Earth Resources Observation System (EROS) Data Centre, the University of Nebraska-Lincoln (UNL), and the Joint Research Centre (JRC) of the European Commission.

for use with Global AEZ results. The distribution of these aggregate land-cover classes by major world region is presented in Table 47.

**Table 48 Land under forest ecosystems with potential for rain-fed cultivation of major cereals**[36]

| **Region** | **Total of forest ecosystems** (mill. ha) | **VS+S for wheat, rice, maize (high input)** Total (mill. ha) | **Under forest ecosystems** Extent (mill. ha) | % of forest | % of suitable | **VS+S+MS for wheat, rice, maize (mixed inputs)** Total (mill. ha) | **Under forest ecosystems** Extent (mill. ha) | % of forest | % of suitable |
|---|---|---|---|---|---|---|---|---|---|
| North America | 562.1 | 192.9 | 64.9 | 11.6 | 33.7 | 342.0 | 114.8 | 20.4 | 33.6 |
| Eastern Europe | 17.0 | 57.8 | 0.9 | 5.3 | 1.6 | 110.9 | 3.9 | 23.2 | 3.6 |
| Northern Europe | 63.6 | 24.0 | 2.7 | 4.2 | 11.2 | 38.2 | 8.2 | 12.9 | 21.4 |
| Southern Europe | 23.9 | 14.0 | 0.8 | 3.4 | 5.9 | 43.6 | 3.5 | 14.4 | 7.9 |
| Western Europe | 14.3 | 35.4 | 0.5 | 3.4 | 1.4 | 58.9 | 2.1 | 14.4 | 3.5 |
| Russian Federation | 641.7 | 74.2 | 22.2 | 3.5 | 29.9 | 211.5 | 57.5 | 9.0 | 27.2 |
| | 760.5 | 205.4 | 27.1 | 3.6 | 13.2 | 463.2 | 75.2 | 9.9 | 16.2 |
| Caribbean | 3.8 | 4.2 | 0.3 | 8.7 | 7.9 | 7.3 | 0.6 | 16.3 | 8.6 |
| Central America | 66.4 | 22.0 | 4.7 | 7.0 | 21.2 | 39.1 | 9.4 | 14.2 | 24.1 |
| | 70.2 | 26.2 | 5.0 | 7.1 | 19.0 | 46.4 | 10.0 | 14.3 | 21.6 |
| South America | 680.5 | 314.0 | 103.8 | 15.2 | 33.0 | 528.3 | 186.6 | 27.4 | 35.3 |
| Oceania | 38.1 | 33.5 | 4.1 | 10.9 | 12.4 | 70.2 | 10.5 | 27.6 | 15.0 |
| Polynesia | 33.6 | 2.3 | 0.3 | 1.0 | 14.8 | 2.9 | 0.6 | 1.8 | 20.5 |
| | 71.7 | 35.8 | 4.5 | 6.2 | 12.5 | 73.1 | 11.1 | 15.5 | 15.2 |
| Eastern Africa | 32.8 | 118.8 | 2.4 | 7.2 | 2.0 | 196.2 | 5.4 | 16.4 | 2.7 |
| Middle Africa | 190.2 | 112.2 | 17.0 | 9.0 | 15.2 | 183.4 | 33.8 | 17.8 | 18.4 |
| Northern Africa | 4.9 | 52.7 | 0.4 | 7.7 | 0.7 | 74.0 | 0.5 | 10.8 | 0.7 |
| Southern Africa | 4.2 | 2.7 | 0.0 | 0.7 | 1.1 | 15.6 | 0.5 | 12.1 | 3.2 |
| Western Africa | 13.5 | 82.1 | 1.0 | 7.6 | 1.3 | 123.3 | 2.1 | 15.8 | 1.7 |
| | 245.6 | 368.5 | 20.8 | 8.5 | 5.6 | 592.5 | 42.4 | 17.3 | 7.2 |
| Western Asia | 7.6 | 4.0 | 0.1 | 1.0 | 1.9 | 28.6 | 1.0 | 13.1 | 3.5 |
| Southeast. Asia | 207.4 | 54.0 | 6.2 | 3.0 | 11.5 | 71.8 | 10.5 | 5.1 | 14.7 |
| South Asia | 39.6 | 116.7 | 2.1 | 5.3 | 1.8 | 153.9 | 3.4 | 8.6 | 2.2 |
| East Asia | 111.7 | 57.9 | 1.7 | 1.5 | 2.9 | 108.1 | 5.7 | 5.1 | 5.3 |
| Central Asia | 8.7 | 1.1 | 0.2 | 2.1 | 16.6 | 11.9 | 0.7 | 8.3 | 6.0 |
| Japan | 20.6 | 4.8 | 0.6 | 3.1 | 13.4 | 9.2 | 2.3 | 11.3 | 25.3 |
| | 388.0 | 234.5 | 10.8 | 2.8 | 4.6 | 354.9 | 22.7 | 5.9 | 6.4 |
| **DEVELOPING** | 1404.8 | 944.6 | 140.1 | 10.0 | 14.8 | 1544.3 | 261.0 | 18.6 | 16.9 |
| **DEVELOPED** | 1381.4 | 436.7 | 96.8 | 7.0 | 22.2 | 884.6 | 202.8 | 14.7 | 22.9 |
| **WORLD TOTAL** | 2786.1 | 1381.3 | 236.9 | 8.5 | 17.2 | 2428.9 | 463.8 | 16.6 | 19.1 |

As an example of combining AEZ results with spatial land-cover information, the extent of land with cultivation potential presently under forest ecosystems was estimated by overlaying the current land cover according to the GLCC database onto land with rain-fed cultivation potential. This revealed that some 464 million hectares of land with cultivation potential (VS, S, or MS) for wheat, rice, or grain-maize coincides with land dominantly classified as forest ecosystem. Around 8.5 percent, i.e., about 237 million hectares, of the area classified as forest ecosystems was assessed as very suitable or suitable (VS+S) for cultivation of these crops at high level of inputs. On the other hand, the analysis shows that globally almost 85

36 In some countries the extents of forest ecosystems derived from the GLCC exceed the area of forest and woodland published by FAO. In such cases, the estimates of suitable areas under forest ecosystems were adjusted proportionally. Suitable extents are also adjusted for housing and infrastructure land requirements using a spatially explicit gridded global 1995 population distribution database (CIESIN, 2000).

percent of forest ecosystems are considered not or at best marginally suitable for these major cereal crops.

Table 48, presenting regional and global extents of land with cereal crop cultivation potential under GLCC forest ecosystems, shows rather wide variations among regions. In the Russian Federation, for example, only 9 percent of the land with forest ecosystems are adjudged having cultivation potential for one or more of the three major cereals, while in South America this share is as high as 27 percent. Only 3.5 percent of forest ecosystems in Russia is considered to be very suitable or suitable (VS+S) for the three cereal crops; in South America the respective value is 15 percent.

Also, we have estimated as to how important the land with cereal cultivation potential covered by forest ecosystems is within the overall potential. Our estimation suggests that close to 19 percent of the land with cultivation potential (VS+S+MS) is under forest ecosystems (i.e., 464 million hectares out of a total with cultivation potential of 2.43 thousand million hectares). A similar share, 17 percent (i.e., 237 million ha out of 1.38 thousand million ha), holds for very suitable and suitable lands. On a regional scale, the largest shares of land with crop production potential currently under forest are found in South and North America where more than one third of the potentially cultivable land determined by AEZ is classified as dominantly forest ecosystems according to GLCC. Considerable potentials with forest land cover were also assessed in the sub-humid and humid zones of Central America and Middle Africa. Our results indicate that relatively more land with cultivation potential for major cereals is covered by forest ecosystems in developed countries (about 23 percent) than in developing countries (about 17 percent).

## 5.9 Climate sensitivity

Our experiences with various climate sensitivity scenarios and preliminary results with GCM based climate scenarios underpin the appropriateness of the AEZ methods for climate change impact assessments. It confirms findings of earlier work with AEZ applications in case studies of Kenya (Fischer and van Velthuizen, 1996) and Nigeria (Voortman *et al.*, 1999), demonstrating that AEZ is very flexible in capturing all three types of impacts, namely on yields, on extents suitable for crop cultivation, and on changes in number of crops per year (sequential multi-cropping). It thus accounts for a wide range of rational adaptations, i.e., simulating impacts to ‘smart’ farmers. Recently, a number of experiments with GCM derived climate change scenarios were completed. A detailed report with results of these simulations on AEZ crop suitability and productivity is in preparation (Fischer and van Velthuizen, forthcoming).

Meanwhile, in order to demonstrate possible effects of climate change on potential distribution patterns of some key crops, a limited set of temperature and rainfall sensitivity scenarios were applied as follows:

- Respectively $1^oC$, $2^oC$, and $3^oC$ temperature increase uniformly in each month for both minimum and maximum temperatures, and
- Uniformly distributed combined increases of temperature and precipitation of respectively $1^oC$ and +5% monthly precipitation, temperature increase of $2^oC$ and +5% monthly precipitation, $2^oC$ warming combined with +10% change of annual precipitation, and $3^oC$ warming combined with +10% change of annual rainfall distributed proportionally over the twelve months.

Plate 58 presents four small-scale maps of the potential distribution of rain-fed wheat under respectively current climate, +1°C annual temperature, +2°C combined with +5% annual rainfall, and +3°C combined with +10% annual rainfall. The maps show considerable shifts of the potential distribution even when modest changes of temperature or rainfall are applied. Table 49 presents changes in extents of land very suitable, suitable, and moderately suitable for rain-fed wheat. simulated for the selected temperature and rainfall sensitivity scenarios. Table 47 extends the analysis to the three key cereal crops, i.e., wheat, rice and grain-maize.

**Table 49 Impact of temperature and rainfall sensitivity tests on crop suitability, expressed as VS+S+MS extents for rain-fed wheat cultivation (% change relative to current climate)**

| Region | Temperature Increase | | | Temperature Increase, Rainfall Change | | | |
|---|---|---|---|---|---|---|---|
| | +1°C | +2°C | +3°C | +1°C, +5% | +2°C, +5% | +2°C, +10% | +3°C, +10% |
| North America | 10.9 | 14.6 | 18.1 | 14.6 | 18.8 | 21.3 | 25.4 |
| Eastern Europe | 4.1 | 0.1 | -5.5 | 8.0 | 3.4 | 7.5 | 2.9 |
| Northern Europe | 10.7 | 10.8 | 11.4 | 11.8 | 11.9 | 11.1 | 12.3 |
| Southern Europe | 5.7 | 8.5 | 9.4 | 9.6 | 12.3 | 16.4 | 17.2 |
| Western Europe | 0.2 | -3.1 | -5.6 | 0.1 | -2.7 | -3.2 | -7.1 |
| Russian Federation | 21.4 | 31.1 | 39.2 | 25.5 | 36.1 | 40.5 | 48.6 |
| | **12.2** | **15.5** | **17.7** | **15.4** | **19.1** | **22.3** | **24.5** |
| Caribbean | -57.9 | 94.7 | 57.9 | -68.4 | 26.3 | 15.8 | -57.9 |
| Central America | -9.3 | -39.7 | -65.5 | -9.0 | -36.9 | -29.8 | -60.7 |
| | **-9.4** | **-39.4** | **-65.3** | **-9.1** | **-36.8** | **-29.7** | **-60.7** |
| South America | -13.2 | -24.3 | -34.0 | -14.4 | -24.1 | -23.8 | -32.2 |
| Oceania | -4.5 | -6.0 | -8.8 | -1.1 | -0.4 | 2.1 | -2.3 |
| Polynesia | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| | **-4.5** | **-5.9** | **-8.8** | **-1.1** | **-0.4** | **2.1** | **-2.3** |
| Eastern Africa | -44.7 | -63.7 | -78.4 | -46.1 | -65.1 | -66.8 | -80.6 |
| Middle Africa | -50.3 | -76.0 | -92.0 | -53.3 | -76.4 | -77.2 | -91.7 |
| Northern Africa | 4.3 | 5.7 | 7.6 | 23.5 | 24.2 | 43.6 | 46.7 |
| Southern Africa | -24.5 | -33.1 | -51.7 | -8.7 | -16.0 | -2.3 | -29.9 |
| Western Africa | -100.0 | -100.0 | -100.0 | -100.0 | -100.0 | -100.0 | -100.0 |
| | **-38.4** | **-55.1** | **-68.7** | **-36.1** | **-52.4** | **-50.3** | **-64.0** |
| Western Asia | 28.7 | 51.6 | 65.3 | 47.7 | 66.3 | 83.6 | 106.8 |
| Southeast. Asia | -11.8 | -23.0 | -51.6 | -18.0 | -31.2 | -39.7 | -59.6 |
| South Asia | -8.1 | -28.0 | -44.9 | -7.3 | -25.8 | -21.0 | -33.3 |
| East Asia | 15.9 | 6.6 | -0.5 | 17.2 | 8.7 | 10.8 | 1.5 |
| Central Asia | 9.5 | 7.4 | -1.7 | 29.3 | 10.7 | 46.8 | 41.6 |
| Japan | -3.6 | -10.5 | -13.7 | -8.8 | -13.7 | -21.3 | -25.7 |
| | **7.5** | **-3.0** | **-13.2** | **9.1** | **-2.0** | **1.7** | **-8.2** |
| **DEVELOPING** | **-12.5** | **-24.0** | **-34.4** | **-10.8** | **-22.0** | **-19.0** | **-28.5** |
| **DEVELOPED** | **10.7** | **13.8** | **16.2** | **14.0** | **17.7** | **20.5** | **23.0** |
| **WORLD TOTAL** | **3.9** | **2.8** | **1.4** | **6.8** | **6.0** | **8.9** | **7.9** |

The application of the various temperature and rainfall sensitivity scenarios revealed a modest increase of cultivable rain-fed land for temperature increases up to 2°C on a global scale. With a higher temperature increase alone, extents of cultivable rain-fed land start to decrease. When both temperature and rainfall amounts increase, the extents of cultivable rain-fed land increase steadily. For example, a temperature increase of 3°C paired with a rainfall increase of 10 percent, would lead to about 4 percent more land globally suitable for rain-fed cultivation of wheat, rice, or grain-maize. In the developed countries this increase is even markedly higher; it exceeds 25 percent. Contrariwise, for developing countries there would be a decrease of 11 percent.

**Table 50 Impact of temperature and rainfall sensitivity tests on crop suitability, expressed as VS+S+MS extents for rain-fed wheat, rice, or grain-maize cultivation (% change relative to current climate)**

| Region | Temperature Increase | | | Temperature Increase, Rainfall Change | | | |
|---|---|---|---|---|---|---|---|
| | +1°C | +2°C | +3°C | +1°C, +5% | +2°C, +5% | +2°C, +10% | +3°C, +10% |
| North America | 12.0 | 16.1 | 20.3 | 16.1 | 20.9 | 23.8 | 28.4 |
| Eastern Europe | 5.7 | 6.0 | 0.6 | 9.6 | 9.3 | 13.0 | 10.3 |
| Northern Europe | 10.7 | 10.8 | 11.5 | 11.8 | 11.9 | 11.1 | 12.6 |
| Southern Europe | 6.3 | 10.2 | 12.1 | 10.6 | 14.0 | 18.6 | 21.3 |
| Western Europe | 0.4 | -1.6 | -2.9 | 1.1 | -1.0 | -1.3 | -4.3 |
| Russian Federation | 21.6 | 31.5 | 40.3 | 25.8 | 36.6 | 41.0 | 49.7 |
| | **12.8** | **17.4** | **20.2** | **16.1** | **21.1** | **24.3** | **27.5** |
| Caribbean | -1.4 | -1.7 | -1.4 | -5.6 | -3.9 | -12.8 | -10.0 |
| Central America | -0.3 | -4.3 | -9.9 | -3.4 | -6.9 | -8.5 | -14.1 |
| | **-0.5** | **-3.9** | **-8.5** | **-3.7** | **-6.4** | **-9.2** | **-13.4** |
| South America | -4.4 | -11.4 | -19.8 | -6.9 | -12.9 | -13.9 | -22.7 |
| Oceania | -4.3 | -5.3 | -9.0 | 1.0 | 0.0 | 4.1 | 0.4 |
| Polynesia | 3.7 | -9.0 | -18.3 | -11.0 | -10.2 | -19.4 | -23.8 |
| | **-4.1** | **-4.7** | **-9.3** | **0.7** | **-0.2** | **3.6** | **-0.2** |
| Eastern Africa | -4.1 | -8.2 | -12.3 | -5.8 | -9.2 | -10.9 | -14.8 |
| Middle Africa | -2.5 | -7.0 | -11.2 | -7.0 | -11.0 | -13.7 | -17.9 |
| Northern Africa | -1.2 | -3.0 | -5.2 | 3.3 | 1.4 | 6.1 | 4.7 |
| Southern Africa | -17.3 | -21.5 | -30.9 | 7.9 | -4.1 | 16.9 | 3.6 |
| Western Africa | -2.2 | -8.4 | -13.5 | -3.4 | -7.9 | -8.0 | -13.4 |
| | **-3.5** | **-7.8** | **-12.1** | **-4.2** | **-8.1** | **-8.3** | **-12.6** |
| Western Asia | 28.9 | 51.7 | 65.2 | 47.6 | 66.4 | 83.4 | 106.5 |
| Southeast. Asia | -2.7 | -4.5 | -11.7 | -6.5 | -9.2 | -14.0 | -21.2 |
| South Asia | -2.6 | -6.8 | -13.6 | -0.8 | -5.3 | -3.0 | -8.7 |
| East Asia | 17.4 | 18.9 | 18.6 | 16.3 | 18.2 | 18.3 | 20.3 |
| Central Asia | 13.0 | 13.9 | 6.6 | 31.5 | 17.3 | 54.3 | 51.1 |
| Japan | -3.4 | -8.3 | -12.9 | -8.7 | -11.6 | -17.2 | -22.2 |
| | **4.3** | **2.5** | **-2.2** | **4.7** | **2.4** | **3.7** | **0.4** |
| **DEVELOPING** | **-1.3** | **-5.5** | **-11.1** | **-2.1** | **-6.0** | **-5.9** | **-11.1** |
| **DEVELOPED** | **11.1** | **15.0** | **17.7** | **14.8** | **19.1** | **22.2** | **25.3** |
| **WORLD TOTAL** | **3.9** | **3.1** | **1.1** | **5.0** | **4.6** | **5.9** | **4.3** |

## 6. CONCLUDING REMARKS

The term AEZ refers to the Agro-Ecological Zones system, developed by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the International Institute for Applied Systems Analysis (IIASA). The approach enables rational land-use planning on the basis of an inventory of land resources and an evaluation of their biophysical limitations and potentials for plant production relevant in a particular agro-ecological context, for specified management conditions and levels of inputs.

Recent availability of digital global databases of climatic parameters, topography, soil and terrain, and land cover has allowed for revisions and improvements in calculation procedures of AEZ, enabling global coverage. AEZ provides a standardized framework for the characterization of crop-specific limitations of climate, soil and terrain resources in a consistent and empirically founded way. It systematically computes spatial and temporal data on maximum potential and attainable crop yields as well as expected sustainable agricultural production potentials at different specified levels of inputs and management conditions.

In essence, the Global AEZ assessment has provided a comprehensive and spatially explicit database of crop production potential and related factors. The results are a valuable source of information and input to various global and regional applications. The AEZ computations were completed for a range of climatic conditions, including a reference climate (average of period 1961-1990), individual historical years of 1960 to 1996, and scenarios of future climate based on the published outputs of various global climate models. The FAO/UNESCO Digital Soil Map of the World (DSMW) has been made the reference for constructing a land surface database comprising of more than 2.2 million grid-cells at 5-minutes latitude/longitude within a raster of 2160 rows and 4320 columns.

The study confirms that the Earth's land and climate resources are adequate to meet the needs of food and fiber for a world population of 8.9 thousand million, as projected for the year 2050 by the UN medium variant. Despite this hopeful aggregate picture, there are also reasons for profound concerns. Several regions exist, where the rain-fed cultivation potential has already been exhausted, as for example is the case in parts of Asia. Land degradation, if continuing unchecked, may exacerbate regional land scarcities. Concerns for the environment may prevent some resources from being developed for agriculture. Global warming may alter the condition and distribution of land suitable for cropping. In addition, socioeconomic development may infringe on the current agricultural resource base.

On the basis of currently available global soil, terrain and climate data, the AEZ approach estimates that 10.5 thousand million ha, i.e., more than three-quarters of the global land surface (excluding Antarctica), amounting to roughly 13.4 thousand million ha, suffer rather severe constraints for rain-fed cultivation. Some 13 percent is too cold, 27 percent is too dry, 12 percent is too steep, and about 65 percent are constrained by unfavorable soil conditions.

Combining the AEZ results with spatial land cover data, about 237 million hectares of the areas classified as dominantly forest ecosystems were assessed as very suitable or suitable for cultivation. On the other hand, the analysis shows that globally almost 85 percent of forest ecosystems are considered not suitable or at best marginally suitable for crop cultivation.

The application of various temperature and rainfall sensitivity scenarios revealed a modest increase of cultivable rain-fed land for temperature increases up to 2°C on global scale. With a temperature increase alone, extents of cultivable rain-fed land start to decrease. When both temperature and rainfall amounts increase, the extents of cultivable rain-fed land increase steadily. For example, a temperature increase of 3°C paired with a rainfall increase of 10 percent would lead globally to about 4 percent more cultivable rain-fed land. In the developed countries this increase is even markedly higher; it exceeds 25 percent. On the contrary, for developing countries there would be a decrease of 11 percent.

Beyond the conventional use of AEZ for mapping and quantifying crop production potentials, there are several recent applications where AEZ or outputs from AEZ analysis have been used for environmental and economic assessments:

**AEZ and land evaluation for forestry:** With an increased emphasis on multiple use forestry, on agro-forestry, on forest as renewable energy source, and on the role of forests in global $CO_2$ balances, the scope of quantitative land evaluation for forestry is widening. In a recent IIASA study, covering the territory of the Former Soviet Union and China, the AEZ evaluation procedures have been extended for the calculation of potential tree biomass. Three different types of forest resources management and exploitation were assumed. The first type, termed "*conservation forestry*", aims at nature conservation, bio-diversity preservation and limited selective extraction of individual trees. The second type reflects traditional forestry, with the main management objectives of maximizing quality and quantity of timber production. This type is referred to as "*traditional forestry*". The third type captures the fully mechanized biofuel and pulpwood production for energy generation and industrial application of pulpwood. This type was termed "*biomass forestry*".

**AEZ and potentials of fodder and grassland:** Among the total of 154 land utilization types implemented in Global AEZ, there are 13 types concerned with fodder and grass production (six types of silage maize, alfalfa, and six generic types of grasses and pasture legumes). The methodology also includes crop coefficients for quantifying crop residues (e.g., straw) and byproducts (e.g., bran from cereals or cakes from processing of oilseeds) potentially available for animal feeding. Together these can provide comprehensive information to assessments of livestock potentials as well as of regional biomass potentials for energy uses from crop and grassland sources.

**AEZ linkage to economic modeling:** The AEZ land productivity assessment conducted within the Land Use Change Project (LUC) at IIASA provides a multifaceted environmental characterization of land with regard to agricultural uses. Key objectives for its development included the compilation of geographically explicit information that could be embedded within an economic model, to provide a biophysical basis for the estimation of spatially explicit agricultural production relations, and to allow consistent linkage to the modeling of the water sector, in particular the demand for irrigation water. Agricultural production in this economic model is co-determined by the biophysical potential of land, and by the level of factor inputs (in terms of nutrients and power). Potential output is based on results generated by the AEZ model. The rationale behind this specification is that the observed actual crop output level represents a certain fraction of the biophysical potential. The results obtained in LUC's study on China, strongly support the view that it is both possible and worthwhile to integrate information from biophysical/biological process models within an economic model.

**AEZ and land-use planning:** As an extension of basic land productivity assessments, FAO and IIASA have developed AEZWIN, an MS Windows application for use in national and sub-national resource planning. When evaluating the performance of alternative land utilization types, often the specification of a single objective function does not adequately reflect the preferences of decision-makers, which are of a multi-objective nature in many practical problems dealing with resources. Therefore interactive multi-criteria model analysis has been introduced and applied to the analysis of AEZ models. It is at this level of analysis that socioeconomic considerations can effectively be taken into account.

**Limitations**

The Global AEZ results presented are based on a half-degree latitude/longitude world climate data set, 5-minutes soils data derived from the digital version of the FAO Soil Map of the World, the 30 arc-seconds latitude/longitude Global Land Cover Characteristics Database, and a 30 arc-second digital elevation data set. While representing the most recent global data compilations, the quality and reliability of these data sets is known to be uneven across regions. Especially the quality of the world soil map is reason for concern. It is based on a 1:5,000,000 scale map and it is generally accepted that its reliability may vary considerably between different areas. At present substantial improvements to the soil information is in progress, as for example, the recent SOTER updates for South America and the Caribbean, North and Central Eurasia, Northeast Africa, and Eastern Europe.

Another issue is that the current status of land degradation cannot be inferred from the FAO Soil Map of the World. The only study available with global coverage, the Global Assessment of Soil Degradation (GLASOD), compiled by ISRIC and UNEP, indicates that state and rate of various types of degradation might very well affect land productivity. However, the GLASOD study itself offers insufficient detail and quantification for useful application within Global AEZ.

Also the agronomic data, such as the data on environmental requirements for some crops, contain generalizations necessary for global applications. In particular assumptions on occurrence and severity of some agro-climate related constraints to crop production would, no doubt, benefit from additional verification and data.

For the above reasons, the results obtained from this Global AEZ study should be treated in a conservative manner at appropriate aggregation levels, which are commensurate with the resolution of basic data and the scale of the study. While various modes have been pursued for “ground-truthing” and verifying results of the Global AEZ suitability analysis, there is a need for further validation of results and underlying databases.

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## APPENDIX I

## TABLES WITH SELECTED RESULTS OF THE GLOBAL AEZ ASSESSMENT

Table A45 Gross extents with cultivation potential for rain-fed plus irrigated sugar crops – high input level.

Table A46 Gross extents with cultivation potential for rain-fed plus irrigated cotton – high input level.

**Table A1 Climate, soil and terrain constraints to rain-fed crop production - North America**

| Constraints | | | LGP 0 days CC | LGP 1-60 CC | LGP 60-119 C | LGP 120-179 | LGP 180-269 | LGP 270-365 | LGP 365+ C | Totals (1000 ha) | (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 85843 | 178257 | 107678 | 42028 | 289899 | 143876 | 0 | 847581 | 39.6 |
| | $LGP_{t=5} < 180$ | C | 294 | 26592 | 33300 | 464046 | 0 | 0 | 0 | 524232 | 24.5 |
| | $LGP_{t=5} < 120$ | CC | 265685 | 127990 | 373009 | 0 | 0 | 0 | 0 | 766684 | 35.9 |
| Terrain slopes | 0 - 8% | | 229014 | 151159 | 273967 | 310692 | 164875 | 94003 | 0 | 1223710 | 57.2 |
| | 8 - 16% | C | 55155 | 70954 | 73524 | 76499 | 62474 | 32171 | 0 | 370777 | 17.3 |
| | 16 - 30% | C | 45370 | 69323 | 84634 | 66593 | 42420 | 12765 | 0 | 321105 | 15.0 |
| | > 30% | CC | 22282 | 41404 | 81861 | 52290 | 20130 | 4938 | 0 | 222905 | 10.4 |
| Soil depth | Deep | | 133360 | 263190 | 397512 | 421637 | 246856 | 137949 | 0 | 1600504 | 74.8 |
| | Medium | C | 0 | 4621 | 430 | 1193 | 507 | 1 | 0 | 6752 | 0.3 |
| | Shallow | CC | 22711 | 53722 | 90806 | 58291 | 18377 | 3845 | 0 | 247752 | 11.6 |
| Soil fertility | High | | 78442 | 174436 | 152483 | 91240 | 113828 | 20876 | 0 | 631305 | 29.5 |
| | Medium | C | 1794 | 8085 | 63241 | 64594 | 84450 | 77849 | 0 | 300013 | 14.0 |
| | Low | CC | 75834 | 139012 | 273023 | 325287 | 67462 | 43070 | 0 | 923688 | 43.2 |
| Soil drainage | Good | | 155509 | 305345 | 428164 | 425058 | 215240 | 113171 | 0 | 1642487 | 76.8 |
| | Poor | CC | 562 | 16188 | 60583 | 56063 | 50501 | 28624 | 0 | 212521 | 9.9 |
| Soil texture | Medium/fine | | 67393 | 176282 | 263007 | 313121 | 214099 | 118356 | 0 | 1152258 | 53.9 |
| | Sandy/stony | CC | 58092 | 46092 | 31858 | 15425 | 6869 | 7031 | 0 | 165367 | 7.7 |
| | Cracking clay | C | 30585 | 99160 | 193882 | 152574 | 44773 | 16409 | 0 | 537383 | 25.1 |
| Soil chemical constraints | None | | 154715 | 313967 | 485112 | 477123 | 264714 | 140398 | 0 | 1836029 | 85.9 |
| | S/S/G* | CC | 1356 | 7566 | 3635 | 3997 | 1027 | 1397 | 0 | 18978 | 0.9 |
| Miscellaneous land units | | CC | 195752 | 11307 | 25239 | 24954 | 24158 | 2081 | 0 | 283491 | 13.3 |
| Total *without* constraints | | | 0 | 0 | 0 | 15095 | 60007 | 10804 | 0 | 85906 | 4.0 |
| Total with *moderate* constraints | | C | 0 | 0 | 80090 | 59320 | 73411 | 65086 | 0 | 277907 | 13.0 |
| Total with *severe* constraints | | CC | 351822 | 332840 | 433896 | 431660 | 156480 | 67986 | 0 | 1774684 | 83.0 |
| Total | (1000 ha) | | 351822 | 332840 | 513986 | 506075 | 289899 | 143876 | 0 | 2138498 | 100.0 |
| | (%) | | 16.5 | 15.6 | 24.0 | 23.7 | 13.6 | 6.7 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A2 Climate, soil and terrain constraints to rain-fed crop production - Eastern Europe**

| Constraints | | | LGP 0 days CC | LGP 1-60 CC | LGP 60-119 C | LGP 120-179 | LGP 180-269 | LGP 270-365 | LGP 365+ C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5}$ > 180 | | 0 | 0 | 16130 | 29022 | 124968 | 0 | 0 | 170120 | 99.5 |
| | $LGP_{t=5}$ < 180 | C | 0 | 0 | 0 | 834 | 0 | 0 | 0 | 834 | 0.5 |
| | $LGP_{t=5}$ < 120 | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Terrain slopes | 0 - 8% | | 0 | 0 | 8782 | 12144 | 74557 | 0 | 0 | 95483 | 55.9 |
| | 8 - 16% | C | 0 | 0 | 5419 | 9335 | 23679 | 0 | 0 | 38433 | 22.5 |
| | 16 - 30% | C | 0 | 0 | 1903 | 6269 | 18744 | 0 | 0 | 26916 | 15.7 |
| | > 30% | CC | 0 | 0 | 26 | 2107 | 7987 | 0 | 0 | 10120 | 5.9 |
| Soil depth | Deep | | 0 | 0 | 15485 | 27932 | 119933 | 0 | 0 | 163350 | 95.6 |
| | Medium | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | Shallow | CC | 0 | 0 | 92 | 1638 | 4615 | 0 | 0 | 6345 | 3.7 |
| Soil fertility | High | | 0 | 0 | 14794 | 22922 | 45729 | 0 | 0 | 83445 | 48.8 |
| | Medium | C | 0 | 0 | 478 | 4593 | 61903 | 0 | 0 | 66974 | 39.2 |
| | Low | CC | 0 | 0 | 305 | 2054 | 16915 | 0 | 0 | 19274 | 11.3 |
| Soil drainage | Good | | 0 | 0 | 14879 | 27733 | 97488 | 0 | 0 | 140100 | 82.0 |
| | Poor | CC | 0 | 0 | 698 | 1837 | 27059 | 0 | 0 | 29594 | 17.3 |
| Soil texture | Medium/fine | | 0 | 0 | 15189 | 25083 | 84144 | 0 | 0 | 124416 | 72.8 |
| | Sandy/stony | CC | 0 | 0 | 191 | 1782 | 3154 | 0 | 0 | 5127 | 3.0 |
| | Cracking clay | C | 0 | 0 | 197 | 2705 | 37250 | 0 | 0 | 40152 | 23.5 |
| Soil chemical constraints | None | | 0 | 0 | 8025 | 25644 | 120287 | 0 | 0 | 153956 | 90.1 |
| | S/S/G* | CC | 0 | 0 | 7552 | 3926 | 4260 | 0 | 0 | 15738 | 9.2 |
| Miscellaneous land units | | CC | 0 | 0 | 553 | 286 | 420 | 0 | 0 | 1259 | 0.7 |
| Total *without* constraints | | | 0 | 0 | 0 | 11610 | 24193 | 0 | 0 | 35803 | 20.9 |
| Total with *moderate* constraints | | C | 0 | 0 | 7112 | 8758 | 51254 | 0 | 0 | 67124 | 39.3 |
| Total with *severe* constraints | | CC | 0 | 0 | 9018 | 9488 | 49521 | 0 | 0 | 68027 | 39.8 |
| Total | (1000 ha) | | 0 | 0 | 16130 | 29856 | 124968 | 0 | 0 | 170954 | 100.0 |
| | (%) | | 0.0 | 0.0 | 9.4 | 17.5 | 73.1 | 0.0 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A3 Climate, soil and terrain constraints to rain-fed crop production - Northern Europe**

| Constraints | | | LGP 0 days CC | LGP 1-60 CC | LGP 60-119 C | LGP 120-179 | LGP 180-269 | LGP 270-365 | LGP 365+ C | Totals (1000 ha) | (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5}$ > 180 | | 0 | 0 | 0 | 0 | 57982 | 12025 | 0 | 70007 | 40.6 |
| | $LGP_{t=5}$ < 180 | C | 0 | 0 | 0 | 71432 | 0 | 0 | 0 | 71432 | 41.4 |
| | $LGP_{t=5}$ < 120 | CC | 0 | 649 | 30436 | 0 | 0 | 0 | 0 | 31085 | 18.0 |
| Terrain slopes | 0 - 8% | | 0 | 156 | 6307 | 28238 | 37882 | 7409 | 0 | 79992 | 46.4 |
| | 8 - 16% | C | 0 | 185 | 7165 | 19481 | 11372 | 2646 | 0 | 40849 | 23.7 |
| | 16 - 30% | C | 0 | 185 | 9950 | 16203 | 6652 | 1696 | 0 | 34686 | 20.1 |
| | > 30% | CC | 0 | 122 | 7014 | 7510 | 2076 | 275 | 0 | 16997 | 9.9 |
| Soil depth | Deep | | 0 | 135 | 20282 | 59822 | 50735 | 11612 | 0 | 142586 | 82.6 |
| | Medium | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | Shallow | CC | 0 | 148 | 9049 | 7823 | 5413 | 312 | 0 | 22745 | 13.2 |
| Soil fertility | High | | 0 | 55 | 3168 | 3498 | 17279 | 4163 | 0 | 28163 | 16.3 |
| | Medium | C | 0 | 0 | 689 | 5234 | 21132 | 5985 | 0 | 33040 | 19.2 |
| | Low | CC | 0 | 229 | 25474 | 58913 | 17737 | 1777 | 0 | 104130 | 60.4 |
| Soil drainage | Good | | 0 | 283 | 29332 | 66788 | 44842 | 7990 | 0 | 149235 | 86.5 |
| | Poor | CC | 0 | 0 | 0 | 857 | 11306 | 3934 | 0 | 16097 | 9.3 |
| Soil texture | Medium/fine | | 0 | 115 | 11125 | 35175 | 38405 | 10624 | 0 | 95444 | 55.3 |
| | Sandy/stony | CC | 0 | 87 | 5186 | 1506 | 1178 | 63 | 0 | 8020 | 4.6 |
| | Cracking clay | C | 0 | 81 | 13021 | 30965 | 16565 | 1237 | 0 | 61869 | 35.9 |
| Soil chemical constraints | None | | 0 | 283 | 29332 | 67645 | 56148 | 11924 | 0 | 165332 | 95.8 |
| | S/S/G* | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Miscellaneous land units | | CC | 0 | 366 | 1105 | 3787 | 1834 | 102 | 0 | 7194 | 4.2 |
| Total *without* constraints | | | 0 | 0 | 0 | 0 | 5500 | 2067 | 0 | 7567 | 4.4 |
| Total with *moderate* constraints | | C | 0 | 0 | 0 | 6544 | 19053 | 3858 | 0 | 29455 | 17.1 |
| Total with *severe* constraints | | CC | 0 | 649 | 30436 | 64888 | 33429 | 6100 | 0 | 135502 | 78.5 |
| Total | (1000 ha) | | 0 | 649 | 30436 | 71432 | 57982 | 12025 | 0 | 172524 | 100.0 |
| | (%) | | 0.0 | 0.4 | 17.6 | 41.4 | 33.6 | 7.0 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A4 Climate, soil and terrain constraints to rain-fed crop production - Southern Europe**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5}$ > 180 | | 150 | 0 | 429 | 31295 | 81247 | 15374 | 0 | 128495 | 97.6 |
| | $LGP_{t=5}$ < 180 | C | 0 | 0 | 0 | 2267 | 0 | 0 | 0 | 2267 | 1.7 |
| | $LGP_{t=5}$ < 120 | CC | 0 | 47 | 832 | 0 | 0 | 0 | 0 | 879 | 0.7 |
| Terrain slopes | 0 - 8% | | 48 | 0 | 76 | 5341 | 15787 | 4133 | 0 | 25385 | 19.3 |
| | 8 - 16% | C | 35 | 0 | 79 | 6722 | 14325 | 2184 | 0 | 23345 | 17.7 |
| | 16 - 30% | C | 57 | 3 | 189 | 10961 | 26007 | 4907 | 0 | 42124 | 32.0 |
| | > 30% | CC | 10 | 44 | 917 | 10537 | 25128 | 4151 | 0 | 40787 | 31.0 |
| Soil depth | Deep | | 101 | 0 | 572 | 23531 | 59162 | 10882 | 0 | 94248 | 71.6 |
| | Medium | C | 36 | 0 | 0 | 1147 | 550 | 51 | 0 | 1784 | 1.4 |
| | Shallow | CC | 13 | 12 | 630 | 8656 | 21445 | 4372 | 0 | 35128 | 26.7 |
| Soil fertility | High | | 65 | 0 | 393 | 18935 | 37658 | 6581 | 0 | 63632 | 48.3 |
| | Medium | C | 48 | 0 | 107 | 7392 | 24997 | 5569 | 0 | 38113 | 29.0 |
| | Low | CC | 38 | 12 | 702 | 7006 | 18503 | 3155 | 0 | 29416 | 22.3 |
| Soil drainage | Good | | 150 | 12 | 1202 | 32435 | 75658 | 14627 | 0 | 124084 | 94.3 |
| | Poor | CC | 0 | 0 | 0 | 899 | 5500 | 679 | 0 | 7078 | 5.4 |
| Soil texture | Medium/fine | | 110 | 9 | 704 | 20543 | 54493 | 9849 | 0 | 85708 | 65.1 |
| | Sandy/stony | CC | 25 | 0 | 49 | 2605 | 6156 | 1028 | 0 | 9863 | 7.5 |
| | Cracking clay | C | 15 | 3 | 450 | 10186 | 20509 | 4429 | 0 | 35592 | 27.0 |
| Soil chemical constraints | None | | 150 | 12 | 1202 | 31637 | 78180 | 15114 | 0 | 126295 | 95.9 |
| | S/S/G* | CC | 0 | 0 | 0 | 1697 | 2978 | 191 | 0 | 4866 | 3.7 |
| Miscellaneous land units | | CC | 0 | 35 | 59 | 228 | 90 | 69 | 0 | 481 | 0.4 |
| Total *without* constraints | | | 0 | 0 | 0 | 4555 | 11121 | 2116 | 0 | 17792 | 13.5 |
| Total with *moderate* constraints | | C | 0 | 0 | 269 | 13997 | 29878 | 6117 | 0 | 50261 | 38.2 |
| Total with *severe* constraints | | CC | 150 | 47 | 992 | 15010 | 40248 | 7142 | 0 | 63589 | 48.3 |
| Total | (1000 ha) | | 150 | 47 | 1261 | 33562 | 81247 | 15374 | 0 | 131641 | 100.0 |
| | (%) | | 0.1 | 0.0 | 1.0 | 25.5 | 61.7 | 11.7 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A5 Climate, soil and terrain constraints to rain-fed crop production - Western Europe**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 0 | 0 | 0 | 0 | 89637 | 14339 | 0 | 103976 | 94.9 |
| | $LGP_{t=5} < 180$ | C | 0 | 0 | 0 | 4965 | 0 | 0 | 0 | 4965 | 4.5 |
| | $LGP_{t=5} < 120$ | CC | 0 | 164 | 442 | 0 | 0 | 0 | 0 | 606 | 0.6 |
| Terrain slopes | 0 - 8% | | 0 | 0 | 1 | 41 | 38374 | 6930 | 0 | 45346 | 41.4 |
| | 8 - 16% | C | 0 | 1 | 2 | 64 | 21387 | 4654 | 0 | 26108 | 23.8 |
| | 16 - 30% | C | 0 | 9 | 22 | 399 | 20684 | 2206 | 0 | 23320 | 21.3 |
| | > 30% | CC | 0 | 154 | 417 | 4461 | 9192 | 550 | 0 | 14774 | 13.5 |
| Soil depth | Deep | | 0 | 4 | 70 | 2008 | 74223 | 13275 | 0 | 89580 | 81.8 |
| | Medium | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | Shallow | CC | 0 | 154 | 295 | 2808 | 14616 | 1046 | 0 | 18919 | 17.3 |
| Soil fertility | High | | 0 | 0 | 8 | 948 | 36255 | 7000 | 0 | 44211 | 40.4 |
| | Medium | C | 0 | 1 | 29 | 1162 | 32495 | 3860 | 0 | 37547 | 34.3 |
| | Low | CC | 0 | 157 | 328 | 2707 | 20088 | 3460 | 0 | 26740 | 24.4 |
| Soil drainage | Good | | 0 | 158 | 365 | 4686 | 74309 | 11955 | 0 | 91473 | 83.5 |
| | Poor | CC | 0 | 0 | 0 | 131 | 14529 | 2366 | 0 | 17026 | 15.5 |
| Soil texture | Medium/fine | | 0 | 115 | 236 | 2521 | 68214 | 12069 | 0 | 83155 | 75.9 |
| | Sandy/stony | CC | 0 | 0 | 0 | 48 | 1662 | 30 | 0 | 1740 | 1.6 |
| | Cracking clay | C | 0 | 44 | 130 | 2248 | 18962 | 2222 | 0 | 23606 | 21.5 |
| Soil chemical constraints | None | | 0 | 158 | 365 | 4817 | 88699 | 14298 | 0 | 108337 | 98.9 |
| | S/S/G* | CC | 0 | 0 | 0 | 0 | 140 | 24 | 0 | 164 | 0.1 |
| Miscellaneous land units | | CC | 0 | 6 | 77 | 148 | 799 | 18 | 0 | 1048 | 1.0 |
| Total *without* constraints | | | 0 | 0 | 0 | 0 | 18327 | 4543 | 0 | 22870 | 20.9 |
| Total with *moderate* constraints | | C | 0 | 0 | 0 | 584 | 25561 | 3630 | 0 | 29775 | 27.2 |
| Total with *severe* constraints | | CC | 0 | 164 | 442 | 4380 | 45750 | 6166 | 0 | 56902 | 51.9 |
| Total | (1000 ha) | | 0 | 164 | 442 | 4965 | 89637 | 14339 | 0 | 109547 | 100.0 |
| | (%) | | 0.0 | 0.1 | 0.4 | 4.5 | 81.8 | 13.1 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A6 Climate, soil and terrain constraints to rain-fed crop production - Russian Federation**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5}$ > 180 | | 0 | 23969 | 54727 | 23614 | 75513 | 172 | 0 | 177995 | 10.6 |
| | $LGP_{t=5}$ < 180 | C | 0 | 7048 | 54318 | 688891 | 0 | 0 | 0 | 750257 | 44.8 |
| | $LGP_{t=5}$ < 120 | CC | 4682 | 47869 | 693342 | 0 | 0 | 0 | 0 | 745893 | 44.6 |
| Terrain slopes | 0 - 8% | | 468 | 41124 | 313047 | 343433 | 49107 | 8 | 0 | 747187 | 44.6 |
| | 8 - 16% | C | 543 | 12822 | 176957 | 163812 | 17529 | 17 | 0 | 371680 | 22.2 |
| | 16 - 30% | C | 1581 | 13067 | 192718 | 142188 | 6477 | 82 | 0 | 356113 | 21.3 |
| | > 30% | CC | 2090 | 11873 | 119665 | 63073 | 2401 | 64 | 0 | 199166 | 11.9 |
| Soil depth | Deep | | 837 | 50012 | 457678 | 512632 | 69657 | 100 | 0 | 1090916 | 65.2 |
| | Medium | C | 0 | 0 | 0 | 64 | 0 | 0 | 0 | 64 | 0.0 |
| | Shallow | CC | 3691 | 25490 | 333146 | 187526 | 4852 | 71 | 0 | 554776 | 33.1 |
| Soil fertility | High | | 0 | 20819 | 85676 | 92519 | 21091 | 56 | 0 | 220161 | 13.2 |
| | Medium | C | 0 | 2221 | 63900 | 216818 | 47326 | 100 | 0 | 330365 | 19.7 |
| | Low | CC | 4528 | 52463 | 641249 | 390885 | 6092 | 16 | 0 | 1095233 | 65.4 |
| Soil drainage | Good | | 3494 | 57650 | 614716 | 567435 | 61440 | 172 | 0 | 1304907 | 77.9 |
| | Poor | CC | 1034 | 17852 | 176108 | 132787 | 13070 | 0 | 0 | 340851 | 20.4 |
| Soil texture | Medium/fine | | 2783 | 61365 | 674167 | 613615 | 63311 | 172 | 0 | 1415413 | 84.5 |
| | Sandy/stony | CC | 1745 | 12217 | 82941 | 15893 | 82 | 0 | 0 | 112878 | 6.7 |
| | Cracking clay | C | 0 | 1920 | 33716 | 70714 | 11117 | 0 | 0 | 117467 | 7.0 |
| Soil chemical constraints | None | | 4528 | 57108 | 756127 | 690871 | 73584 | 172 | 0 | 1582390 | 94.5 |
| | S/S/G* | CC | 0 | 18394 | 34697 | 9351 | 926 | 0 | 0 | 63368 | 3.8 |
| Miscellaneous land units | | CC | 154 | 3384 | 11563 | 12284 | 1004 | 0 | 0 | 28389 | 1.7 |
| Total *without* constraints | | | 0 | 0 | 0 | 9624 | 11518 | 0 | 0 | 21142 | 1.3 |
| Total with *moderate* constraints | | C | 0 | 0 | 45384 | 152632 | 42410 | 89 | 0 | 240515 | 14.4 |
| Total with *severe* constraints | | CC | 4682 | 78886 | 757002 | 550250 | 21585 | 83 | 0 | 1412488 | 84.4 |
| Total | (1000 ha) | | 4682 | 78886 | 802387 | 712506 | 75513 | 172 | 0 | 1674146 | 100.0 |
| | (%) | | 0.3 | 4.7 | 47.9 | 42.6 | 4.5 | 0.0 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A7 Climate, soil and terrain constraints to rain-fed crop production - the Caribbean**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 0 | 0 | 92 | 0 | 7574 | 15730 | 0 | 23396 | 100.0 |
| | $LGP_{t=5} < 180$ | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | $LGP_{t=5} < 120$ | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Terrain slopes | 0 - 8% | | 0 | 0 | 65 | 0 | 5408 | 6114 | 0 | 11587 | 49.5 |
| | 8 - 16% | C | 0 | 0 | 20 | 0 | 961 | 2480 | 0 | 3461 | 14.8 |
| | 16 - 30% | C | 0 | 0 | 7 | 0 | 721 | 3926 | 0 | 4654 | 19.9 |
| | > 30% | CC | 0 | 0 | 0 | 0 | 484 | 3210 | 0 | 3694 | 15.8 |
| Soil depth | Deep | | 0 | 0 | 17 | 0 | 5064 | 10345 | 0 | 15426 | 65.9 |
| | Medium | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | Shallow | CC | 0 | 0 | 75 | 0 | 2478 | 5081 | 0 | 7634 | 32.6 |
| Soil fertility | High | | 0 | 0 | 17 | 0 | 4283 | 6262 | 0 | 10562 | 45.1 |
| | Medium | C | 0 | 0 | 0 | 0 | 2089 | 6209 | 0 | 8298 | 35.5 |
| | Low | CC | 0 | 0 | 75 | 0 | 1170 | 2955 | 0 | 4200 | 18.0 |
| Soil drainage | Good | | 0 | 0 | 92 | 0 | 6557 | 14400 | 0 | 21049 | 90.0 |
| | Poor | CC | 0 | 0 | 0 | 0 | 985 | 1026 | 0 | 2011 | 8.6 |
| Soil texture | Medium/fine | | 0 | 0 | 92 | 0 | 6142 | 12803 | 0 | 19037 | 81.4 |
| | Sandy/stony | CC | 0 | 0 | 0 | 0 | 1337 | 2497 | 0 | 3834 | 16.4 |
| | Cracking clay | C | 0 | 0 | 0 | 0 | 63 | 126 | 0 | 189 | 0.8 |
| Soil chemical constraints | None | | 0 | 0 | 92 | 0 | 7330 | 15230 | 0 | 22652 | 96.8 |
| | S/S/G* | CC | 0 | 0 | 0 | 0 | 212 | 196 | 0 | 408 | 1.7 |
| Miscellaneous land units | | CC | 0 | 0 | 0 | 0 | 32 | 304 | 0 | 336 | 1.4 |
| Total *without* constraints | | | 0 | 0 | 0 | 0 | 449 | 1345 | 0 | 1794 | 7.7 |
| Total with *moderate* constraints | | C | 0 | 0 | 17 | 0 | 1480 | 4428 | 0 | 5925 | 25.3 |
| Total with *severe* constraints | | CC | 0 | 0 | 75 | 0 | 5645 | 9957 | 0 | 15677 | 67.0 |
| Total | (1000 ha) | | 0 | 0 | 92 | 0 | 7574 | 15730 | 0 | 23396 | 100.0 |
| | (%) | | 0.0 | 0.0 | 0.4 | 0.0 | 32.4 | 67.2 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A8 Climate, soil and terrain constraints to rain-fed crop production - Central America**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 55915 | 22222 | 26709 | 29382 | 54766 | 58353 | 1006 | 248353 | 100.0 |
| | $LGP_{t=5} < 180$ | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | $LGP_{t=5} < 120$ | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Terrain slopes | 0 - 8% | | 21982 | 8302 | 6225 | 4545 | 14952 | 23485 | 239 | 79730 | 32.1 |
| | 8 - 16% | C | 13131 | 4636 | 5123 | 4017 | 5533 | 8793 | 75 | 41308 | 16.6 |
| | 16 - 30% | C | 13048 | 5470 | 8557 | 9008 | 13107 | 12716 | 185 | 62091 | 25.0 |
| | > 30% | CC | 7754 | 3814 | 6804 | 11813 | 21175 | 13358 | 507 | 65225 | 26.3 |
| Soil depth | Deep | | 26227 | 12048 | 12874 | 20192 | 35917 | 44807 | 768 | 152833 | 61.5 |
| | Medium | C | 1130 | 861 | 594 | 376 | 0 | 0 | 0 | 2961 | 1.2 |
| | Shallow | CC | 28370 | 9042 | 13225 | 8605 | 18052 | 12889 | 238 | 90421 | 36.4 |
| Soil fertility | High | | 44947 | 16873 | 17872 | 14671 | 26965 | 18362 | 200 | 139890 | 56.3 |
| | Medium | C | 358 | 742 | 1808 | 6514 | 15601 | 25800 | 612 | 51435 | 20.7 |
| | Low | CC | 10421 | 4335 | 7013 | 7988 | 11403 | 13534 | 194 | 54888 | 22.1 |
| Soil drainage | Good | | 55703 | 21311 | 26094 | 28673 | 51246 | 50698 | 844 | 234569 | 94.4 |
| | Poor | CC | 24 | 639 | 599 | 500 | 2722 | 6998 | 162 | 11644 | 4.7 |
| Soil texture | Medium/fine | | 45467 | 19084 | 24560 | 21724 | 38203 | 49636 | 917 | 199591 | 80.4 |
| | Sandy/stony | CC | 6418 | 2683 | 1566 | 5265 | 11881 | 6878 | 74 | 34765 | 14.0 |
| | Cracking clay | C | 3842 | 184 | 567 | 2184 | 3884 | 1182 | 15 | 11858 | 4.8 |
| Soil chemical constraints | None | | 54108 | 21798 | 26554 | 29090 | 53379 | 57136 | 1004 | 243069 | 97.9 |
| | S/S/G* | CC | 1619 | 153 | 140 | 84 | 589 | 560 | 2 | 3147 | 1.3 |
| Miscellaneous land units | | CC | 189 | 271 | 15 | 209 | 798 | 657 | 0 | 2139 | 0.9 |
| Total *without* constraints | | | 0 | 0 | 0 | 5243 | 7098 | 4872 | 0 | 17213 | 6.9 |
| Total with *moderate* constraints | | C | 0 | 0 | 10543 | 6389 | 10655 | 18358 | 371 | 46316 | 18.6 |
| Total with *severe* constraints | | CC | 55915 | 22222 | 16166 | 17750 | 37014 | 35122 | 635 | 184824 | 74.4 |
| Total | (1000 ha) | | 55915 | 22222 | 26709 | 29382 | 54766 | 58353 | 1006 | 248353 | 100.0 |
| | (%) | | 22.5 | 8.9 | 10.8 | 11.8 | 22.1 | 23.5 | 0.4 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A9 Climate, soil and terrain constraints to rain-fed crop production - South America**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 118920 | 54806 | 92024 | 128820 | 379752 | 858595 | 118565 | 1751482 | 98.5 |
| | $LGP_{t=5} < 180$ | C | 6375 | 2783 | 3874 | 3478 | 0 | 0 | 0 | 16510 | 0.9 |
| | $LGP_{t=5} < 120$ | CC | 7268 | 1997 | 316 | 0 | 0 | 0 | 0 | 9581 | 0.5 |
| Terrain slopes | 0 - 8% | | 44747 | 25599 | 39234 | 72395 | 265661 | 629789 | 98085 | 1175510 | 66.1 |
| | 8 - 16% | C | 26573 | 11538 | 13425 | 21223 | 59658 | 119619 | 9262 | 261298 | 14.7 |
| | 16 - 30% | C | 32285 | 11374 | 18959 | 20344 | 38163 | 79920 | 7262 | 208307 | 11.7 |
| | > 30% | CC | 28957 | 11076 | 24596 | 18336 | 16269 | 29267 | 3955 | 132456 | 7.5 |
| Soil depth | Deep | | 98497 | 44883 | 70455 | 104351 | 344340 | 806230 | 112792 | 1581548 | 89.0 |
| | Medium | C | 2966 | 2929 | 3464 | 2653 | 2977 | 2183 | 0 | 17172 | 1.0 |
| | Shallow | CC | 26029 | 10023 | 18979 | 22126 | 29348 | 37191 | 4274 | 147970 | 8.3 |
| Soil fertility | High | | 75772 | 35802 | 44898 | 40905 | 51187 | 113182 | 5244 | 366990 | 20.6 |
| | Medium | C | 9348 | 5000 | 15069 | 40512 | 115899 | 282057 | 38599 | 506484 | 28.5 |
| | Low | CC | 42372 | 17033 | 32930 | 47714 | 209579 | 450366 | 73222 | 873216 | 49.1 |
| Soil drainage | Good | | 126147 | 57410 | 89156 | 120592 | 331505 | 741707 | 97199 | 1563716 | 88.0 |
| | Poor | CC | 1345 | 425 | 3742 | 8539 | 45160 | 103898 | 19867 | 182976 | 10.3 |
| Soil texture | Medium/fine | | 92136 | 41268 | 67103 | 94745 | 290028 | 746127 | 112765 | 1444172 | 81.2 |
| | Sandy/stony | CC | 14857 | 5266 | 8310 | 7911 | 9938 | 21525 | 439 | 68246 | 3.8 |
| | Cracking clay | C | 20500 | 11301 | 17485 | 26475 | 76699 | 77953 | 3863 | 234276 | 13.2 |
| Soil chemical constraints | None | | 108672 | 48611 | 74797 | 106444 | 354929 | 829062 | 116699 | 1639214 | 92.2 |
| | S/S/G* | CC | 18821 | 9223 | 18101 | 22686 | 21736 | 16543 | 367 | 107477 | 6.0 |
| Miscellaneous land units | | CC | 5071 | 1751 | 3317 | 3167 | 3088 | 12990 | 1499 | 30883 | 1.7 |
| Total *without* constraints | | | 0 | 0 | 0 | 12457 | 19682 | 48002 | 0 | 80141 | 4.5 |
| Total with *moderate* constraints | | C | 0 | 0 | 37587 | 41635 | 96234 | 239377 | 30821 | 445654 | 25.1 |
| Total with *severe* constraints | | CC | 132563 | 59586 | 58627 | 78206 | 263837 | 571215 | 87744 | 1251778 | 70.4 |
| Total | (1000 ha) | | 132563 | 59586 | 96214 | 132298 | 379752 | 858595 | 118565 | 1777573 | 100.0 |
| | (%) | | 7.5 | 3.4 | 5.4 | 7.4 | 21.4 | 48.3 | 6.7 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A10 Climate, soil and terrain constraints to rain-fed crop production - Oceania**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 398936 | 89839 | 126118 | 73949 | 50218 | 52283 | 1203 | 792546 | 99.9 |
| | $LGP_{t=5} < 180$ | C | 0 | 0 | 0 | 882 | 0 | 0 | 0 | 882 | 0.1 |
| | $LGP_{t=5} < 120$ | CC | 111 | 0 | 0 | 0 | 0 | 0 | 0 | 111 | 0.0 |
| Terrain slopes | 0 - 8% | | 385892 | 87425 | 115622 | 65126 | 27912 | 16469 | 178 | 698624 | 88.0 |
| | 8 - 16% | C | 11050 | 2034 | 8743 | 7042 | 9256 | 13092 | 280 | 51497 | 6.5 |
| | 16 - 30% | C | 1979 | 366 | 1639 | 1716 | 7036 | 15910 | 473 | 29119 | 3.7 |
| | > 30% | CC | 126 | 14 | 115 | 947 | 6015 | 6813 | 272 | 14302 | 1.8 |
| Soil depth | Deep | | 293420 | 68024 | 95757 | 61563 | 41284 | 47226 | 1142 | 608416 | 76.7 |
| | Medium | C | 65290 | 14978 | 10359 | 3332 | 1568 | 84 | 0 | 95611 | 12.0 |
| | Shallow | CC | 33126 | 5950 | 19219 | 9695 | 7039 | 4523 | 60 | 79612 | 10.0 |
| Soil fertility | High | | 199215 | 41879 | 53018 | 25401 | 11994 | 10375 | 135 | 342017 | 43.1 |
| | Medium | C | 74968 | 23922 | 27624 | 19599 | 21133 | 25507 | 711 | 193464 | 24.4 |
| | Low | CC | 117653 | 23152 | 44692 | 29591 | 16764 | 15951 | 357 | 248160 | 31.3 |
| Soil drainage | Good | | 378450 | 83845 | 112644 | 62924 | 40379 | 41886 | 1177 | 721305 | 90.9 |
| | Poor | CC | 13386 | 5107 | 12690 | 11667 | 9512 | 9947 | 26 | 62335 | 7.9 |
| Soil texture | Medium/fine | | 182570 | 37340 | 54634 | 34307 | 28339 | 34337 | 744 | 372271 | 46.9 |
| | Sandy/stony | CC | 77606 | 19028 | 30330 | 15034 | 6584 | 4775 | 0 | 153357 | 19.3 |
| | Cracking clay | C | 131659 | 32585 | 40371 | 25250 | 14968 | 12721 | 459 | 258013 | 32.5 |
| Soil chemical constraints | None | | 315089 | 75418 | 99871 | 54835 | 39639 | 45312 | 1203 | 631367 | 79.6 |
| | S/S/G* | CC | 76747 | 13535 | 25463 | 19755 | 10252 | 6521 | 0 | 152273 | 19.2 |
| Miscellaneous land units | | CC | 7212 | 887 | 784 | 240 | 328 | 450 | 0 | 9901 | 1.2 |
| Total *without* constraints | | | 0 | 0 | 0 | 8121 | 4307 | 5302 | 0 | 17730 | 2.2 |
| Total with *moderate* constraints | | C | 0 | 0 | 36872 | 9452 | 12493 | 17530 | 719 | 77066 | 9.7 |
| Total with *severe* constraints | | CC | 399047 | 89839 | 89246 | 57259 | 33419 | 29451 | 484 | 698745 | 88.1 |
| Total | (1000 ha) | | 399047 | 89839 | 126118 | 74831 | 50218 | 52283 | 1203 | 793539 | 100.0 |
| | (%) | | 50.3 | 11.3 | 15.9 | 9.4 | 6.3 | 6.6 | 0.2 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A11 Climate, soil and terrain constraints to rain-fed crop production - Polynesia**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5}$ > 180 | | 0 | 0 | 0 | 0 | 2252 | 22107 | 31330 | 55689 | 99.2 |
| | $LGP_{t=5}$ < 180 | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | $LGP_{t=5}$ < 120 | CC | 428 | 0 | 0 | 0 | 0 | 0 | 0 | 428 | 0.8 |
| Terrain slopes | 0 - 8% | | 71 | 0 | 0 | 0 | 930 | 9299 | 10428 | 20728 | 36.9 |
| | 8 - 16% | C | 106 | 0 | 0 | 0 | 270 | 2818 | 4755 | 7949 | 14.2 |
| | 16 - 30% | C | 148 | 0 | 0 | 0 | 602 | 4538 | 8169 | 13457 | 24.0 |
| | > 30% | CC | 103 | 0 | 0 | 0 | 451 | 5451 | 7978 | 13983 | 24.9 |
| Soil depth | Deep | | 416 | 0 | 0 | 0 | 1758 | 19049 | 26383 | 47606 | 84.8 |
| | Medium | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | Shallow | CC | 12 | 0 | 0 | 0 | 494 | 2685 | 4863 | 8054 | 14.4 |
| Soil fertility | High | | 124 | 0 | 0 | 0 | 645 | 3652 | 7165 | 11586 | 20.6 |
| | Medium | C | 271 | 0 | 0 | 0 | 575 | 10020 | 16174 | 27040 | 48.2 |
| | Low | CC | 33 | 0 | 0 | 0 | 1032 | 8063 | 7906 | 17034 | 30.4 |
| Soil drainage | Good | | 428 | 0 | 0 | 0 | 2139 | 19524 | 28943 | 51034 | 90.9 |
| | Poor | CC | 0 | 0 | 0 | 0 | 113 | 2211 | 2302 | 4626 | 8.2 |
| Soil texture | Medium/fine | | 214 | 0 | 0 | 0 | 2008 | 19779 | 27875 | 49876 | 88.9 |
| | Sandy/stony | CC | 10 | 0 | 0 | 0 | 93 | 1262 | 2235 | 3600 | 6.4 |
| | Cracking clay | C | 204 | 0 | 0 | 0 | 152 | 694 | 1136 | 2186 | 3.9 |
| Soil chemical constraints | None | | 428 | 0 | 0 | 0 | 2223 | 21530 | 31035 | 55216 | 98.4 |
| | S/S/G* | CC | 0 | 0 | 0 | 0 | 30 | 205 | 211 | 446 | 0.8 |
| Miscellaneous land units | | CC | 0 | 0 | 0 | 0 | 0 | 372 | 85 | 457 | 0.8 |
| Total *without* constraints | | | 0 | 0 | 0 | 0 | 366 | 873 | 0 | 1239 | 2.2 |
| Total with *moderate* constraints | | C | 0 | 0 | 0 | 0 | 546 | 7820 | 14084 | 22450 | 40.0 |
| Total with *severe* constraints | | CC | 428 | 0 | 0 | 0 | 1340 | 13414 | 17246 | 32428 | 57.8 |
| Total | (1000 ha) | | 428 | 0 | 0 | 0 | 2252 | 22107 | 31330 | 56117 | 100.0 |
| | (%) | | 0.8 | 0.0 | 0.0 | 0.0 | 4.0 | 39.4 | 55.8 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A12 Climate, soil and terrain constraints to rain-fed crop production - Eastern Africa**

| Constraints | | | 0 days | 1-60 days | 60-119 days | 120-179 days | 180-269 days | 270-365 days | 365+ days | Totals | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CC | CC | C | | | | C | (1000 ha) | (%) |
| Temperature | $LGP_{t=5} > 180$ | | 72049 | 46225 | 72046 | 149284 | 230233 | 69637 | 0 | 639474 | 100.0 |
| | $LGP_{t=5} < 180$ | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | $LGP_{t=5} < 120$ | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Terrain slopes | 0 - 8% | | 37021 | 24615 | 35803 | 59655 | 102247 | 21617 | 0 | 280958 | 43.9 |
| | 8 - 16% | C | 14799 | 11548 | 16417 | 38638 | 56443 | 15650 | 0 | 153495 | 24.0 |
| | 16 - 30% | C | 12178 | 7035 | 12352 | 35996 | 51112 | 21086 | 0 | 139759 | 21.9 |
| | > 30% | CC | 8050 | 3027 | 7473 | 14995 | 20431 | 11284 | 0 | 65260 | 10.2 |
| Soil depth | Deep | | 42073 | 32586 | 52157 | 129313 | 199546 | 57293 | 0 | 512968 | 80.2 |
| | Medium | C | 13639 | 991 | 954 | 1050 | 1022 | 428 | 0 | 18084 | 2.8 |
| | Shallow | CC | 14125 | 12385 | 18852 | 17489 | 21799 | 5089 | 0 | 89739 | 14.0 |
| Soil fertility | High | | 35831 | 27867 | 38228 | 38458 | 54810 | 14341 | 0 | 209535 | 32.8 |
| | Medium | C | 7182 | 7649 | 22105 | 63435 | 86830 | 23745 | 0 | 210946 | 33.0 |
| | Low | CC | 26823 | 10446 | 11629 | 45959 | 80728 | 24723 | 0 | 200308 | 31.3 |
| Soil drainage | Good | | 68163 | 45493 | 70790 | 138300 | 206550 | 59115 | 0 | 588411 | 92.0 |
| | Poor | CC | 1674 | 469 | 1173 | 9551 | 15818 | 3695 | 0 | 32380 | 5.1 |
| Soil texture | Medium/fine | | 49859 | 30021 | 44046 | 96324 | 154365 | 53720 | 0 | 428335 | 67.0 |
| | Sandy/stony | CC | 13710 | 11275 | 18578 | 13026 | 21548 | 4730 | 0 | 82867 | 13.0 |
| | Cracking clay | C | 6267 | 4665 | 9340 | 38501 | 46455 | 4360 | 0 | 109588 | 17.1 |
| Soil chemical constraints | None | | 59537 | 38222 | 65813 | 142453 | 219413 | 62533 | 0 | 587971 | 91.9 |
| | S/S/G* | CC | 10299 | 7739 | 6149 | 5399 | 2954 | 277 | 0 | 32817 | 5.1 |
| Miscellaneous land units | | CC | 2212 | 264 | 83 | 1432 | 7865 | 6827 | 0 | 18683 | 2.9 |
| Total *without* constraints | | | 0 | 0 | 0 | 12068 | 15673 | 4884 | 0 | 32625 | 5.1 |
| Total with *moderate* constraints | | C | 0 | 0 | 35404 | 62301 | 82314 | 22119 | 0 | 202138 | 31.6 |
| Total with *severe* constraints | | CC | 72049 | 46225 | 36642 | 74915 | 132246 | 42634 | 0 | 404711 | 63.3 |
| Total | (1000 ha) | | 72049 | 46225 | 72046 | 149284 | 230233 | 69637 | 0 | 639474 | 100.0 |
| | (%) | | 11.3 | 7.2 | 11.3 | 23.3 | 36.0 | 10.9 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A13 Climate, soil and terrain constraints to rain-fed crop production - Middle Africa**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 63174 | 22958 | 23073 | 58319 | 200583 | 287412 | 1543 | 657062 | 100.0 |
| | $LGP_{t=5} < 180$ | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | $LGP_{t=5} < 120$ | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Terrain slopes | 0 - 8% | | 41498 | 14710 | 14970 | 41655 | 88472 | 217745 | 1539 | 420589 | 64.0 |
| | 8 - 16% | C | 9439 | 4730 | 5190 | 10224 | 44455 | 38826 | 4 | 112868 | 17.2 |
| | 16 - 30% | C | 8117 | 2715 | 2081 | 5109 | 58217 | 25927 | 0 | 102166 | 15.5 |
| | > 30% | CC | 4120 | 804 | 833 | 1331 | 9438 | 4914 | 0 | 21440 | 3.3 |
| Soil depth | Deep | | 26639 | 18718 | 19104 | 52734 | 192080 | 278017 | 1543 | 588835 | 89.6 |
| | Medium | C | 0 | 0 | 962 | 3316 | 740 | 1421 | 0 | 6439 | 1.0 |
| | Shallow | CC | 17988 | 2349 | 2158 | 2086 | 6119 | 5003 | 0 | 35703 | 5.4 |
| Soil fertility | High | | 22409 | 3028 | 6043 | 18969 | 22350 | 16867 | 207 | 89873 | 13.7 |
| | Medium | C | 3682 | 12885 | 11156 | 28139 | 62331 | 89322 | 153 | 207668 | 31.6 |
| | Low | CC | 18535 | 5154 | 5026 | 11028 | 114258 | 178251 | 1183 | 333435 | 50.7 |
| Soil drainage | Good | | 44582 | 20499 | 18869 | 46753 | 182809 | 234459 | 1198 | 549169 | 83.6 |
| | Poor | CC | 44 | 568 | 3356 | 11383 | 16131 | 49982 | 344 | 81808 | 12.5 |
| Soil texture | Medium/fine | | 16611 | 7966 | 11348 | 27199 | 115096 | 192443 | 1482 | 372145 | 56.6 |
| | Sandy/stony | CC | 3690 | 2154 | 4314 | 10394 | 13096 | 6019 | 0 | 39667 | 6.0 |
| | Cracking clay | C | 24325 | 10947 | 6563 | 20542 | 70747 | 85979 | 61 | 219164 | 33.4 |
| Soil chemical constraints | None | | 44050 | 17810 | 17436 | 55713 | 198678 | 283916 | 1543 | 619146 | 94.2 |
| | S/S/G* | CC | 576 | 3257 | 4789 | 2423 | 261 | 525 | 0 | 11831 | 1.8 |
| Miscellaneous land units | | CC | 18547 | 1891 | 848 | 183 | 1643 | 2971 | 0 | 26083 | 4.0 |
| Total *without* constraints | | | 0 | 0 | 0 | 2279 | 2854 | 3332 | 0 | 8465 | 1.3 |
| Total with *moderate* constraints | | C | 0 | 0 | 9158 | 22857 | 54865 | 46642 | 72 | 133594 | 20.3 |
| Total with *severe* constraints | | CC | 63174 | 22958 | 13915 | 33183 | 142864 | 237438 | 1471 | 515003 | 78.4 |
| Total | (1000 ha) | | 63174 | 22958 | 23073 | 58319 | 200583 | 287412 | 1543 | 657062 | 100.0 |
| | (%) | | 9.6 | 3.5 | 3.5 | 8.9 | 30.5 | 43.7 | 0.2 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A14 Climate, soil and terrain constraints to rain-fed crop production - Northern Africa**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 575390 | 39201 | 57499 | 57802 | 62990 | 1230 | 0 | 794112 | 100.0 |
| | $LGP_{t=5} < 180$ | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | $LGP_{t=5} < 120$ | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Terrain slopes | 0 - 8% | | 354543 | 23024 | 29047 | 31730 | 37497 | 388 | 0 | 476229 | 60.0 |
| | 8 - 16% | C | 126105 | 9763 | 14183 | 11211 | 10199 | 457 | 0 | 171918 | 21.6 |
| | 16 - 30% | C | 74347 | 4535 | 8446 | 9275 | 7571 | 355 | 0 | 104529 | 13.2 |
| | > 30% | CC | 20395 | 1879 | 5823 | 5586 | 7723 | 31 | 0 | 41437 | 5.2 |
| Soil depth | Deep | | 321109 | 31806 | 42331 | 45388 | 51547 | 1188 | 0 | 493369 | 62.1 |
| | Medium | C | 9159 | 1052 | 4476 | 5511 | 4012 | 0 | 0 | 24210 | 3.0 |
| | Shallow | CC | 94151 | 5815 | 10361 | 6711 | 7417 | 42 | 0 | 124497 | 15.7 |
| Soil fertility | High | | 301322 | 21935 | 33476 | 34764 | 25401 | 34 | 0 | 416932 | 52.5 |
| | Medium | C | 2874 | 9078 | 12944 | 14492 | 20049 | 158 | 0 | 59595 | 7.5 |
| | Low | CC | 120223 | 7659 | 10748 | 8353 | 17527 | 1038 | 0 | 165548 | 20.8 |
| Soil drainage | Good | | 421900 | 37407 | 55773 | 52911 | 54644 | 1184 | 0 | 623819 | 78.6 |
| | Poor | CC | 2518 | 1265 | 1395 | 4699 | 8333 | 46 | 0 | 18256 | 2.3 |
| Soil texture | Medium/fine | | 169613 | 14952 | 28695 | 32380 | 36672 | 1019 | 0 | 283331 | 35.7 |
| | Sandy/stony | CC | 73471 | 9781 | 14004 | 17528 | 20651 | 99 | 0 | 135534 | 17.1 |
| | Cracking clay | C | 181334 | 13939 | 14469 | 7703 | 5654 | 113 | 0 | 223212 | 28.1 |
| Soil chemical constraints | None | | 402787 | 35291 | 54656 | 55678 | 62302 | 1230 | 0 | 611944 | 77.1 |
| | S/S/G* | CC | 21631 | 3381 | 2512 | 1932 | 675 | 0 | 0 | 30131 | 3.8 |
| Miscellaneous land units | | CC | 150972 | 529 | 331 | 192 | 14 | 0 | 0 | 152038 | 19.1 |
| Total *without* constraints | | | 0 | 0 | 0 | 7130 | 4162 | 20 | 0 | 11312 | 1.4 |
| Total with *moderate* constraints | | C | 0 | 0 | 28450 | 17118 | 9047 | 28 | 0 | 54643 | 6.9 |
| Total with *severe* constraints | | CC | 575390 | 39201 | 29048 | 33554 | 49781 | 1182 | 0 | 728156 | 91.7 |
| Total | (1000 ha) | | 575390 | 39201 | 57499 | 57802 | 62990 | 1230 | 0 | 794112 | 100.0 |
| | (%) | | 72.5 | 4.9 | 7.2 | 7.3 | 7.9 | 0.2 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A15 Climate, soil and terrain constraints to rain-fed crop production - Southern Africa**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 104711 | 46827 | 64047 | 23896 | 22454 | 4493 | 0 | 266428 | 100.0 |
| | $LGP_{t=5} < 180$ | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | $LGP_{t=5} < 120$ | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Terrain slopes | 0 - 8% | | 45219 | 23364 | 38202 | 4990 | 985 | 405 | 0 | 113165 | 42.5 |
| | 8 - 16% | C | 28089 | 10195 | 13405 | 4370 | 2316 | 465 | 0 | 58840 | 22.1 |
| | 16 - 30% | C | 21574 | 8310 | 8405 | 8146 | 8395 | 1337 | 0 | 56167 | 21.1 |
| | > 30% | CC | 9829 | 4958 | 4034 | 6390 | 10758 | 2285 | 0 | 38254 | 14.4 |
| Soil depth | Deep | | 87091 | 38459 | 56201 | 20066 | 18958 | 3820 | 0 | 224595 | 84.3 |
| | Medium | C | 1272 | 95 | 1862 | 0 | 0 | 0 | 0 | 3229 | 1.2 |
| | Shallow | CC | 12843 | 6320 | 4531 | 3784 | 3413 | 612 | 0 | 31503 | 11.8 |
| Soil fertility | High | | 45139 | 14785 | 20292 | 5744 | 8325 | 1180 | 0 | 95465 | 35.8 |
| | Medium | C | 25871 | 17256 | 25476 | 11743 | 8852 | 1783 | 0 | 90981 | 34.1 |
| | Low | CC | 30197 | 12834 | 16826 | 6362 | 5194 | 1469 | 0 | 72882 | 27.4 |
| Soil drainage | Good | | 101044 | 44313 | 55675 | 21876 | 21221 | 4409 | 0 | 248538 | 93.3 |
| | Poor | CC | 162 | 561 | 6918 | 1973 | 1150 | 23 | 0 | 10787 | 4.0 |
| Soil texture | Medium/fine | | 41280 | 21520 | 27005 | 14744 | 16927 | 3384 | 0 | 124860 | 46.9 |
| | Sandy/stony | CC | 7039 | 3347 | 7849 | 2257 | 2893 | 48 | 0 | 23433 | 8.8 |
| | Cracking clay | C | 52887 | 20007 | 27740 | 6849 | 2551 | 1000 | 0 | 111034 | 41.7 |
| Soil chemical constraints | None | | 97442 | 41334 | 53256 | 22333 | 21563 | 4064 | 0 | 239992 | 90.1 |
| | S/S/G* | CC | 3765 | 3540 | 9338 | 1516 | 808 | 368 | 0 | 19335 | 7.3 |
| Miscellaneous land units | | CC | 3505 | 1953 | 1453 | 47 | 83 | 61 | 0 | 7102 | 2.7 |
| Total *without* constraints | | | 0 | 0 | 0 | 2238 | 3204 | 648 | 0 | 6090 | 2.3 |
| Total with *moderate* constraints | | C | 0 | 0 | 30287 | 10329 | 7446 | 1674 | 0 | 49736 | 18.7 |
| Total with *severe* constraints | | CC | 104711 | 46827 | 33760 | 11329 | 11804 | 2171 | 0 | 210602 | 79.0 |
| Total | (1000 ha) | | 104711 | 46827 | 64047 | 23896 | 22454 | 4493 | 0 | 266428 | 100.0 |
| | (%) | | 39.3 | 17.6 | 24.0 | 9.0 | 8.4 | 1.7 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A16 Climate, soil and terrain constraints to rain-fed crop production - Western Africa**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 276409 | 45835 | 65798 | 77894 | 111616 | 55443 | 0 | 632995 | 100.0 |
| | $LGP_{t=5} < 180$ | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | $LGP_{t=5} < 120$ | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Terrain slopes | 0 - 8% | | 252377 | 35742 | 50589 | 49527 | 72732 | 42067 | 0 | 503034 | 79.5 |
| | 8 - 16% | C | 16462 | 8032 | 12759 | 20569 | 22043 | 8701 | 0 | 88566 | 14.0 |
| | 16 - 30% | C | 6868 | 1847 | 2351 | 7003 | 14403 | 4061 | 0 | 36533 | 5.8 |
| | > 30% | CC | 702 | 214 | 99 | 795 | 2437 | 614 | 0 | 4861 | 0.8 |
| Soil depth | Deep | | 137649 | 38386 | 56680 | 53638 | 83792 | 48568 | 0 | 418713 | 66.1 |
| | Medium | C | 712 | 1063 | 3499 | 6420 | 7441 | 2006 | 0 | 21141 | 3.3 |
| | Shallow | CC | 34131 | 2384 | 4746 | 17677 | 19543 | 3574 | 0 | 82055 | 13.0 |
| Soil fertility | High | | 111224 | 11750 | 18721 | 18429 | 11194 | 4626 | 0 | 175944 | 27.8 |
| | Medium | C | 23611 | 26691 | 39959 | 43678 | 59828 | 24357 | 0 | 218124 | 34.5 |
| | Low | CC | 37657 | 3393 | 6244 | 15628 | 39754 | 25164 | 0 | 127840 | 20.2 |
| Soil drainage | Good | | 171001 | 37747 | 57732 | 67770 | 100269 | 48998 | 0 | 483517 | 76.4 |
| | Poor | CC | 1491 | 4087 | 7192 | 9964 | 10508 | 5150 | 0 | 38392 | 6.1 |
| Soil texture | Medium/fine | | 51937 | 8070 | 18028 | 39097 | 74797 | 37956 | 0 | 229885 | 36.3 |
| | Sandy/stony | CC | 14415 | 4312 | 8435 | 10142 | 3491 | 423 | 0 | 41218 | 6.5 |
| | Cracking clay | C | 106140 | 29452 | 38460 | 28495 | 32487 | 15769 | 0 | 250803 | 39.6 |
| Soil chemical constraints | None | | 170666 | 38784 | 59727 | 75839 | 109364 | 52660 | 0 | 507040 | 80.1 |
| | S/S/G* | CC | 1826 | 3050 | 5197 | 1896 | 1412 | 1488 | 0 | 14869 | 2.3 |
| Miscellaneous land units | | CC | 103917 | 4001 | 874 | 159 | 839 | 1295 | 0 | 111085 | 17.5 |
| Total *without* constraints | | | 0 | 0 | 0 | 1369 | 4412 | 2195 | 0 | 7976 | 1.3 |
| Total with *moderate* constraints | | C | 0 | 0 | 42616 | 37864 | 53973 | 21414 | 0 | 155867 | 24.6 |
| Total with *severe* constraints | | CC | 276409 | 45835 | 23182 | 38660 | 53231 | 31834 | 0 | 469151 | 74.1 |
| Total | (1000 ha) | | 276409 | 45835 | 65798 | 77894 | 111616 | 55443 | 0 | 632995 | 100.0 |
| | (%) | | 43.7 | 7.2 | 10.4 | 12.3 | 17.6 | 8.8 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A17 Climate, soil and terrain constraints to rain-fed crop production - Western Asia**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5}$ > 180 | | 314486 | 7968 | 48226 | 44420 | 16610 | 239 | 0 | 431949 | 99.8 |
| | $LGP_{t=5}$ < 180 | C | 0 | 0 | 702 | 341 | 0 | 0 | 0 | 1043 | 0.2 |
| | $LGP_{t=5}$ < 120 | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Terrain slopes | 0 - 8% | | 136158 | 5374 | 11246 | 7010 | 2421 | 86 | 0 | 162295 | 37.5 |
| | 8 - 16% | C | 83098 | 1500 | 9103 | 8181 | 2451 | 17 | 0 | 104350 | 24.1 |
| | 16 - 30% | C | 61218 | 585 | 14422 | 13988 | 5082 | 62 | 0 | 95357 | 22.0 |
| | > 30% | CC | 34012 | 509 | 14157 | 15583 | 6657 | 73 | 0 | 70991 | 16.4 |
| Soil depth | Deep | | 171147 | 5574 | 28037 | 28128 | 10701 | 203 | 0 | 243790 | 56.3 |
| | Medium | C | 15041 | 1221 | 3610 | 1647 | 36 | 0 | 0 | 21555 | 5.0 |
| | Shallow | CC | 94221 | 1122 | 16481 | 14729 | 5781 | 36 | 0 | 132370 | 30.6 |
| Soil fertility | High | | 172143 | 3523 | 31448 | 26698 | 8608 | 16 | 0 | 242436 | 56.0 |
| | Medium | C | 24693 | 197 | 1914 | 7812 | 4323 | 203 | 0 | 39142 | 9.0 |
| | Low | CC | 83572 | 4197 | 14766 | 9994 | 3586 | 20 | 0 | 116135 | 26.8 |
| Soil drainage | Good | | 278945 | 7654 | 47430 | 44228 | 15929 | 239 | 0 | 394425 | 91.1 |
| | Poor | CC | 1463 | 263 | 697 | 276 | 588 | 0 | 0 | 3287 | 0.8 |
| Soil texture | Medium/fine | | 131224 | 6213 | 33639 | 31828 | 11030 | 226 | 0 | 214160 | 49.5 |
| | Sandy/stony | CC | 16568 | 471 | 4196 | 4344 | 1656 | 0 | 0 | 27235 | 6.3 |
| | Cracking clay | C | 132616 | 1234 | 10293 | 8332 | 3831 | 13 | 0 | 156319 | 36.1 |
| Soil chemical constraints | None | | 263079 | 5578 | 46118 | 43986 | 16369 | 239 | 0 | 375369 | 86.7 |
| | S/S/G* | CC | 17329 | 2340 | 2010 | 518 | 149 | 0 | 0 | 22346 | 5.2 |
| Miscellaneous land units | | CC | 34078 | 50 | 800 | 258 | 93 | 0 | 0 | 35279 | 8.1 |
| Total *without* constraints | | | 0 | 0 | 0 | 9926 | 2209 | 0 | 0 | 12135 | 2.8 |
| Total with *moderate* constraints | | C | 0 | 0 | 20583 | 12090 | 5418 | 191 | 0 | 38282 | 8.8 |
| Total with *severe* constraints | | CC | 314486 | 7968 | 28345 | 22745 | 8984 | 48 | 0 | 382576 | 88.4 |
| Total | (1000 ha) | | 314486 | 7968 | 48928 | 44761 | 16610 | 239 | 0 | 432992 | 100.0 |
| | (%) | | 72.6 | 1.8 | 11.3 | 10.3 | 3.8 | 0.1 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A18 Climate, soil and terrain constraints to rain-fed crop production - Southeast Asia**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 0 | 0 | 0 | 0 | 114847 | 217371 | 112001 | 444219 | 99.9 |
| | $LGP_{t=5} < 180$ | C | 0 | 0 | 0 | 264 | 0 | 0 | 0 | 264 | 0.1 |
| | $LGP_{t=5} < 120$ | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Terrain slopes | 0 - 8% | | 0 | 0 | 0 | 3 | 54549 | 83865 | 50042 | 188459 | 42.4 |
| | 8 - 16% | C | 0 | 0 | 0 | 9 | 17955 | 26697 | 18374 | 63035 | 14.2 |
| | 16 - 30% | C | 0 | 0 | 0 | 35 | 21551 | 49499 | 25418 | 96503 | 21.7 |
| | > 30% | CC | 0 | 0 | 0 | 218 | 20792 | 57311 | 18167 | 96488 | 21.7 |
| Soil depth | Deep | | 0 | 0 | 0 | 83 | 84474 | 159400 | 98559 | 342516 | 77.1 |
| | Medium | C | 0 | 0 | 0 | 0 | 0 | 2903 | 3572 | 6475 | 1.5 |
| | Shallow | CC | 0 | 0 | 0 | 181 | 29999 | 54509 | 9776 | 94465 | 21.3 |
| Soil fertility | High | | 0 | 0 | 0 | 0 | 15922 | 24545 | 7033 | 47500 | 10.7 |
| | Medium | C | 0 | 0 | 0 | 83 | 67282 | 124128 | 68648 | 260141 | 58.5 |
| | Low | CC | 0 | 0 | 0 | 181 | 31269 | 68139 | 36226 | 135815 | 30.6 |
| Soil drainage | Good | | 0 | 0 | 0 | 264 | 88671 | 196279 | 101250 | 386464 | 86.9 |
| | Poor | CC | 0 | 0 | 0 | 0 | 25802 | 20533 | 10657 | 56992 | 12.8 |
| Soil texture | Medium/fine | | 0 | 0 | 0 | 170 | 103410 | 193878 | 101694 | 399152 | 89.8 |
| | Sandy/stony | CC | 0 | 0 | 0 | 0 | 4319 | 7649 | 3121 | 15089 | 3.4 |
| | Cracking clay | C | 0 | 0 | 0 | 94 | 6744 | 15286 | 7092 | 29216 | 6.6 |
| Soil chemical constraints | None | | 0 | 0 | 0 | 264 | 112144 | 214012 | 110131 | 436551 | 98.2 |
| | S/S/G* | CC | 0 | 0 | 0 | 0 | 2329 | 2801 | 1776 | 6906 | 1.6 |
| Miscellaneous land units | | CC | 0 | 0 | 0 | 0 | 374 | 559 | 94 | 1027 | 0.2 |
| Total *without* constraints | | | 0 | 0 | 0 | 0 | 2444 | 7403 | 0 | 9847 | 2.2 |
| Total with *moderate* constraints | | C | 0 | 0 | 0 | 66 | 33934 | 72171 | 56655 | 162826 | 36.6 |
| Total with *severe* constraints | | CC | 0 | 0 | 0 | 198 | 78469 | 137798 | 55346 | 271811 | 61.2 |
| Total | (1000 ha) | | 0 | 0 | 0 | 264 | 114847 | 217371 | 112001 | 444483 | 100.0 |
| | (%) | | 0.0 | 0.0 | 0.0 | 0.1 | 25.8 | 48.9 | 25.2 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A19 Climate, soil and terrain constraints to rain-fed crop production - South Asia**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 115023 | 95162 | 135094 | 153894 | 93026 | 47034 | 0 | 639233 | 95.1 |
| | $LGP_{t=5} < 180$ | C | 0 | 6927 | 5421 | 3528 | 0 | 0 | 0 | 15876 | 2.4 |
| | $LGP_{t=5} < 120$ | CC | 868 | 10254 | 5610 | 0 | 0 | 0 | 0 | 16732 | 2.5 |
| Terrain slopes | 0 - 8% | | 55915 | 32426 | 50584 | 94672 | 49633 | 15808 | 0 | 299038 | 44.5 |
| | 8 - 16% | C | 22849 | 20253 | 16106 | 30902 | 12420 | 4538 | 0 | 107068 | 15.9 |
| | 16 - 30% | C | 22678 | 24631 | 27699 | 18921 | 11278 | 7346 | 0 | 112553 | 16.8 |
| | > 30% | CC | 14449 | 35032 | 51735 | 12928 | 19696 | 19341 | 0 | 153181 | 22.8 |
| Soil depth | Deep | | 81665 | 74269 | 102402 | 137213 | 76177 | 35395 | 0 | 507121 | 75.5 |
| | Medium | C | 0 | 0 | 24 | 779 | 1983 | 275 | 0 | 3061 | 0.5 |
| | Shallow | CC | 10105 | 21022 | 29396 | 17232 | 12989 | 10933 | 0 | 101677 | 15.1 |
| Soil fertility | High | | 57014 | 55651 | 87495 | 86163 | 36393 | 9264 | 0 | 331980 | 49.4 |
| | Medium | C | 6758 | 4280 | 7860 | 49815 | 38520 | 27506 | 0 | 134739 | 20.1 |
| | Low | CC | 27998 | 35361 | 36467 | 19246 | 16236 | 9833 | 0 | 145141 | 21.6 |
| Soil drainage | Good | | 90600 | 93078 | 130254 | 150130 | 80646 | 40498 | 0 | 585206 | 87.1 |
| | Poor | CC | 1170 | 2213 | 1568 | 5094 | 10502 | 6105 | 0 | 26652 | 4.0 |
| Soil texture | Medium/fine | | 57319 | 65512 | 93081 | 82938 | 73696 | 43708 | 0 | 416254 | 62.0 |
| | Sandy/stony | CC | 19968 | 18082 | 25531 | 55008 | 5716 | 597 | 0 | 124902 | 18.6 |
| | Cracking clay | C | 14483 | 11697 | 13211 | 17277 | 11736 | 2299 | 0 | 70703 | 10.5 |
| Soil chemical constraints | None | | 67697 | 76686 | 113704 | 148517 | 87760 | 46115 | 0 | 540479 | 80.4 |
| | S/S/G* | CC | 24073 | 18606 | 18118 | 6706 | 3388 | 488 | 0 | 71379 | 10.6 |
| Miscellaneous land units | | CC | 24121 | 17052 | 14302 | 2199 | 1878 | 430 | 0 | 59982 | 8.9 |
| Total *without* constraints | | | 0 | 0 | 0 | 20290 | 15396 | 2753 | 0 | 38439 | 5.7 |
| Total with *moderate* constraints | | C | 0 | 0 | 52445 | 49543 | 36929 | 19063 | 0 | 157980 | 23.5 |
| Total with *severe* constraints | | CC | 115891 | 112343 | 93679 | 87589 | 40702 | 25217 | 0 | 475421 | 70.8 |
| Total | (1000 ha) | | 115891 | 112343 | 146124 | 157422 | 93026 | 47034 | 0 | 671840 | 100.0 |
| | (%) | | 17.2 | 16.7 | 21.7 | 23.4 | 13.8 | 7.0 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum

C: Moderate or slight constraint

CC: Severe constraint

*Notes* Individual constraints are non-additive, i.e., they may overlap.

In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A20 Climate, soil and terrain constraints to rain-fed crop production - East Asia**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 184969 | 35651 | 67521 | 53144 | 108982 | 220562 | 1671 | 672500 | 60.5 |
| | $LGP_{t=5} < 180$ | C | 60011 | 43842 | 66075 | 85051 | 0 | 0 | 0 | 254979 | 22.9 |
| | $LGP_{t=5} < 120$ | CC | 40663 | 58645 | 85507 | 0 | 0 | 0 | 0 | 184815 | 16.6 |
| Terrain slopes | 0 - 8% | | 118802 | 35149 | 53389 | 32124 | 19704 | 52261 | 153 | 311582 | 28.0 |
| | 8 - 16% | C | 81561 | 30152 | 38819 | 20702 | 11411 | 31539 | 111 | 214295 | 19.3 |
| | 16 - 30% | C | 53125 | 33589 | 71173 | 44210 | 28559 | 61155 | 277 | 292088 | 26.3 |
| | > 30% | CC | 32154 | 39249 | 55723 | 41159 | 49308 | 75607 | 1130 | 294330 | 26.5 |
| Soil depth | Deep | | 176943 | 70622 | 115110 | 69342 | 54973 | 161081 | 581 | 648652 | 58.3 |
| | Medium | C | 11539 | 191 | 0 | 0 | 0 | 0 | 0 | 11730 | 1.1 |
| | Shallow | CC | 29391 | 30547 | 63752 | 56661 | 46073 | 52190 | 1090 | 279704 | 25.1 |
| Soil fertility | High | | 120959 | 57555 | 97600 | 56113 | 42277 | 45422 | 202 | 420128 | 37.8 |
| | Medium | C | 1460 | 3948 | 12495 | 23121 | 21522 | 86552 | 106 | 149204 | 13.4 |
| | Low | CC | 95454 | 39857 | 68767 | 46769 | 37247 | 81297 | 1363 | 370754 | 33.3 |
| Soil drainage | Good | | 208523 | 98074 | 159259 | 101117 | 86357 | 173229 | 1557 | 828116 | 74.5 |
| | Poor | CC | 9350 | 3286 | 19603 | 24885 | 14689 | 40041 | 114 | 111968 | 10.1 |
| Soil texture | Medium/fine | | 203124 | 99363 | 174046 | 124300 | 98029 | 200577 | 1671 | 901110 | 81.0 |
| | Sandy/stony | CC | 0 | 19 | 1223 | 1055 | 1045 | 8622 | 0 | 11964 | 1.1 |
| | Cracking clay | C | 14750 | 1978 | 3593 | 648 | 1971 | 4071 | 0 | 27011 | 2.4 |
| Soil chemical constraints | None | | 163182 | 89222 | 160783 | 115865 | 99084 | 211660 | 1671 | 841467 | 75.7 |
| | S/S/G* | CC | 54692 | 12138 | 18079 | 10138 | 1962 | 1610 | 0 | 98619 | 8.9 |
| Miscellaneous land units | | CC | 67769 | 36779 | 40242 | 12192 | 7936 | 7292 | 0 | 172210 | 15.5 |
| Total *without* constraints | | | 0 | 0 | 0 | 11145 | 11477 | 5391 | 0 | 28013 | 2.5 |
| Total with *moderate* constraints | | C | 0 | 0 | 64892 | 27204 | 18382 | 62268 | 152 | 172898 | 15.5 |
| Total with *severe* constraints | | CC | 285642 | 138139 | 154212 | 99845 | 79123 | 152904 | 1519 | 911384 | 81.9 |
| Total | (1000 ha) | | 285642 | 138139 | 219104 | 138195 | 108982 | 220562 | 1671 | 1112295 | 100.0 |
| | (%) | | 25.7 | 12.4 | 19.7 | 12.4 | 9.8 | 19.8 | 0.2 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A21 Climate, soil and terrain constraints to rain-fed crop production - Central Asia**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5}$ > 180 | | 0 | 278918 | 54054 | 7540 | 3836 | 986 | 0 | 345334 | 83.3 |
| | $LGP_{t=5}$ < 180 | C | 0 | 37112 | 17420 | 4098 | 0 | 0 | 0 | 58630 | 14.1 |
| | $LGP_{t=5}$ < 120 | CC | 211 | 9395 | 793 | 0 | 0 | 0 | 0 | 10399 | 2.5 |
| Terrain slopes | 0 - 8% | | 0 | 251666 | 25385 | 2342 | 328 | 357 | 0 | 280078 | 67.6 |
| | 8 - 16% | C | 3 | 46825 | 12545 | 1208 | 369 | 124 | 0 | 61074 | 14.7 |
| | 16 - 30% | C | 16 | 12907 | 14911 | 2729 | 942 | 206 | 0 | 31711 | 7.7 |
| | > 30% | CC | 191 | 14028 | 19426 | 5359 | 2196 | 300 | 0 | 41500 | 10.0 |
| Soil depth | Deep | | 19 | 203783 | 42090 | 6088 | 1865 | 757 | 0 | 254602 | 61.4 |
| | Medium | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | Shallow | CC | 91 | 38784 | 18462 | 4834 | 1959 | 230 | 0 | 64360 | 15.5 |
| Soil fertility | High | | 2 | 146039 | 36347 | 4402 | 933 | 173 | 0 | 187896 | 45.3 |
| | Medium | C | 20 | 11754 | 7474 | 2107 | 1028 | 577 | 0 | 22960 | 5.5 |
| | Low | CC | 89 | 84774 | 16732 | 4413 | 1863 | 236 | 0 | 108107 | 26.1 |
| Soil drainage | Good | | 111 | 220371 | 54802 | 10111 | 3489 | 938 | 0 | 289822 | 69.9 |
| | Poor | CC | 0 | 22197 | 5751 | 811 | 335 | 48 | 0 | 29142 | 7.0 |
| Soil texture | Medium/fine | | 111 | 206502 | 55954 | 9729 | 3697 | 944 | 0 | 276937 | 66.8 |
| | Sandy/stony | CC | 0 | 192 | 171 | 225 | 82 | 31 | 0 | 701 | 0.2 |
| | Cracking clay | C | 0 | 35874 | 4429 | 968 | 45 | 11 | 0 | 41327 | 10.0 |
| Soil chemical constraints | None | | 111 | 97583 | 49329 | 10507 | 3824 | 986 | 0 | 162340 | 39.2 |
| | S/S/G* | CC | 0 | 144985 | 11223 | 415 | 0 | 0 | 0 | 156623 | 37.8 |
| Miscellaneous land units | | CC | 100 | 82858 | 11714 | 716 | 12 | 0 | 0 | 95400 | 23.0 |
| Total *without* constraints | | | 0 | 0 | 0 | 1418 | 243 | 34 | 0 | 1695 | 0.4 |
| Total with *moderate* constraints | | C | 0 | 0 | 26225 | 2846 | 1059 | 542 | 0 | 30672 | 7.4 |
| Total with *severe* constraints | | CC | 211 | 325426 | 46041 | 7375 | 2534 | 410 | 0 | 381997 | 92.2 |
| Total | (1000 ha) | | 211 | 325426 | 72267 | 11639 | 3836 | 986 | 0 | 414365 | 100.0 |
| | (%) | | 0.1 | 78.5 | 17.4 | 2.8 | 0.9 | 0.2 | 0.0 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A22 Climate, soil and terrain constraints to rain-fed crop production - Japan**

| Constraints | | | 0 days CC | 1-60 days CC | 60-119 days C | 120-179 days | 180-269 days | 270-365 days | 365+ days C | Totals (1000 ha) | Totals (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | $LGP_{t=5} > 180$ | | 0 | 0 | 0 | 0 | 23002 | 12356 | 652 | 36010 | 96.9 |
| | $LGP_{t=5} < 180$ | C | 0 | 0 | 0 | 1168 | 0 | 0 | 0 | 1168 | 3.1 |
| | $LGP_{t=5} < 120$ | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Terrain slopes | 0 - 8% | | 0 | 0 | 0 | 115 | 3338 | 2977 | 124 | 6554 | 17.6 |
| | 8 - 16% | C | 0 | 0 | 0 | 125 | 2920 | 1695 | 116 | 4856 | 13.1 |
| | 16 - 30% | C | 0 | 0 | 0 | 383 | 7867 | 3909 | 250 | 12409 | 33.4 |
| | > 30% | CC | 0 | 0 | 0 | 545 | 8877 | 3775 | 161 | 13358 | 35.9 |
| Soil depth | Deep | | 0 | 0 | 0 | 358 | 10638 | 10282 | 477 | 21755 | 58.5 |
| | Medium | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | Shallow | CC | 0 | 0 | 0 | 810 | 12364 | 2004 | 174 | 15352 | 41.3 |
| Soil fertility | High | | 0 | 0 | 0 | 174 | 5729 | 3563 | 100 | 9566 | 25.7 |
| | Medium | C | 0 | 0 | 0 | 528 | 11654 | 6443 | 378 | 19003 | 51.1 |
| | Low | CC | 0 | 0 | 0 | 467 | 5619 | 2281 | 174 | 8541 | 23.0 |
| Soil drainage | Good | | 0 | 0 | 0 | 1165 | 22324 | 11664 | 652 | 35805 | 96.3 |
| | Poor | CC | 0 | 0 | 0 | 2 | 677 | 623 | 0 | 1302 | 3.5 |
| Soil texture | Medium/fine | | 0 | 0 | 0 | 1106 | 21878 | 12090 | 643 | 35717 | 96.1 |
| | Sandy/stony | CC | 0 | 0 | 0 | 62 | 1124 | 196 | 9 | 1391 | 3.7 |
| | Cracking clay | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Soil chemical constraints | None | | 0 | 0 | 0 | 1168 | 23002 | 12287 | 652 | 37109 | 99.8 |
| | S/S/G* | CC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Miscellaneous land units | | CC | 0 | 0 | 0 | 0 | 0 | 70 | 0 | 70 | 0.2 |
| Total *without* constraints | | | 0 | 0 | 0 | 0 | 1742 | 1834 | 0 | 3576 | 9.6 |
| Total with *moderate* constraints | | C | 0 | 0 | 0 | 242 | 5790 | 5367 | 351 | 11750 | 31.6 |
| Total with *severe* constraints | | CC | 0 | 0 | 0 | 926 | 15470 | 5156 | 301 | 21853 | 58.8 |
| Total | (1000 ha) | | 0 | 0 | 0 | 1168 | 23002 | 12356 | 652 | 37178 | 100.0 |
| | (%) | | 0.0 | 0.0 | 0.0 | 3.1 | 61.9 | 33.2 | 1.8 | 100.0 | |

* Salinity/Sodicity/Gypsum
C: Moderate or slight constraint
CC: Severe constraint
*Notes* Individual constraints are non-additive, i.e., they may overlap.
In areas with 365 days temperature growing periods, LGP 0 days is referred to as Hyper-arid moisture regime, LGP 1-60 days as Arid, LGP 60-119 days as Dry Semi-arid LGP 120-179 days as Moist Semi-arid, LGP 180-269 as Sub-humid, LGP 270-365 days as Humid, and LGP 365+ as Per-humid regime.

**Table A23 Gross extents with cultivation potential for rain-fed cereals (1000 ha) - intermediate input level**

| REGION | NAME | TOTAL[37] | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 58101 | 138333 | 102550 | 14.0 | 87590 | 18.1 | 1751924 | 81.9 |
| 21 | Eastern Europe | 170952 | 23125 | 40632 | 39337 | 60.3 | 23604 | 74.1 | 44254 | 25.9 |
| 22 | Northern Europe | 172524 | 7905 | 16118 | 14005 | 22.0 | 9817 | 27.7 | 124679 | 72.3 |
| 23 | Southern Europe | 131643 | 7297 | 13512 | 16069 | 28.0 | 13540 | 38.3 | 81225 | 61.7 |
| 24 | Western Europe | 109547 | 20214 | 22311 | 15493 | 53.0 | 9230 | 61.4 | 42299 | 38.6 |
| 25 | Russian Fed. | 1674146 | 29461 | 79188 | 73301 | 10.9 | 80533 | 15.7 | 1411663 | 84.3 |
| | | **2258812** | **88002** | **171761** | **158205** | **18.5** | **136724** | **24.6** | **1704120** | **75.4** |
| 31 | Caribbean | 23397 | 2888 | 3168 | 2652 | 37.2 | 1376 | 43.1 | 13313 | 56.9 |
| 32 | Central America | 248353 | 10061 | 15218 | 14526 | 16.0 | 12056 | 20.9 | 196492 | 79.1 |
| | | **271750** | **12949** | **18386** | **17178** | **17.9** | **13432** | **22.8** | **209805** | **77.2** |
| 41 | South America | 1777573 | 129633 | 267930 | 178526 | 32.4 | 178166 | 42.4 | 1023318 | 57.6 |
| 51 | Oceania | 793540 | 20903 | 29102 | 37384 | 11.0 | 28892 | 14.7 | 677259 | 85.3 |
| 52 | Polynesia | 56118 | 215 | 1353 | 1138 | 4.8 | 4352 | 12.6 | 49060 | 87.4 |
| | | **849658** | **21118** | **30455** | **38522** | **10.6** | **33244** | **14.5** | **726319** | **85.5** |
| 61 | Eastern Africa | 639474 | 39774 | 81932 | 93996 | 33.7 | 57394 | 42.7 | 366378 | 57.3 |
| 62 | Middle Africa | 657061 | 49793 | 84460 | 82549 | 33.0 | 58757 | 41.9 | 381502 | 58.1 |
| 63 | Northern Africa | 794112 | 19415 | 25473 | 24948 | 8.8 | 19282 | 11.2 | 704994 | 88.8 |
| 64 | Southern Africa | 266428 | 2367 | 7600 | 14446 | 9.2 | 13306 | 14.2 | 228709 | 85.8 |
| 65 | Western Africa | 632996 | 21984 | 83933 | 58792 | 26.0 | 29351 | 30.7 | 438936 | 69.3 |
| | | **2990071** | **133333** | **283398** | **274731** | **23.1** | **178090** | **29.1** | **2120519** | **70.9** |
| 71 | Western Asia | 432992 | 1105 | 6246 | 15445 | 5.3 | 14979 | 8.7 | 395217 | 91.3 |
| 81 | Southeast. Asia | 444483 | 13273 | 31033 | 30337 | 16.8 | 33157 | 24.3 | 336683 | 75.7 |
| 82 | South Asia | 671842 | 60342 | 62476 | 36319 | 23.7 | 26013 | 27.6 | 486692 | 72.4 |
| 84 | East Asia | 1112296 | 13682 | 40605 | 46031 | 9.0 | 43633 | 12.9 | 968345 | 87.1 |
| 85 | Central Asia | 414363 | 815 | 1798 | 7956 | 2.6 | 13942 | 5.9 | 389852 | 94.1 |
| 86 | Japan | 37178 | 1588 | 3780 | 3413 | 23.6 | 2741 | 31.0 | 25656 | 69.0 |
| | | **2680162** | **89700** | **139692** | **124056** | **13.2** | **119486** | **17.6** | **2207228** | **82.4** |
| | **DEVELOPING** | **8171488** | **365347** | **713225** | **607661** | **20.6** | **505764** | **26.8** | **5979491** | **73.2** |
| | **DEVELOPED** | **5228028** | **168594** | **342976** | **301552** | **15.6** | **255947** | **20.4** | **4158959** | **79.6** |
| | **WORLD TOTAL** | **13399516** | **533941** | **1056201** | **909213** | **18.7** | **761711** | **24.3** | **10138450** | **75.7** |

[37] Total extent derived from digital version of the Soil Map of the World (FAO, 1995c).

**Table A24 Gross extents with cultivation potential for rain-fed root and tuber crops (1000 ha) - intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 7697 | 50970 | 109676 | 7.9 | 133873 | 14.1 | 1836282 | 85.9 |
| 21 | Eastern Europe | 170952 | 12759 | 20906 | 32195 | 38.5 | 27226 | 54.5 | 77866 | 45.5 |
| 22 | Northern Europe | 172524 | 4957 | 7027 | 8300 | 11.8 | 16304 | 21.2 | 135936 | 78.8 |
| 23 | Southern Europe | 131643 | 649 | 4791 | 9837 | 11.6 | 10438 | 19.5 | 105928 | 80.5 |
| 24 | Western Europe | 109547 | 2022 | 10667 | 20275 | 30.1 | 13836 | 42.7 | 62747 | 57.3 |
| 25 | Russian Fed. | 1674146 | 17376 | 66487 | 61981 | 8.7 | 60911 | 12.3 | 1467391 | 87.7 |
| | | **2258812** | **37763** | **109878** | **132588** | **12.4** | **128715** | **18.1** | **1849868** | **81.9** |
| 31 | Caribbean | 23397 | 2165 | 3356 | 1757 | 31.1 | 1190 | 36.2 | 14929 | 63.8 |
| 32 | Central America | 248353 | 4744 | 11180 | 9836 | 10.4 | 9009 | 14.0 | 213584 | 86.0 |
| | | **271750** | **6909** | **14536** | **11593** | **12.2** | **10199** | **15.9** | **228513** | **84.1** |
| 41 | South America | 1777573 | 56759 | 202812 | 162248 | 23.7 | 156478 | 32.5 | 1199276 | 67.5 |
| 51 | Oceania | 793540 | 3385 | 10310 | 19807 | 4.2 | 23732 | 7.2 | 736306 | 92.8 |
| 52 | Polynesia | 56118 | 111 | 683 | 666 | 2.6 | 3197 | 8.3 | 51461 | 91.7 |
| | | **849658** | **3496** | **10993** | **20473** | **4.1** | **26929** | **7.3** | **787767** | **92.7** |
| 61 | Eastern Africa | 639474 | 11657 | 37990 | 54252 | 16.2 | 52742 | 24.5 | 482833 | 75.5 |
| 62 | Middle Africa | 657061 | 14536 | 69582 | 78614 | 24.8 | 80174 | 37.0 | 414155 | 63.0 |
| 63 | Northern Africa | 794112 | 1441 | 12409 | 16981 | 3.9 | 13002 | 5.5 | 750279 | 94.5 |
| 64 | Southern Africa | 266428 | 251 | 1848 | 3580 | 2.1 | 5941 | 4.4 | 254808 | 95.6 |
| 65 | Western Africa | 632996 | 10046 | 40890 | 35243 | 13.6 | 20861 | 16.9 | 525956 | 83.1 |
| | | **2990071** | **37931** | **162719** | **188670** | **13.0** | **172720** | **18.8** | **2428031** | **81.2** |
| 71 | Western Asia | 432992 | 52 | 262 | 1794 | 0.5 | 3962 | 1.4 | 426922 | 98.6 |
| 81 | Southeast. Asia | 444483 | 8231 | 22508 | 23246 | 12.1 | 26134 | 18.0 | 364364 | 82.0 |
| 82 | South Asia | 671842 | 9722 | 27730 | 30622 | 10.1 | 37031 | 15.6 | 566737 | 84.4 |
| 84 | East Asia | 1112296 | 4197 | 18379 | 36091 | 5.3 | 43595 | 9.2 | 1010034 | 90.8 |
| 85 | Central Asia | 414363 | 178 | 703 | 853 | 0.4 | 2249 | 1.0 | 410380 | 99.0 |
| 86 | Japan | 37178 | 445 | 1834 | 2532 | 12.9 | 3235 | 21.6 | 29132 | 78.4 |
| | | **2680162** | **22773** | **71154** | **93344** | **7.0** | **112244** | **11.2** | **2380647** | **88.8** |
| | **DEVELOPING** | **8171488** | **124090** | **450332** | **455783** | **12.6** | **455565** | **18.2** | **6685718** | **81.8** |
| | **DEVELOPED** | **5228028** | **49290** | **172992** | **264603** | **9.3** | **289555** | **14.9** | **4451588** | **85.1** |
| | **WORLD TOTAL** | **13399516** | **173380** | **623324** | **720386** | **11.3** | **745120** | **16.9** | **11137306** | **83.1** |

**Table A25 Gross extents with cultivation potential for rain-fed pulses (1000 ha) - intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 17657 | 67530 | 104363 | 8.9 | 69668 | 12.1 | 1879280 | 87.9 |
| 21 | Eastern Europe | 170952 | 14853 | 27577 | 26868 | 40.5 | 16957 | 50.5 | 84697 | 49.5 |
| 22 | Northern Europe | 172524 | 2947 | 9368 | 7321 | 11.4 | 4399 | 13.9 | 148489 | 86.1 |
| 23 | Southern Europe | 131643 | 2212 | 5129 | 6312 | 10.4 | 3448 | 13.0 | 114542 | 87.0 |
| 24 | Western Europe | 109547 | 6899 | 13879 | 12851 | 30.7 | 10099 | 39.9 | 65819 | 60.1 |
| 25 | Russian Fed. | 1674146 | 6744 | 50493 | 62468 | 7.2 | 40286 | 9.6 | 1514155 | 90.4 |
| | | **2258812** | **33655** | **106446** | **115820** | **11.3** | **75189** | **14.7** | **1927702** | **85.3** |
| 31 | Caribbean | 23397 | 929 | 2625 | 2848 | 27.4 | 1847 | 35.3 | 15148 | 64.7 |
| 32 | Central America | 248353 | 4393 | 8994 | 11269 | 9.9 | 9212 | 13.6 | 214485 | 86.4 |
| | | **271750** | **5322** | **11619** | **14117** | **11.4** | **11059** | **15.5** | **229633** | **84.5** |
| 41 | South America | 1777573 | 26146 | 89094 | 193639 | 17.4 | 174984 | 27.2 | 1293710 | 72.8 |
| 51 | Oceania | 793540 | 5120 | 14108 | 19907 | 4.9 | 19582 | 7.4 | 734823 | 92.6 |
| 52 | Polynesia | 56118 | 48 | 287 | 666 | 1.8 | 641 | 2.9 | 54476 | 97.1 |
| | | **849658** | **5168** | **14395** | **20573** | **4.7** | **20223** | **7.1** | **789299** | **92.9** |
| 61 | Eastern Africa | 639474 | 26782 | 64323 | 75793 | 26.1 | 55797 | 34.8 | 416779 | 65.2 |
| 62 | Middle Africa | 657061 | 12980 | 40936 | 80554 | 20.5 | 76350 | 32.1 | 446241 | 67.9 |
| 63 | Northern Africa | 794112 | 12048 | 19358 | 14663 | 5.8 | 15093 | 7.7 | 732950 | 92.3 |
| 64 | Southern Africa | 266428 | 1338 | 4425 | 7287 | 4.9 | 10043 | 8.7 | 243335 | 91.3 |
| 65 | Western Africa | 632996 | 6811 | 44096 | 50180 | 16.0 | 45820 | 23.2 | 486089 | 76.8 |
| | | **2990071** | **59959** | **173138** | **228477** | **15.4** | **203103** | **22.2** | **2325394** | **77.8** |
| 71 | Western Asia | 432992 | 417 | 367 | 777 | 0.4 | 651 | 0.5 | 430780 | 99.5 |
| 81 | Southeast. Asia | 444483 | 1499 | 15833 | 21602 | 8.8 | 20573 | 13.4 | 384976 | 86.6 |
| 82 | South Asia | 671842 | 13307 | 52587 | 36376 | 15.2 | 27395 | 19.3 | 542177 | 80.7 |
| 84 | East Asia | 1112296 | 4336 | 21441 | 32562 | 5.2 | 36327 | 8.5 | 1017630 | 91.5 |
| 85 | Central Asia | 414363 | 40 | 606 | 1602 | 0.5 | 3192 | 1.3 | 408923 | 98.7 |
| 86 | Japan | 37178 | 496 | 2227 | 3079 | 15.6 | 2993 | 23.7 | 28383 | 76.3 |
| | | **2680162** | **19678** | **92694** | **95221** | **7.7** | **90480** | **11.1** | **2382089** | **88.9** |
| | **DEVELOPING** | **8171488** | **111074** | **364972** | **529818** | **12.3** | **477925** | **18.2** | **6687699** | **81.8** |
| | **DEVELOPED** | **5228028** | **56928** | **190311** | **243169** | **9.4** | **167432** | **12.6** | **4570188** | **87.4** |
| | **WORLD TOTAL** | **13399516** | **168002** | **555283** | **772987** | **11.2** | **645357** | **16.0** | **11257887** | **84.0** |

**Table A26 Gross extents with cultivation potential for rain-fed oil crops (1000 ha) - intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 16288 | 96819 | 142621 | 12.0 | 81023 | 15.7 | 1801747 | 84.3 |
| 21 | Eastern Europe | 170952 | 19180 | 29927 | 31713 | 47.3 | 28942 | 64.2 | 61190 | 35.8 |
| 22 | Northern Europe | 172524 | 6085 | 9150 | 11535 | 15.5 | 9453 | 21.0 | 136301 | 79.0 |
| 23 | Southern Europe | 131643 | 4840 | 14161 | 16361 | 26.9 | 15090 | 38.3 | 81191 | 61.7 |
| 24 | Western Europe | 109547 | 7504 | 15974 | 19366 | 39.1 | 15212 | 53.0 | 51491 | 47.0 |
| 25 | Russian Fed. | 1674146 | 24302 | 46492 | 46857 | 7.0 | 69057 | 11.2 | 1487438 | 88.8 |
| | | **2258812** | **61911** | **115704** | **125832** | **13.4** | **137754** | **19.5** | **1817611** | **80.5** |
| 31 | Caribbean | 23397 | 1156 | 3052 | 2562 | 28.9 | 2026 | 37.6 | 14601 | 62.4 |
| 32 | Central America | 248353 | 6806 | 11379 | 12779 | 12.5 | 10934 | 16.9 | 206455 | 83.1 |
| | | **271750** | **7962** | **14431** | **15341** | **13.9** | **12960** | **18.7** | **221056** | **81.3** |
| 41 | South America | 1777573 | 49020 | 191935 | 229954 | 26.5 | 201070 | 37.8 | 1105594 | 62.2 |
| 51 | Oceania | 793540 | 9320 | 25658 | 32820 | 8.5 | 42008 | 13.8 | 683734 | 86.2 |
| 52 | Polynesia | 56118 | 465 | 2617 | 5196 | 14.8 | 2456 | 19.1 | 45384 | 80.9 |
| | | **849658** | **9785** | **28275** | **38016** | **9.0** | **44464** | **14.2** | **729118** | **85.8** |
| 61 | Eastern Africa | 639474 | 31738 | 90285 | 72356 | 30.4 | 50226 | 38.3 | 394869 | 61.7 |
| 62 | Middle Africa | 657061 | 20317 | 92552 | 84282 | 30.0 | 83405 | 42.7 | 376505 | 57.3 |
| 63 | Northern Africa | 794112 | 13879 | 28952 | 23144 | 8.3 | 21393 | 11.0 | 706744 | 89.0 |
| 64 | Southern Africa | 266428 | 1041 | 6693 | 12415 | 7.6 | 15629 | 13.4 | 230650 | 86.6 |
| 65 | Western Africa | 632996 | 8324 | 61972 | 56066 | 20.0 | 53855 | 28.5 | 452779 | 71.5 |
| | | **2990071** | **75299** | **280454** | **248263** | **20.2** | **224508** | **27.7** | **2161547** | **72.3** |
| 71 | Western Asia | 432992 | 2094 | 5048 | 7184 | 3.3 | 7835 | 5.1 | 410831 | 94.9 |
| 81 | Southeast. Asia | 444483 | 7869 | 29161 | 39587 | 17.2 | 28363 | 23.6 | 339503 | 76.4 |
| 82 | South Asia | 671842 | 21908 | 61224 | 50884 | 19.9 | 30893 | 24.5 | 506933 | 75.5 |
| 84 | East Asia | 1112296 | 5347 | 17311 | 29416 | 4.7 | 38394 | 8.1 | 1021828 | 91.9 |
| 85 | Central Asia | 414363 | 502 | 1129 | 1688 | 0.8 | 5829 | 2.2 | 405215 | 97.8 |
| 86 | Japan | 37178 | 872 | 2939 | 3217 | 18.9 | 3236 | 27.6 | 26914 | 72.4 |
| | | **2680162** | **36498** | **111764** | **124792** | **10.2** | **106715** | **14.2** | **2300393** | **85.8** |
| | **DEVELOPING** | **8171488** | **170466** | **603310** | **627513** | **17.1** | **552308** | **23.9** | **6217891** | **76.1** |
| | **DEVELOPED** | **5228028** | **88391** | **241120** | **304490** | **12.1** | **264021** | **17.2** | **4330006** | **82.8** |
| | **WORLD TOTAL** | **13399516** | **258857** | **844430** | **932003** | **15.2** | **816329** | **21.3** | **10547897** | **78.7** |

**Table A27 Gross extents with cultivation potential for rain-fed sugar crops (1000 ha) - intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 14042 | 73899 | 77636 | 7.7 | 50780 | 10.1 | 1922141 | 89.9 |
| 21 | Eastern Europe | 170952 | 5844 | 21346 | 18829 | 26.9 | 12138 | 34.0 | 112795 | 66.0 |
| 22 | Northern Europe | 172524 | 138 | 5754 | 9395 | 8.9 | 9641 | 14.4 | 147596 | 85.6 |
| 23 | Southern Europe | 131643 | 1770 | 6758 | 6809 | 11.7 | 4591 | 15.1 | 111715 | 84.9 |
| 24 | Western Europe | 109547 | 7275 | 13569 | 9611 | 27.8 | 6088 | 33.4 | 73004 | 66.6 |
| 25 | Russian Fed. | 1674146 | 47 | 3131 | 32729 | 2.1 | 62155 | 5.9 | 1576084 | 94.1 |
| | | **2258812** | **15074** | **50558** | **77373** | **6.3** | **94613** | **10.5** | **2021194** | **89.5** |
| 31 | Caribbean | 23397 | 1331 | 2420 | 2360 | 26.1 | 1652 | 33.2 | 15634 | 66.8 |
| 32 | Central America | 248353 | 1676 | 6313 | 8227 | 6.5 | 6887 | 9.3 | 225250 | 90.7 |
| | | **271750** | **3007** | **8733** | **10587** | **8.2** | **8539** | **11.4** | **240884** | **88.6** |
| 41 | South America | 1777573 | 33906 | 81767 | 187859 | 17.1 | 174208 | 26.9 | 1299833 | 73.1 |
| 51 | Oceania | 793540 | 2770 | 6439 | 10136 | 2.4 | 14272 | 4.2 | 759923 | 95.8 |
| 52 | Polynesia | 56118 | 111 | 784 | 2639 | 6.3 | 4837 | 14.9 | 47747 | 85.1 |
| | | **849658** | **2881** | **7223** | **12775** | **2.7** | **19109** | **4.9** | **807670** | **95.1** |
| 61 | Eastern Africa | 639474 | 750 | 6969 | 13771 | 3.4 | 28051 | 7.7 | 589933 | 92.3 |
| 62 | Middle Africa | 657061 | 4327 | 45002 | 52556 | 15.5 | 46890 | 22.6 | 508286 | 77.4 |
| 63 | Northern Africa | 794112 | 0 | 536 | 4449 | 0.6 | 11348 | 2.1 | 777779 | 97.9 |
| 64 | Southern Africa | 266428 | 44 | 288 | 966 | 0.5 | 1840 | 1.2 | 263290 | 98.8 |
| 65 | Western Africa | 632996 | 123 | 2347 | 11429 | 2.2 | 24481 | 6.1 | 594616 | 93.9 |
| | | **2990071** | **5244** | **55142** | **83171** | **4.8** | **112610** | **8.6** | **2733904** | **91.4** |
| 71 | Western Asia | 432992 | 77 | 372 | 1027 | 0.3 | 1392 | 0.7 | 430124 | 99.3 |
| 81 | Southeast. Asia | 444483 | 1471 | 8199 | 29177 | 8.7 | 41347 | 18.0 | 364289 | 82.0 |
| 82 | South Asia | 671842 | 409 | 3575 | 11075 | 2.2 | 22802 | 5.6 | 633981 | 94.4 |
| 84 | East Asia | 1112296 | 2775 | 11514 | 21840 | 3.2 | 27073 | 5.7 | 1049094 | 94.3 |
| 85 | Central Asia | 414363 | 44 | 240 | 446 | 0.2 | 746 | 0.4 | 412887 | 99.6 |
| 86 | Japan | 37178 | 854 | 2276 | 2693 | 15.7 | 2832 | 23.3 | 28523 | 76.7 |
| | | **2680162** | **5553** | **25804** | **65231** | **3.6** | **94800** | **7.1** | **2488774** | **92.9** |
| | **DEVELOPING** | **8171488** | **47044** | **170326** | **347821** | **6.9** | **393554** | **11.7** | **7212743** | **88.3** |
| | **DEVELOPED** | **5228028** | **32740** | **133172** | **167838** | **6.4** | **162497** | **9.5** | **4731781** | **90.5** |
| | **WORLD TOTAL** | **13399516** | **79784** | **303498** | **515659** | **6.7** | **556051** | **10.9** | **11944524** | **89.1** |

**Table A28 Gross extents with cultivation potential for rain-fed cotton (1000 ha) - intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 554 | 2087 | 7229 | 0.5 | 21576 | 1.5 | 2107052 | 98.5 |
| 21 | Eastern Europe | 170952 | 0 | 0 | 0 | 0.0 | 23 | 0.0 | 170929 | 100.0 |
| 22 | Northern Europe | 172524 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 172524 | 100.0 |
| 23 | Southern Europe | 131643 | 0 | 0 | 135 | 0.1 | 362 | 0.4 | 131146 | 99.6 |
| 24 | Western Europe | 109547 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 109547 | 100.0 |
| 25 | Russian Fed. | 1674146 | 0 | 0 | 0 | 0.0 | 133 | 0.0 | 1674013 | 100.0 |
| | | **2258812** | **0** | **0** | **135** | **0.0** | **518** | **0.0** | **2258159** | **100.0** |
| 31 | Caribbean | 23397 | 0 | 394 | 1730 | 9.1 | 2837 | 21.2 | 18436 | 78.8 |
| 32 | Central America | 248353 | 1898 | 3618 | 5896 | 4.6 | 7462 | 7.6 | 229479 | 92.4 |
| | | **271750** | **1898** | **4012** | **7626** | **5.0** | **10299** | **8.8** | **247915** | **91.2** |
| 41 | South America | 1777573 | 3680 | 29778 | 63845 | 5.5 | 114413 | 11.9 | 1565857 | 88.1 |
| 51 | Oceania | 793540 | 4046 | 12895 | 16324 | 4.2 | 13271 | 5.9 | 747004 | 94.1 |
| 52 | Polynesia | 56118 | 62 | 77 | 210 | 0.6 | 303 | 1.2 | 55466 | 98.8 |
| | | **849658** | **4108** | **12972** | **16534** | **4.0** | **13574** | **5.6** | **802470** | **94.4** |
| 61 | Eastern Africa | 639474 | 13991 | 42766 | 56381 | 17.7 | 54111 | 26.2 | 472225 | 73.8 |
| 62 | Middle Africa | 657061 | 6403 | 15618 | 28907 | 7.8 | 46369 | 14.8 | 559764 | 85.2 |
| 63 | Northern Africa | 794112 | 9035 | 17572 | 15983 | 5.4 | 17258 | 7.5 | 734264 | 92.5 |
| 64 | Southern Africa | 266428 | 19 | 388 | 2447 | 1.1 | 6297 | 3.4 | 257277 | 96.6 |
| 65 | Western Africa | 632996 | 5920 | 28241 | 35123 | 10.9 | 33494 | 16.2 | 530218 | 83.8 |
| | | **2990071** | **35368** | **104585** | **138841** | **9.3** | **157529** | **14.6** | **2553748** | **85.4** |
| 71 | Western Asia | 432992 | 0 | 0 | 243 | 0.1 | 473 | 0.2 | 432276 | 99.8 |
| 81 | Southeast. Asia | 444483 | 300 | 1063 | 7937 | 2.1 | 14851 | 5.4 | 420332 | 94.6 |
| 82 | South Asia | 671842 | 22627 | 57464 | 53941 | 19.9 | 28817 | 24.2 | 508993 | 75.8 |
| 84 | East Asia | 1112296 | 0 | 386 | 2378 | 0.2 | 7731 | 0.9 | 1101801 | 99.1 |
| 85 | Central Asia | 414363 | 0 | 0 | 155 | 0.0 | 390 | 0.1 | 413818 | 99.9 |
| 86 | Japan | 37178 | 0 | 0 | 0 | 0.0 | 278 | 0.7 | 36900 | 99.3 |
| | | **2680162** | **22927** | **58913** | **64411** | **5.5** | **52067** | **7.4** | **2481844** | **92.6** |
| | **DEVELOPING** | **8171488** | **63935** | **197365** | **275176** | **6.6** | **334806** | **10.7** | **7300206** | **89.3** |
| | **DEVELOPED** | **5228028** | **4600** | **14982** | **23688** | **0.8** | **35643** | **1.5** | **5149115** | **98.5** |
| | **WORLD TOTAL** | **13399516** | **68535** | **212347** | **298864** | **4.3** | **370449** | **7.1** | **12449321** | **92.9** |

**Table A29 Gross extents with cultivation potential for rain-fed cereals (1000ha) - high input level**

| REGION | NAME | TOTAL[38] | VS | S | MS | % VS+S MS | mS | %VS+S+MS+mS | NS | %NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 88731 | 130385 | 69697 | 13.5 | 38335 | 15.3 | 1811350 | 84.7 |
| 21 | Eastern Europe | 170952 | 21874 | 41697 | 32047 | 55.9 | 17711 | 66.3 | 57623 | 33.7 |
| 22 | Northern Europe | 172524 | 6635 | 21242 | 13057 | 23.7 | 9058 | 29.0 | 122532 | 71.0 |
| 23 | Southern Europe | 131643 | 6508 | 8767 | 6052 | 16.2 | 2666 | 18.2 | 107650 | 81.8 |
| 24 | Western Europe | 109547 | 17673 | 20276 | 11796 | 45.4 | 5644 | 50.6 | 54158 | 49.4 |
| 25 | Russian Fed. | 1674146 | 26789 | 62807 | 87762 | 10.6 | 45487 | 13.3 | 1451301 | 86.7 |
| | | **2258812** | **79479** | **154789** | **150714** | **17.0** | **80566** | **20.6** | **1793264** | **79.4** |
| 31 | Caribbean | 23397 | 4055 | 3445 | 1583 | 38.8 | 611 | 41.4 | 13703 | 58.6 |
| 32 | Central America | 248353 | 13402 | 16304 | 9155 | 15.6 | 3201 | 16.9 | 206291 | 83.1 |
| | | **271750** | **17457** | **19749** | **10738** | **17.6** | **3812** | **19.0** | **219994** | **81.0** |
| 41 | South America | 1777573 | 220063 | 297140 | 180779 | 39.3 | 125759 | 46.3 | 953832 | 53.7 |
| 51 | Oceania | 793540 | 27017 | 26508 | 20340 | 9.3 | 11178 | 10.7 | 708497 | 89.3 |
| 52 | Polynesia | 56118 | 1088 | 2304 | 4242 | 13.6 | 7481 | 26.9 | 41003 | 73.1 |
| | | **849658** | **28105** | **28812** | **24582** | **9.6** | **18659** | **11.8** | **749500** | **88.2** |
| 61 | Eastern Africa | 639474 | 73794 | 80540 | 57164 | 33.1 | 21100 | 36.4 | 406876 | 63.6 |
| 62 | Middle Africa | 657061 | 103090 | 117349 | 70201 | 44.2 | 22947 | 47.7 | 343474 | 52.3 |
| 63 | Northern Africa | 794112 | 45471 | 25425 | 12303 | 10.5 | 6139 | 11.3 | 704774 | 88.7 |
| 64 | Southern Africa | 266428 | 2196 | 4067 | 4088 | 3.9 | 1990 | 4.6 | 254087 | 95.4 |
| 65 | Western Africa | 632996 | 60173 | 76166 | 44164 | 28.5 | 19070 | 31.5 | 433423 | 68.5 |
| | | **2990071** | **284724** | **303547** | **187920** | **26.0** | **71246** | **28.3** | **2142634** | **71.7** |
| 71 | Western Asia | 432992 | 824 | 4189 | 6055 | 2.6 | 2967 | 3.2 | 418957 | 96.8 |
| 81 | Southeast. Asia | 444483 | 37632 | 50917 | 28857 | 26.4 | 32480 | 33.7 | 294597 | 66.3 |
| 82 | South Asia | 671842 | 94278 | 71252 | 26814 | 28.6 | 7845 | 29.8 | 471653 | 70.2 |
| 84 | East Asia | 1112296 | 40318 | 43563 | 31889 | 10.4 | 13814 | 11.7 | 982712 | 88.3 |
| 85 | Central Asia | 414363 | 519 | 759 | 4919 | 1.5 | 2809 | 2.2 | 405357 | 97.8 |
| 86 | Japan | 37178 | 2871 | 2415 | 1349 | 17.8 | 744 | 19.8 | 29799 | 80.2 |
| | | **2680162** | **175618** | **168906** | **93828** | **16.4** | **57692** | **18.5** | **2184118** | **81.5** |
| | **DEVELOPING** | **8171488** | **696903** | **793420** | **482213** | **24.1** | **268213** | **27.4** | **5930739** | **72.6** |
| | **DEVELOPED** | **5228028** | **198098** | **314097** | **242100** | **14.4** | **130823** | **16.9** | **4342910** | **83.1** |
| | **WORLD TOTAL** | **13399516** | **895001** | **1107517** | **724313** | **20.4** | **399036** | **23.3** | **10273649** | **76.7** |

[38] Total extent derived from digital version of the Soil Map of the World (FAO, 1995c).

**Table A30 Gross extents with cultivation potential for rain-fed roots and tuber crops (1000ha) - high input level**

| REGION | NAME | TOTAL | VS | S | MS | % VS+S MS | mS | %VS+S+MS+mS | NS | %NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 7148 | 47805 | 116431 | 8.0 | 100740 | 12.7 | 1866374 | 87.3 |
| 21 | Eastern Europe | 170952 | 7633 | 26714 | 32085 | 38.9 | 14541 | 47.4 | 89979 | 52.6 |
| 22 | Northern Europe | 172524 | 2437 | 6796 | 9930 | 11.1 | 9201 | 16.4 | 144160 | 83.6 |
| 23 | Southern Europe | 131643 | 825 | 2976 | 6297 | 7.7 | 4734 | 11.3 | 116811 | 88.7 |
| 24 | Western Europe | 109547 | 2079 | 6231 | 12996 | 19.4 | 11513 | 30.0 | 76728 | 70.0 |
| 25 | Russian Fed. | 1674146 | 7653 | 63661 | 59876 | 7.8 | 39167 | 10.2 | 1503789 | 89.8 |
| | | **2258812** | **20627** | **106378** | **121184** | **11.0** | **79156** | **14.5** | **1931467** | **85.5** |
| 31 | Caribbean | 23397 | 4136 | 3320 | 1300 | 37.4 | 638 | 40.2 | 14003 | 59.8 |
| 32 | Central America | 248353 | 10920 | 14592 | 8633 | 13.7 | 5922 | 16.1 | 208286 | 83.9 |
| | | **271750** | **15056** | **17912** | **9933** | **15.8** | **6560** | **18.2** | **222289** | **81.8** |
| 41 | South America | 1777573 | 166031 | 210351 | 156556 | 30.0 | 166572 | 39.4 | 1078063 | 60.6 |
| 51 | Oceania | 793540 | 4451 | 12174 | 16212 | 4.1 | 16037 | 6.2 | 744666 | 93.8 |
| 52 | Polynesia | 56118 | 948 | 550 | 1470 | 5.3 | 9377 | 22.0 | 43773 | 78.0 |
| | | **849658** | **5399** | **12724** | **17682** | **4.2** | **25414** | **7.2** | **788439** | **92.8** |
| 61 | Eastern Africa | 639474 | 26652 | 56116 | 53339 | 21.3 | 38174 | 27.3 | 465193 | 72.7 |
| 62 | Middle Africa | 657061 | 60524 | 89335 | 92882 | 36.9 | 84938 | 49.9 | 329382 | 50.1 |
| 63 | Northern Africa | 794112 | 10564 | 22508 | 19941 | 6.7 | 11204 | 8.1 | 729895 | 91.9 |
| 64 | Southern Africa | 266428 | 255 | 498 | 866 | 0.6 | 1612 | 1.2 | 263197 | 98.8 |
| 65 | Western Africa | 632996 | 34118 | 48395 | 32711 | 18.2 | 17433 | 21.0 | 500339 | 79.0 |
| | | **2990071** | **132113** | **216852** | **199739** | **18.4** | **153361** | **23.5** | **2288006** | **76.5** |
| 71 | Western Asia | 432992 | 56 | 318 | 669 | 0.2 | 439 | 0.3 | 431510 | 99.7 |
| 81 | Southeast. Asia | 444483 | 46364 | 32513 | 26495 | 23.7 | 41743 | 33.1 | 297368 | 66.9 |
| 82 | South Asia | 671842 | 27442 | 43596 | 38843 | 16.4 | 38738 | 22.1 | 523223 | 77.9 |
| 84 | East Asia | 1112296 | 7178 | 23632 | 34162 | 5.8 | 30580 | 8.6 | 1016744 | 91.4 |
| 85 | Central Asia | 414363 | 212 | 415 | 264 | 0.2 | 232 | 0.3 | 413240 | 99.7 |
| 86 | Japan | 37178 | 981 | 1643 | 1406 | 10.8 | 2235 | 16.9 | 30913 | 83.1 |
| | | **2680162** | **82177** | **101799** | **101170** | **10.6** | **113528** | **14.9** | **2281488** | **85.1** |
| | **DEVELOPING** | **8171488** | **395400** | **546139** | **468131** | **17.3** | **447602** | **22.7** | **6314216** | **77.3** |
| | **DEVELOPED** | **5228028** | **33207** | **168000** | **255233** | **8.7** | **198168** | **12.5** | **4573420** | **87.5** |
| | **WORLD TOTAL** | **13399516** | **428607** | **714139** | **723364** | **13.9** | **645770** | **18.7** | **10887636** | **81.3** |

**Table A31 Gross extents with cultivation potential for rain-fed pulses (1000ha) - high input level**

| REGION | NAME | TOTAL | VS | S | MS | % VS+S MS | mS | %VS+S+MS+mS | NS | %NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 21146 | 80537 | 65618 | 7.8 | 22586 | 8.9 | 1948611 | 91.1 |
| 21 | Eastern Europe | 170952 | 9526 | 20078 | 9507 | 22.9 | 825 | 23.4 | 131016 | 76.6 |
| 22 | Northern Europe | 172524 | 1179 | 2516 | 1683 | 3.1 | 1149 | 3.8 | 165997 | 96.2 |
| 23 | Southern Europe | 131643 | 2041 | 5716 | 1711 | 7.2 | 574 | 7.6 | 121601 | 92.4 |
| 24 | Western Europe | 109547 | 6263 | 4921 | 2635 | 12.6 | 616 | 13.2 | 95112 | 86.8 |
| 25 | Russian Fed. | 1674146 | 5892 | 47326 | 19620 | 4.4 | 3263 | 4.5 | 1598045 | 95.5 |
| | | **2258812** | **24901** | **80557** | **35156** | **6.2** | **6427** | **6.5** | **2111771** | **93.5** |
| 31 | Caribbean | 23397 | 1402 | 3326 | 2536 | 31.0 | 1634 | 38.0 | 14499 | 62.0 |
| 32 | Central America | 248353 | 7308 | 11509 | 10108 | 11.6 | 8023 | 14.9 | 211405 | 85.1 |
| | | **271750** | **8710** | **14835** | **12644** | **13.3** | **9657** | **16.9** | **225904** | **83.1** |
| 41 | South America | 1777573 | 36104 | 164193 | 223175 | 23.8 | 176612 | 33.8 | 1177489 | 66.2 |
| 51 | Oceania | 793540 | 7523 | 15789 | 18695 | 5.3 | 11261 | 6.7 | 740272 | 93.3 |
| 52 | Polynesia | 56118 | 117 | 693 | 645 | 2.6 | 3353 | 8.6 | 51310 | 91.4 |
| | | **849658** | **7640** | **16482** | **19340** | **5.1** | **14614** | **6.8** | **791582** | **93.2** |
| 61 | Eastern Africa | 639474 | 62917 | 71327 | 53970 | 29.4 | 34706 | 34.9 | 416554 | 65.1 |
| 62 | Middle Africa | 657061 | 41226 | 76303 | 83719 | 30.6 | 91616 | 44.6 | 364197 | 55.4 |
| 63 | Northern Africa | 794112 | 26802 | 26391 | 13087 | 8.3 | 9414 | 9.5 | 718418 | 90.5 |
| 64 | Southern Africa | 266428 | 350 | 1329 | 3334 | 1.9 | 4838 | 3.7 | 256577 | 96.3 |
| 65 | Western Africa | 632996 | 33240 | 56496 | 48373 | 21.8 | 35946 | 27.5 | 458941 | 72.5 |
| | | **2990071** | **164535** | **231846** | **202483** | **20.0** | **176520** | **25.9** | **2214687** | **74.1** |
| 71 | Western Asia | 432992 | 0 | 159 | 32 | 0.0 | 75 | 0.1 | 432726 | 99.9 |
| 81 | Southeast. Asia | 444483 | 16986 | 37704 | 24423 | 17.8 | 30635 | 24.7 | 334735 | 75.3 |
| 82 | South Asia | 671842 | 20299 | 71849 | 50872 | 21.3 | 16370 | 23.7 | 512452 | 76.3 |
| 84 | East Asia | 1112296 | 10160 | 36740 | 35885 | 7.4 | 25062 | 9.7 | 1004449 | 90.3 |
| 85 | Central Asia | 414363 | 162 | 193 | 160 | 0.1 | 244 | 0.2 | 413604 | 99.8 |
| 86 | Japan | 37178 | 1327 | 2853 | 1842 | 16.2 | 1008 | 18.9 | 30148 | 81.1 |
| | | **2680162** | **48934** | **149339** | **113182** | **11.6** | **73319** | **14.4** | **2295388** | **85.6** |
| | **DEVELOPING** | **8171488** | **257073** | **558212** | **550319** | **16.7** | **438528** | **22.1** | **6367356** | **77.9** |
| | **DEVELOPED** | **5228028** | **54897** | **179736** | **121311** | **6.8** | **41282** | **7.6** | **4830802** | **92.4** |
| | **WORLD TOTAL** | **13399516** | **311970** | **737948** | **671630** | **12.8** | **479810** | **16.4** | **11198158** | **83.6** |

**Table A32 Gross extents with cultivation potential for rain-fed oil crops (1000ha) - high input level**

| REGION | NAME | TOTAL | VS | S | MS | % VS+S MS | mS | %VS+S+MS+mS | NS | %NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 12456 | 76481 | 132788 | 10.4 | 74949 | 13.9 | 1841824 | 86.1 |
| 21 | Eastern Europe | 170952 | 12418 | 23605 | 35161 | 41.6 | 22106 | 54.6 | 77662 | 45.4 |
| 22 | Northern Europe | 172524 | 3571 | 9908 | 14273 | 16.1 | 9125 | 21.4 | 135647 | 78.6 |
| 23 | Southern Europe | 131643 | 2890 | 9709 | 7492 | 15.3 | 6020 | 19.8 | 105532 | 80.2 |
| 24 | Western Europe | 109547 | 6599 | 8415 | 19659 | 31.7 | 6834 | 37.9 | 68040 | 62.1 |
| 25 | Russian Fed. | 1674146 | 22219 | 37731 | 36467 | 5.8 | 69194 | 9.9 | 1508535 | 90.1 |
| | | **2258812** | **47697** | **89368** | **113052** | **11.1** | **113279** | **16.1** | **1895416** | **83.9** |
| 31 | Caribbean | 23397 | 1090 | 2444 | 3915 | 31.8 | 1919 | 40.0 | 14029 | 60.0 |
| 32 | Central America | 248353 | 11108 | 10627 | 11654 | 13.4 | 8832 | 17.0 | 206132 | 83.0 |
| | | **271750** | **12198** | **13071** | **15569** | **15.0** | **10751** | **19.0** | **220161** | **81.0** |
| 41 | South America | 1777573 | 146383 | 267376 | 237711 | 36.6 | 208420 | 48.4 | 917683 | 51.6 |
| 51 | Oceania | 793540 | 11500 | 25388 | 34357 | 9.0 | 23040 | 11.9 | 699255 | 88.1 |
| 52 | Polynesia | 56118 | 6887 | 3191 | 3119 | 23.5 | 3053 | 29.0 | 39868 | 71.0 |
| | | **849658** | **18387** | **28579** | **37476** | **9.9** | **26093** | **13.0** | **739123** | **87.0** |
| 61 | Eastern Africa | 639474 | 74475 | 89478 | 46022 | 32.8 | 26204 | 36.9 | 403295 | 63.1 |
| 62 | Middle Africa | 657061 | 85490 | 113846 | 99814 | 45.5 | 78946 | 57.5 | 278965 | 42.5 |
| 63 | Northern Africa | 794112 | 27221 | 31674 | 17083 | 9.6 | 13275 | 11.2 | 704859 | 88.8 |
| 64 | Southern Africa | 266428 | 591 | 2307 | 6309 | 3.5 | 6089 | 5.7 | 251132 | 94.3 |
| 65 | Western Africa | 632996 | 52004 | 53432 | 55199 | 25.4 | 38857 | 31.5 | 433504 | 68.5 |
| | | **2990071** | **239781** | **290737** | **224427** | **25.2** | **163371** | **30.7** | **2071755** | **69.3** |
| 71 | Western Asia | 432992 | 1161 | 2542 | 3621 | 1.7 | 3922 | 2.6 | 421746 | 97.4 |
| 81 | Southeast. Asia | 444483 | 47773 | 42381 | 47338 | 30.9 | 27168 | 37.0 | 279823 | 63.0 |
| 82 | South Asia | 671842 | 41771 | 79410 | 64404 | 27.6 | 20708 | 30.7 | 465549 | 69.3 |
| 84 | East Asia | 1112296 | 12944 | 22070 | 32674 | 6.1 | 26448 | 8.5 | 1018160 | 91.5 |
| 85 | Central Asia | 414363 | 343 | 352 | 395 | 0.3 | 2932 | 1.0 | 410341 | 99.0 |
| 86 | Japan | 37178 | 1842 | 2369 | 1685 | 15.9 | 1327 | 19.4 | 29955 | 80.6 |
| | | **2680162** | **104673** | **146582** | **146496** | **14.8** | **78583** | **17.8** | **2203828** | **82.2** |
| | **DEVELOPING** | **8171488** | **509241** | **721130** | **629258** | **22.8** | **466773** | **28.5** | **5845086** | **71.5** |
| | **DEVELOPED** | **5228028** | **73495** | **193606** | **281882** | **10.5** | **212595** | **14.6** | **4466450** | **85.4** |
| | **WORLD TOTAL** | **13399516** | **582736** | **914736** | **911140** | **18.0** | **679368** | **23.0** | **10311536** | **77.0** |

**Table A33 Gross extents with cultivation potential for rain-fed sugar crops (1000ha) - high input level**

| REGION | NAME | TOTAL | VS | S | MS | % VS+S MS | mS | %VS+S+MS+mS | NS | %NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 13916 | 42566 | 44034 | 4.7 | 28495 | 6.0 | 2009487 | 94.0 |
| 21 | Eastern Europe | 170952 | 4968 | 3608 | 1096 | 5.7 | 312 | 5.8 | 160968 | 94.2 |
| 22 | Northern Europe | 172524 | 27 | 1424 | 4718 | 3.6 | 4390 | 6.1 | 161965 | 93.9 |
| 23 | Southern Europe | 131643 | 1861 | 3519 | 2262 | 5.8 | 633 | 6.3 | 123368 | 93.7 |
| 24 | Western Europe | 109547 | 5613 | 4322 | 1376 | 10.3 | 261 | 10.6 | 97975 | 89.4 |
| 25 | Russian Fed. | 1674146 | 497 | 3951 | 12484 | 1.0 | 37229 | 3.2 | 1619985 | 96.8 |
| | | **2258812** | **12966** | **16824** | **21936** | **2.3** | **42825** | **4.2** | **2164261** | **95.8** |
| 31 | Caribbean | 23397 | 1151 | 3658 | 3070 | 33.7 | 662 | 36.5 | 14856 | 63.5 |
| 32 | Central America | 248353 | 5616 | 9299 | 8346 | 9.4 | 5708 | 11.7 | 219384 | 88.3 |
| | | **271750** | **6767** | **12957** | **11416** | **11.5** | **6370** | **13.8** | **234240** | **86.2** |
| 41 | South America | 1777573 | 49368 | 143689 | 278488 | 26.5 | 224469 | 39.2 | 1081559 | 60.8 |
| 51 | Oceania | 793540 | 2511 | 5099 | 6482 | 1.8 | 9866 | 3.0 | 769582 | 97.0 |
| 52 | Polynesia | 56118 | 514 | 4065 | 6738 | 20.2 | 4361 | 27.9 | 40440 | 72.1 |
| | | **849658** | **3025** | **9164** | **13220** | **3.0** | **14227** | **4.7** | **810022** | **95.3** |
| 61 | Eastern Africa | 639474 | 3462 | 9128 | 21027 | 5.3 | 43155 | 12.0 | 562702 | 88.0 |
| 62 | Middle Africa | 657061 | 34571 | 85814 | 77516 | 30.1 | 68342 | 40.5 | 390818 | 59.5 |
| 63 | Northern Africa | 794112 | 0 | 1529 | 5144 | 0.8 | 22784 | 3.7 | 764655 | 96.3 |
| 64 | Southern Africa | 266428 | 45 | 119 | 289 | 0.2 | 199 | 0.2 | 265776 | 99.8 |
| 65 | Western Africa | 632996 | 940 | 7454 | 21565 | 4.7 | 37204 | 10.6 | 565833 | 89.4 |
| | | **2990071** | **39018** | **104044** | **125541** | **9.0** | **171684** | **14.7** | **2549784** | **85.3** |
| 71 | Western Asia | 432992 | 414 | 309 | 415 | 0.3 | 244 | 0.3 | 431610 | 99.7 |
| 81 | Southeast. Asia | 444483 | 3741 | 31217 | 61903 | 21.8 | 44295 | 31.8 | 303327 | 68.2 |
| 82 | South Asia | 671842 | 1450 | 8546 | 19656 | 4.4 | 33119 | 9.3 | 609071 | 90.7 |
| 84 | East Asia | 1112296 | 6653 | 26241 | 32320 | 5.9 | 18797 | 7.6 | 1028285 | 92.4 |
| 85 | Central Asia | 414363 | 65 | 79 | 96 | 0.1 | 198 | 0.1 | 413925 | 99.9 |
| 86 | Japan | 37178 | 1404 | 2460 | 2154 | 16.2 | 1055 | 19.0 | 30105 | 81.0 |
| | | **2680162** | **13313** | **68543** | **116129** | **7.4** | **97464** | **11.0** | **2384713** | **89.0** |
| | **DEVELOPING** | **8171488** | **107990** | **331147** | **536573** | **11.9** | **503537** | **18.1** | **6692241** | **81.9** |
| | **DEVELOPED** | **5228028** | **30797** | **66949** | **74606** | **3.3** | **82241** | **4.9** | **4973435** | **95.1** |
| | **WORLD TOTAL** | **13399516** | **138787** | **398096** | **611179** | **8.6** | **585778** | **12.9** | **11665676** | **87.1** |

**Table A34 Gross extents with cultivation potential for rain-fed cotton (1000ha) - high input level**

| REGION | NAME | TOTAL | VS | S | MS | % VS+S MS | mS | %VS+S+MS+mS | NS | %NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 1054 | 2316 | 3559 | 0.3 | 6692 | 0.6 | 2124877 | 99.4 |
| 21 | Eastern Europe | 170952 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 170952 | 100.0 |
| 22 | Northern Europe | 172524 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 172524 | 100.0 |
| 23 | Southern Europe | 131643 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 131643 | 100.0 |
| 24 | Western Europe | 109547 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 109547 | 100.0 |
| 25 | Russian Fed. | 1674146 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 1674146 | 100.0 |
| | | **2258812** | **0** | **0** | **0** | **0.0** | **0** | **0.0** | **2258812** | **100.0** |
| 31 | Caribbean | 23397 | 0 | 292 | 2152 | 10.4 | 3554 | 25.6 | 17399 | 74.4 |
| 32 | Central America | 248353 | 3740 | 4184 | 4835 | 5.1 | 7116 | 8.0 | 228478 | 92.0 |
| | | **271750** | **3740** | **4476** | **6987** | **5.6** | **10670** | **9.5** | **245877** | **90.5** |
| 41 | South America | 1777573 | 6576 | 33652 | 71551 | 6.3 | 137213 | 14.0 | 1528581 | 86.0 |
| 51 | Oceania | 793540 | 4612 | 15017 | 12182 | 4.0 | 5683 | 4.7 | 756046 | 95.3 |
| 52 | Polynesia | 56118 | 90 | 86 | 315 | 0.9 | 440 | 1.7 | 55187 | 98.3 |
| | | **849658** | **4702** | **15103** | **12497** | **3.8** | **6123** | **4.5** | **811233** | **95.5** |
| 61 | Eastern Africa | 639474 | 32944 | 56024 | 53730 | 22.3 | 32226 | 27.4 | 464550 | 72.6 |
| 62 | Middle Africa | 657061 | 17568 | 26944 | 41924 | 13.2 | 52771 | 21.2 | 517854 | 78.8 |
| 63 | Northern Africa | 794112 | 21232 | 25279 | 13597 | 7.6 | 10404 | 8.9 | 723600 | 91.1 |
| 64 | Southern Africa | 266428 | 3 | 345 | 1351 | 0.6 | 1462 | 1.2 | 263267 | 98.8 |
| 65 | Western Africa | 632996 | 18862 | 42440 | 38322 | 15.7 | 35312 | 21.3 | 498060 | 78.7 |
| | | **2990071** | **90609** | **151032** | **148924** | **13.1** | **132175** | **17.5** | **2467331** | **82.5** |
| 71 | Western Asia | 432992 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 432992 | 100.0 |
| 81 | Southeast. Asia | 444483 | 590 | 3508 | 22690 | 6.0 | 35996 | 14.1 | 381699 | 85.9 |
| 82 | South Asia | 671842 | 40589 | 83846 | 47429 | 25.6 | 16619 | 28.1 | 483359 | 71.9 |
| 84 | East Asia | 1112296 | 0 | 118 | 836 | 0.1 | 12833 | 1.2 | 1098509 | 98.8 |
| 85 | Central Asia | 414363 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 414363 | 100.0 |
| 86 | Japan | 37178 | 0 | 0 | 0 | 0.0 | 1152 | 3.1 | 36026 | 96.9 |
| | | **2680162** | **41179** | **87472** | **70955** | **7.4** | **66600** | **9.9** | **2413956** | **90.1** |
| | **DEVELOPING** | **8171488** | **142194** | **276718** | **298732** | **8.8** | **345946** | **13.0** | **7107898** | **87.0** |
| | **DEVELOPED** | **5228028** | **5666** | **17333** | **15741** | **0.7** | **13527** | **1.0** | **5175761** | **99.0** |
| | **WORLD TOTAL** | **13399516** | **147860** | **294051** | **314473** | **5.6** | **359473** | **8.3** | **12283659** | **91.7** |

**Table A35 Gross extents with cultivation potential for rain-fed plus irrigated cereals (1000 ha) - intermediate input level**

| REGION | NAME | TOTAL[39] | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 83358 | 137565 | 97233 | 14.9 | 76474 | 18.5 | 1743868 | 81.5 |
| 21 | Eastern Europe | 170952 | 26738 | 41297 | 37408 | 61.7 | 21797 | 74.4 | 43712 | 25.6 |
| 22 | Northern Europe | 172524 | 8584 | 15557 | 13899 | 22.0 | 9807 | 27.7 | 124677 | 72.3 |
| 23 | Southern Europe | 131643 | 9836 | 13105 | 15194 | 29.0 | 12844 | 38.7 | 80664 | 61.3 |
| 24 | Western Europe | 109547 | 21633 | 21839 | 14727 | 53.1 | 9131 | 61.5 | 42217 | 38.5 |
| 25 | Russian Fed. | 1674146 | 39671 | 89441 | 68471 | 11.8 | 66818 | 15.8 | 1409745 | 84.2 |
| | | **2258812** | **106462** | **181239** | **149699** | **19.4** | **120397** | **24.7** | **1701015** | **75.3** |
| 31 | Caribbean | 23397 | 3142 | 3427 | 2348 | 38.1 | 1230 | 43.4 | 13250 | 56.6 |
| 32 | Central America | 248353 | 11325 | 16405 | 14595 | 17.0 | 10611 | 21.3 | 195417 | 78.7 |
| | | **271750** | **14467** | **19832** | **16943** | **18.9** | **11841** | **23.2** | **208667** | **76.8** |
| 41 | South America | 1777573 | 146289 | 273503 | 177696 | 33.6 | 164869 | 42.9 | 1015216 | 57.1 |
| 51 | Oceania | 793540 | 42486 | 40236 | 29818 | 14.2 | 20244 | 16.7 | 660756 | 83.3 |
| 52 | Polynesia | 56118 | 215 | 1376 | 1189 | 5.0 | 4281 | 12.6 | 49057 | 87.4 |
| | | **849658** | **42701** | **41612** | **31007** | **13.6** | **24525** | **16.5** | **709813** | **83.5** |
| 61 | Eastern Africa | 639474 | 46624 | 84995 | 91042 | 34.8 | 53918 | 43.3 | 362895 | 56.7 |
| 62 | Middle Africa | 657061 | 52200 | 89304 | 84580 | 34.4 | 52481 | 42.4 | 378496 | 57.6 |
| 63 | Northern Africa | 794112 | 28395 | 27817 | 26666 | 10.4 | 15669 | 12.4 | 695565 | 87.6 |
| 64 | Southern Africa | 266428 | 4375 | 8015 | 13801 | 9.8 | 12749 | 14.6 | 227488 | 85.4 |
| 65 | Western Africa | 632996 | 24451 | 86726 | 58976 | 26.9 | 27032 | 31.2 | 435811 | 68.8 |
| | | **2990071** | **156045** | **296857** | **275065** | **24.3** | **161849** | **29.8** | **2100255** | **70.2** |
| 71 | Western Asia | 432992 | 5442 | 7633 | 14676 | 6.4 | 14228 | 9.7 | 391013 | 90.3 |
| 81 | Southeast. Asia | 444483 | 13329 | 31949 | 31036 | 17.2 | 31830 | 24.3 | 336339 | 75.7 |
| 82 | South Asia | 671842 | 69263 | 62729 | 37256 | 25.2 | 20735 | 28.3 | 481859 | 71.7 |
| 84 | East Asia | 1112296 | 21498 | 45098 | 43988 | 9.9 | 39738 | 13.5 | 961974 | 86.5 |
| 85 | Central Asia | 414363 | 4859 | 5204 | 7057 | 4.1 | 9616 | 6.5 | 387627 | 93.5 |
| 86 | Japan | 37178 | 1588 | 3864 | 3453 | 24.0 | 2659 | 31.1 | 25614 | 68.9 |
| | | **2680162** | **110537** | **148844** | **122790** | **14.3** | **104578** | **18.2** | **2193413** | **81.8** |
| | **DEVELOPING** | **8171488** | **431407** | **744181** | **604906** | **21.8** | **458987** | **27.4** | **5932007** | **72.6** |
| | **DEVELOPED** | **5228028** | **233894** | **362904** | **280203** | **16.8** | **219774** | **21.0** | **4131253** | **79.0** |
| | **WORLD TOTAL** | **13399516** | **665301** | **1107085** | **885109** | **19.8** | **678761** | **24.9** | **10063260** | **75.1** |

[39] Total extent derived from digital version of the Soil Map of the World (FAO, 1995c).

**Table A36 Gross extents with cultivation potential for rain-fed plus irrigated root and tubers (1000 ha) - Intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 21649 | 64026 | 99656 | 8.7 | 124601 | 14.5 | 1828566 | 85.5 |
| 21 | Eastern Europe | 170952 | 13498 | 23692 | 30649 | 39.7 | 25386 | 54.5 | 77727 | 45.5 |
| 22 | Northern Europe | 172524 | 4957 | 7532 | 7861 | 11.8 | 16238 | 21.2 | 135936 | 78.8 |
| 23 | Southern Europe | 131643 | 2324 | 5934 | 9227 | 13.3 | 9954 | 20.8 | 104204 | 79.2 |
| 24 | Western Europe | 109547 | 2965 | 11841 | 19238 | 31.1 | 13097 | 43.0 | 62406 | 57.0 |
| 25 | Russian Fed. | 1674146 | 20653 | 79373 | 61119 | 9.6 | 48652 | 12.5 | 1464349 | 87.5 |
| | | **2258812** | **44397** | **128372** | **128094** | **13.3** | **113327** | **18.3** | **1844622** | **81.7** |
| 31 | Caribbean | 23397 | 2216 | 3416 | 1736 | 31.5 | 1167 | 36.5 | 14862 | 63.5 |
| 32 | Central America | 248353 | 5756 | 11784 | 9974 | 11.1 | 8536 | 14.5 | 212303 | 85.5 |
| | | **271750** | **7972** | **15200** | **11710** | **12.8** | **9703** | **16.4** | **227165** | **83.6** |
| 41 | South America | 1777573 | 72898 | 212371 | 157087 | 24.9 | 149107 | 33.3 | 1186110 | 66.7 |
| 51 | Oceania | 793540 | 17904 | 27179 | 18433 | 8.0 | 16673 | 10.1 | 713351 | 89.9 |
| 52 | Polynesia | 56118 | 209 | 766 | 670 | 2.9 | 3102 | 8.5 | 51371 | 91.5 |
| | | **849658** | **18113** | **27945** | **19103** | **7.7** | **19775** | **10.0** | **764722** | **90.0** |
| 61 | Eastern Africa | 639474 | 18742 | 44145 | 52037 | 18.0 | 49451 | 25.7 | 475099 | 74.3 |
| 62 | Middle Africa | 657061 | 16291 | 74618 | 78276 | 25.7 | 76653 | 37.4 | 411223 | 62.6 |
| 63 | Northern Africa | 794112 | 8881 | 20477 | 13719 | 5.4 | 11037 | 6.8 | 739998 | 93.2 |
| 64 | Southern Africa | 266428 | 959 | 2528 | 3757 | 2.7 | 5731 | 4.9 | 253453 | 95.1 |
| 65 | Western Africa | 632996 | 12342 | 46048 | 34493 | 14.7 | 18898 | 17.7 | 521215 | 82.3 |
| | | **2990071** | **57215** | **187816** | **182282** | **14.3** | **161770** | **19.7** | **2400988** | **80.3** |
| 71 | Western Asia | 432992 | 2240 | 2341 | 1824 | 1.5 | 3813 | 2.4 | 422774 | 97.6 |
| 81 | Southeast. Asia | 444483 | 9015 | 23723 | 23087 | 12.6 | 25334 | 18.3 | 363324 | 81.7 |
| 82 | South Asia | 671842 | 19066 | 41006 | 28898 | 13.2 | 26447 | 17.2 | 556425 | 82.8 |
| 84 | East Asia | 1112296 | 9619 | 23093 | 34349 | 6.0 | 39308 | 9.6 | 1005927 | 90.4 |
| 85 | Central Asia | 414363 | 1071 | 2279 | 1522 | 1.2 | 1623 | 1.6 | 407868 | 98.4 |
| 86 | Japan | 37178 | 445 | 1857 | 2561 | 13.1 | 3183 | 21.6 | 29132 | 78.4 |
| | | **2680162** | **39216** | **91958** | **90417** | **8.3** | **95895** | **11.8** | **2362676** | **88.2** |
| | **DEVELOPING** | **8171488** | **179305** | **508595** | **441429** | **13.8** | **420207** | **19.0** | **6621952** | **81.0** |
| | **DEVELOPED** | **5228028** | **84395** | **221434** | **248744** | **10.6** | **257784** | **15.5** | **4415671** | **84.5** |
| | **WORLD TOTAL** | **13399516** | **263700** | **730029** | **690173** | **12.6** | **677991** | **17.6** | **11037623** | **82.4** |

**Table A37 Gross extents with cultivation potential for rain-fed plus irrigated pulses (1000 ha) - intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 28812 | 80200 | 95227 | 9.6 | 68161 | 12.7 | 1866098 | 87.3 |
| 21 | Eastern Europe | 170952 | 18720 | 26991 | 25510 | 41.7 | 16529 | 51.3 | 83202 | 48.7 |
| 22 | Northern Europe | 172524 | 3408 | 9749 | 7095 | 11.7 | 4337 | 14.3 | 147935 | 85.7 |
| 23 | Southern Europe | 131643 | 4527 | 6496 | 5833 | 12.8 | 3314 | 15.3 | 111473 | 84.7 |
| 24 | Western Europe | 109547 | 8891 | 15816 | 12124 | 33.6 | 9473 | 42.3 | 63243 | 57.7 |
| 25 | Russian Fed. | 1674146 | 9113 | 59325 | 62724 | 7.8 | 38383 | 10.1 | 1504601 | 89.9 |
| | | **2258812** | **44659** | **118377** | **113286** | **12.2** | **72036** | **15.4** | **1910454** | **84.6** |
| 31 | Caribbean | 23397 | 932 | 2636 | 2855 | 27.5 | 1830 | 35.3 | 15144 | 64.7 |
| 32 | Central America | 248353 | 5196 | 9313 | 11301 | 10.4 | 8929 | 14.0 | 213614 | 86.0 |
| | | **271750** | **6128** | **11949** | **14156** | **11.9** | **10759** | **15.8** | **228758** | **84.2** |
| 41 | South America | 1777573 | 37439 | 91627 | 189935 | 17.9 | 171408 | 27.6 | 1287164 | 72.4 |
| 51 | Oceania | 793540 | 27138 | 24699 | 15400 | 8.5 | 12166 | 10.0 | 714137 | 90.0 |
| 52 | Polynesia | 56118 | 48 | 292 | 684 | 1.8 | 618 | 2.9 | 54476 | 97.1 |
| | | **849658** | **27186** | **24991** | **16084** | **8.0** | **12784** | **9.5** | **768613** | **90.5** |
| 61 | Eastern Africa | 639474 | 30460 | 68429 | 75384 | 27.3 | 53618 | 35.6 | 411583 | 64.4 |
| 62 | Middle Africa | 657061 | 13472 | 41966 | 79850 | 20.6 | 75829 | 32.1 | 445944 | 67.9 |
| 63 | Northern Africa | 794112 | 19650 | 22032 | 13793 | 7.0 | 14069 | 8.8 | 724568 | 91.2 |
| 64 | Southern Africa | 266428 | 2159 | 4818 | 7037 | 5.3 | 9615 | 8.9 | 242799 | 91.1 |
| 65 | Western Africa | 632996 | 8456 | 45309 | 49962 | 16.4 | 44889 | 23.5 | 484380 | 76.5 |
| | | **2990071** | **74197** | **182554** | **226026** | **16.1** | **198020** | **22.8** | **2309274** | **77.2** |
| 71 | Western Asia | 432992 | 3542 | 2790 | 1122 | 1.7 | 557 | 1.9 | 424981 | 98.1 |
| 81 | Southeast. Asia | 444483 | 1499 | 15902 | 21631 | 8.8 | 20480 | 13.4 | 384971 | 86.6 |
| 82 | South Asia | 671842 | 17508 | 68630 | 39813 | 18.7 | 24948 | 22.5 | 520943 | 77.5 |
| 84 | East Asia | 1112296 | 5380 | 26679 | 31931 | 5.8 | 34168 | 8.8 | 1014138 | 91.2 |
| 85 | Central Asia | 414363 | 702 | 3257 | 3290 | 1.7 | 2462 | 2.3 | 404652 | 97.7 |
| 86 | Japan | 37178 | 496 | 2237 | 3092 | 15.7 | 2970 | 23.7 | 28383 | 76.3 |
| | | **2680162** | **25585** | **116705** | **99757** | **9.0** | **85028** | **12.2** | **2353087** | **87.8** |
| | **DEVELOPING** | **8171488** | **146443** | **403680** | **528588** | **13.2** | **463420** | **18.9** | **6629357** | **81.1** |
| | **DEVELOPED** | **5228028** | **101105** | **225513** | **227005** | **10.6** | **155333** | **13.6** | **4519072** | **86.4** |
| | **WORLD TOTAL** | **13399516** | **247548** | **629193** | **755593** | **12.2** | **618753** | **16.8** | **11148429** | **83.2** |

**Table A38 Gross extents with cultivation potential for rain-fed plus irrigated oil crops (1000 ha) - intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 33879 | 101981 | 132872 | 12.6 | 75288 | 16.1 | 1794478 | 83.9 |
| 21 | Eastern Europe | 170952 | 22850 | 30530 | 29682 | 48.6 | 26873 | 64.3 | 61017 | 35.7 |
| 22 | Northern Europe | 172524 | 6135 | 10167 | 10591 | 15.6 | 9332 | 21.0 | 136299 | 79.0 |
| 23 | Southern Europe | 131643 | 6891 | 14340 | 15447 | 27.9 | 14114 | 38.6 | 80851 | 61.4 |
| 24 | Western Europe | 109547 | 9439 | 17601 | 17429 | 40.6 | 14078 | 53.4 | 51000 | 46.6 |
| 25 | Russian Fed. | 1674146 | 27819 | 53363 | 48590 | 7.8 | 63068 | 11.5 | 1481306 | 88.5 |
| | | **2258812** | **73134** | **126001** | **121739** | **14.2** | **127465** | **19.8** | **1810473** | **80.2** |
| 31 | Caribbean | 23397 | 1473 | 3139 | 2290 | 29.5 | 1904 | 37.6 | 14591 | 62.4 |
| 32 | Central America | 248353 | 9118 | 11384 | 12268 | 13.2 | 10071 | 17.3 | 205512 | 82.7 |
| | | **271750** | **10591** | **14523** | **14558** | **14.6** | **11975** | **19.0** | **220103** | **81.0** |
| 41 | South America | 1777573 | 78891 | 224299 | 220965 | 29.5 | 156604 | 38.3 | 1096814 | 61.7 |
| 51 | Oceania | 793540 | 31570 | 34807 | 29412 | 12.1 | 27550 | 15.5 | 670201 | 84.5 |
| 52 | Polynesia | 56118 | 562 | 2841 | 5115 | 15.2 | 2275 | 19.2 | 45325 | 80.8 |
| | | **849658** | **32132** | **37648** | **34527** | **12.3** | **29825** | **15.8** | **715526** | **84.2** |
| 61 | Eastern Africa | 639474 | 40864 | 91202 | 70883 | 31.7 | 47760 | 39.2 | 388765 | 60.8 |
| 62 | Middle Africa | 657061 | 25145 | 98798 | 80954 | 31.2 | 76373 | 42.8 | 375791 | 57.2 |
| 63 | Northern Africa | 794112 | 21715 | 31430 | 22283 | 9.5 | 20073 | 12.0 | 698611 | 88.0 |
| 64 | Southern Africa | 266428 | 1904 | 7800 | 12181 | 8.2 | 14902 | 13.8 | 229641 | 86.2 |
| 65 | Western Africa | 632996 | 18551 | 63375 | 51838 | 21.1 | 48656 | 28.8 | 450576 | 71.2 |
| | | **2990071** | **108179** | **292605** | **238139** | **21.4** | **207764** | **28.3** | **2143384** | **71.7** |
| 71 | Western Asia | 432992 | 5352 | 6893 | 7117 | 4.5 | 7330 | 6.2 | 406300 | 93.8 |
| 81 | Southeast. Asia | 444483 | 9521 | 30655 | 37840 | 17.6 | 27100 | 23.6 | 339367 | 76.4 |
| 82 | South Asia | 671842 | 31583 | 68619 | 43192 | 21.3 | 25678 | 25.2 | 502770 | 74.8 |
| 84 | East Asia | 1112296 | 11857 | 20072 | 29172 | 5.5 | 37693 | 8.9 | 1013502 | 91.1 |
| 85 | Central Asia | 414363 | 3054 | 3952 | 2183 | 2.2 | 3568 | 3.1 | 401606 | 96.9 |
| 86 | Japan | 37178 | 872 | 2939 | 3220 | 18.9 | 3233 | 27.6 | 26914 | 72.4 |
| | | **2680162** | **56887** | **126237** | **115607** | **11.1** | **97272** | **14.8** | **2284159** | **85.2** |
| | **DEVELOPING** | **8171488** | **259590** | **664459** | **598281** | **18.6** | **479987** | **24.5** | **6169171** | **75.5** |
| | **DEVELOPED** | **5228028** | **139455** | **265728** | **287243** | **13.2** | **233536** | **17.7** | **4302066** | **82.3** |
| | **WORLD TOTAL** | **13399516** | **399045** | **930187** | **885524** | **16.5** | **713523** | **21.9** | **10471237** | **78.1** |

**Table A39 Gross extents with cultivation potential for rain-fed plus irrigated sugar crops (1000 ha) - intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 31432 | 80918 | 73291 | 8.7 | 47509 | 10.9 | 1905348 | 89.1 |
| 21 | Eastern Europe | 170952 | 9361 | 22721 | 17894 | 29.2 | 11779 | 36.1 | 109197 | 63.9 |
| 22 | Northern Europe | 172524 | 387 | 6062 | 9157 | 9.0 | 9622 | 14.6 | 147296 | 85.4 |
| 23 | Southern Europe | 131643 | 4758 | 7547 | 6588 | 14.4 | 4261 | 17.6 | 108489 | 82.4 |
| 24 | Western Europe | 109547 | 9354 | 15579 | 9643 | 31.6 | 5845 | 36.9 | 69126 | 63.1 |
| 25 | Russian Fed. | 1674146 | 1440 | 6648 | 33215 | 2.5 | 61427 | 6.1 | 1571416 | 93.9 |
| | | **2258812** | **25300** | **58557** | **76497** | **7.1** | **92934** | **11.2** | **2005524** | **88.8** |
| 31 | Caribbean | 23397 | 2037 | 2567 | 1870 | 27.7 | 1442 | 33.8 | 15481 | 66.2 |
| 32 | Central America | 248353 | 3011 | 8772 | 8066 | 8.0 | 5644 | 10.3 | 222860 | 89.7 |
| | | **271750** | **5048** | **11339** | **9936** | **9.7** | **7086** | **12.3** | **238341** | **87.7** |
| 41 | South America | 1777573 | 47382 | 106251 | 186298 | 19.1 | 157627 | 28.0 | 1280015 | 72.0 |
| 51 | Oceania | 793540 | 27159 | 26984 | 14966 | 8.7 | 9274 | 9.9 | 715157 | 90.1 |
| 52 | Polynesia | 56118 | 135 | 828 | 2680 | 6.5 | 4829 | 15.1 | 47646 | 84.9 |
| | | **849658** | **27294** | **27812** | **17646** | **8.6** | **14103** | **10.2** | **762803** | **89.8** |
| 61 | Eastern Africa | 639474 | 11303 | 22487 | 17539 | 8.0 | 17355 | 10.7 | 570790 | 89.3 |
| 62 | Middle Africa | 657061 | 9782 | 65122 | 52479 | 19.4 | 38992 | 25.3 | 490686 | 74.7 |
| 63 | Northern Africa | 794112 | 8017 | 11443 | 10543 | 3.8 | 8418 | 4.8 | 755691 | 95.2 |
| 64 | Southern Africa | 266428 | 468 | 1799 | 1630 | 1.5 | 1778 | 2.1 | 260753 | 97.9 |
| 65 | Western Africa | 632996 | 3512 | 15266 | 17724 | 5.8 | 20853 | 9.1 | 575641 | 90.9 |
| | | **2990071** | **33082** | **116117** | **99915** | **8.3** | **87396** | **11.3** | **2653561** | **88.7** |
| 71 | Western Asia | 432992 | 2931 | 2982 | 1455 | 1.7 | 1294 | 2.0 | 424330 | 98.0 |
| 81 | Southeast. Asia | 444483 | 2298 | 12101 | 28859 | 9.7 | 37842 | 18.2 | 363383 | 81.8 |
| 82 | South Asia | 671842 | 17747 | 35683 | 20265 | 11.0 | 10921 | 12.6 | 587226 | 87.4 |
| 84 | East Asia | 1112296 | 7767 | 16953 | 21974 | 4.2 | 25747 | 6.5 | 1039855 | 93.5 |
| 85 | Central Asia | 414363 | 1700 | 2157 | 1068 | 1.2 | 655 | 1.3 | 408783 | 98.7 |
| 86 | Japan | 37178 | 854 | 2325 | 2755 | 16.0 | 2797 | 23.5 | 28447 | 76.5 |
| | | **2680162** | **30366** | **69219** | **74921** | **6.5** | **77962** | **9.4** | **2427694** | **90.6** |
| | **DEVELOPING** | **8171488** | **118090** | **304411** | **372450** | **9.7** | **333397** | **13.8** | **7043140** | **86.2** |
| | **DEVELOPED** | **5228028** | **84745** | **168784** | **167509** | **8.1** | **152514** | **11.0** | **4654476** | **89.0** |
| | **WORLD TOTAL** | **13399516** | **202835** | **473195** | **539959** | **9.1** | **485911** | **12.7** | **11697616** | **87.3** |

**Table A40 Gross extents with cultivation potential for rain-fed plus irrigated cotton (1000 ha) - intermediate input level**

| REGION | NAME | TOTAL | VS | S | MS | %VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 7440 | 10451 | 9394 | 1.3 | 19904 | 2.2 | 2091309 | 97.8 |
| 21 | Eastern Europe | 170952 | 0 | 7 | 7 | 0.0 | 17 | 0.0 | 170921 | 100.0 |
| 22 | Northern Europe | 172524 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 172524 | 100.0 |
| 23 | Southern Europe | 131643 | 341 | 883 | 422 | 1.3 | 259 | 1.4 | 129738 | 98.6 |
| 24 | Western Europe | 109547 | 0 | 76 | 30 | 0.1 | 0 | 0.1 | 109441 | 99.9 |
| 25 | Russian Fed. | 1674146 | 0 | 356 | 316 | 0.0 | 36 | 0.0 | 1673438 | 100.0 |
| | | **2258812** | **341** | **1322** | **775** | **0.1** | **312** | **0.1** | **2256062** | **99.9** |
| 31 | Caribbean | 23397 | 18 | 409 | 1699 | 9.1 | 2835 | 21.2 | 18436 | 78.8 |
| 32 | Central America | 248353 | 2689 | 4261 | 6051 | 5.2 | 7113 | 8.1 | 228239 | 91.9 |
| | | **271750** | **2707** | **4670** | **7750** | **5.6** | **9948** | **9.2** | **246675** | **90.8** |
| 41 | South America | 1777573 | 14309 | 39598 | 59206 | 6.4 | 109242 | 12.5 | 1555218 | 87.5 |
| 51 | Oceania | 793540 | 22408 | 26104 | 14051 | 7.9 | 8027 | 8.9 | 722950 | 91.1 |
| 52 | Polynesia | 56118 | 63 | 78 | 210 | 0.6 | 302 | 1.2 | 55465 | 98.8 |
| | | **849658** | **22471** | **26182** | **14261** | **7.4** | **8329** | **8.4** | **778415** | **91.6** |
| 61 | Eastern Africa | 639474 | 20122 | 48859 | 54235 | 19.3 | 50933 | 27.2 | 465325 | 72.8 |
| 62 | Middle Africa | 657061 | 8000 | 18603 | 27070 | 8.2 | 44484 | 14.9 | 558904 | 85.1 |
| 63 | Northern Africa | 794112 | 18721 | 21934 | 14331 | 6.9 | 15048 | 8.8 | 724078 | 91.2 |
| 64 | Southern Africa | 266428 | 840 | 1255 | 2590 | 1.8 | 5995 | 4.0 | 255748 | 96.0 |
| 65 | Western Africa | 632996 | 8550 | 31535 | 33271 | 11.6 | 32342 | 16.7 | 527298 | 83.3 |
| | | **2990071** | **56233** | **122186** | **131497** | **10.4** | **148802** | **15.3** | **2531353** | **84.7** |
| 71 | Western Asia | 432992 | 3093 | 1532 | 422 | 1.2 | 395 | 1.3 | 427550 | 98.7 |
| 81 | Southeast. Asia | 444483 | 304 | 1079 | 7946 | 2.1 | 14822 | 5.4 | 420332 | 94.6 |
| 82 | South Asia | 671842 | 33310 | 61958 | 48004 | 21.3 | 23927 | 24.9 | 504643 | 75.1 |
| 84 | East Asia | 1112296 | 4103 | 3234 | 1679 | 0.8 | 7198 | 1.5 | 1096082 | 98.5 |
| 85 | Central Asia | 414363 | 370 | 844 | 672 | 0.5 | 266 | 0.5 | 412211 | 99.5 |
| 86 | Japan | 37178 | 0 | 0 | 0 | 0.0 | 278 | 0.7 | 36900 | 99.3 |
| | | **2680162** | **38087** | **67115** | **58301** | **6.1** | **46491** | **7.8** | **2470168** | **92.2** |
| | **DEVELOPING** | **8171488** | **114492** | **235179** | **257386** | **7.4** | **314902** | **11.3** | **7249529** | **88.7** |
| | **DEVELOPED** | **5228028** | **30189** | **37877** | **24220** | **1.8** | **28521** | **2.3** | **5107221** | **97.7** |
| | **WORLD TOTAL** | **13399516** | **144681** | **273056** | **281606** | **5.2** | **343423** | **7.8** | **12356750** | **92.2** |

**Table A41 Gross extents with cultivation potential for rain-fed plus irrigated cereals (1000ha) - high input level**

| REGION | NAME | TOTAL[40] | VS | S | MS | % VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 133718 | 122906 | 60465 | 14.8 | 34387 | 16.4 | 1787022 | 83.6 |
| 21 | Eastern Europe | 170952 | 31700 | 38375 | 28766 | 57.8 | 15855 | 67.1 | 56256 | 32.9 |
| 22 | Northern Europe | 172524 | 9638 | 18462 | 12833 | 23.7 | 9058 | 29.0 | 122533 | 71.0 |
| 23 | Southern Europe | 131643 | 10430 | 7671 | 4825 | 17.4 | 2354 | 19.2 | 106363 | 80.8 |
| 24 | Western Europe | 109547 | 23004 | 16921 | 10484 | 46.0 | 5599 | 51.1 | 53539 | 48.9 |
| 25 | Russian Fed. | 1674146 | 45141 | 80934 | 75006 | 12.0 | 39977 | 14.4 | 1433088 | 85.6 |
| | | **2258812** | **119913** | **162363** | **131914** | **18.3** | **72843** | **21.6** | **1771779** | **78.4** |
| 31 | Caribbean | 23397 | 4607 | 3246 | 1292 | 39.1 | 550 | 41.4 | 13702 | 58.6 |
| 32 | Central America | 248353 | 15577 | 16613 | 8940 | 16.6 | 3009 | 17.8 | 204214 | 82.2 |
| | | **271750** | **20184** | **19859** | **10232** | **18.5** | **3559** | **19.8** | **217916** | **80.2** |
| 41 | South America | 1777573 | 246217 | 293796 | 174822 | 40.2 | 122409 | 47.1 | 940329 | 52.9 |
| 51 | Oceania | 793540 | 56657 | 34627 | 18609 | 13.8 | 8985 | 15.0 | 674662 | 85.0 |
| 52 | Polynesia | 56118 | 1088 | 2310 | 4235 | 13.6 | 7481 | 26.9 | 41004 | 73.1 |
| | | **849658** | **57745** | **36937** | **22844** | **13.8** | **16466** | **15.8** | **715666** | **84.2** |
| 61 | Eastern Africa | 639474 | 86668 | 83072 | 54215 | 35.0 | 19895 | 38.1 | 395624 | 61.9 |
| 62 | Middle Africa | 657061 | 104328 | 117470 | 69523 | 44.3 | 22814 | 47.8 | 342926 | 52.2 |
| 63 | Northern Africa | 794112 | 64138 | 28512 | 11671 | 13.1 | 5290 | 13.8 | 684501 | 86.2 |
| 64 | Southern Africa | 266428 | 6529 | 5046 | 4093 | 5.9 | 1961 | 6.6 | 248799 | 93.4 |
| 65 | Western Africa | 632996 | 65857 | 78010 | 43276 | 29.6 | 18620 | 32.5 | 427233 | 67.5 |
| | | **2990071** | **327520** | **312110** | **182778** | **27.5** | **68580** | **29.8** | **2099083** | **70.2** |
| 71 | Western Asia | 432992 | 8513 | 6549 | 5205 | 4.7 | 2747 | 5.3 | 409978 | 94.7 |
| 81 | Southeast. Asia | 444483 | 38008 | 50580 | 28818 | 26.4 | 32480 | 33.7 | 294597 | 66.3 |
| 82 | South Asia | 671842 | 109688 | 67843 | 26996 | 30.4 | 7214 | 31.5 | 460101 | 68.5 |
| 84 | East Asia | 1112296 | 51432 | 47990 | 29364 | 11.6 | 12870 | 12.7 | 970640 | 87.3 |
| 85 | Central Asia | 414363 | 9657 | 6760 | 5074 | 5.2 | 2527 | 5.8 | 390345 | 94.2 |
| 86 | Japan | 37178 | 2871 | 2415 | 1349 | 17.8 | 744 | 19.8 | 29799 | 80.2 |
| | | **2680162** | **211656** | **175588** | **91601** | **17.9** | **55835** | **19.9** | **2145482** | **80.1** |
| | **DEVELOPING** | **8171488** | **812307** | **807797** | **467524** | **25.5** | **259867** | **28.7** | **5823993** | **71.3** |
| | **DEVELOPED** | **5228028** | **313159** | **322311** | **212337** | **16.2** | **116959** | **18.5** | **4263262** | **81.5** |
| | **WORLD TOTAL** | **13399516** | **1125466** | **1130108** | **679861** | **21.9** | **376826** | **24.7** | **10087255** | **75.3** |

[40] Total extent derived from digital version of the Soil Map of the World (FAO, 1995c).

**Table A42 Gross extents with cultivation potential for rain-fed plus irrigated roots & tubers (1000ha) - high input level**

| REGION | NAME | TOTAL | VS | S | MS | % VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 29224 | 83081 | 100299 | 9.9 | 85834 | 14.0 | 1840060 | 86.0 |
| 21 | Eastern Europe | 170952 | 9356 | 30767 | 31524 | 41.9 | 13112 | 49.6 | 86193 | 50.4 |
| 22 | Northern Europe | 172524 | 2455 | 7785 | 9740 | 11.6 | 9186 | 16.9 | 143358 | 83.1 |
| 23 | Southern Europe | 131643 | 2921 | 4805 | 5625 | 10.1 | 4370 | 13.5 | 113922 | 86.5 |
| 24 | Western Europe | 109547 | 3195 | 9303 | 13437 | 23.7 | 11060 | 33.8 | 72552 | 66.2 |
| 25 | Russian Fed. | 1674146 | 11392 | 81661 | 65191 | 9.5 | 32416 | 11.4 | 1483486 | 88.6 |
| | | **2258812** | **29319** | **134321** | **125517** | **12.8** | **70144** | **15.9** | **1899511** | **84.1** |
| 31 | Caribbean | 23397 | 4200 | 3278 | 1279 | 37.4 | 638 | 40.2 | 14002 | 59.8 |
| 32 | Central America | 248353 | 12689 | 15575 | 8756 | 14.9 | 5314 | 17.0 | 206019 | 83.0 |
| | | **271750** | **16889** | **18853** | **10035** | **16.8** | **5952** | **19.0** | **220021** | **81.0** |
| 41 | South America | 1777573 | 193105 | 217596 | 147801 | 31.4 | 158437 | 40.3 | 1060634 | 59.7 |
| 51 | Oceania | 793540 | 21876 | 34429 | 16530 | 9.2 | 10873 | 10.5 | 709832 | 89.5 |
| 52 | Polynesia | 56118 | 952 | 546 | 1470 | 5.3 | 9377 | 22.0 | 43773 | 78.0 |
| | | **849658** | **22828** | **34975** | **18000** | **8.9** | **20250** | **11.3** | **753605** | **88.7** |
| 61 | Eastern Africa | 639474 | 43254 | 60704 | 49780 | 24.0 | 33562 | 29.3 | 452174 | 70.7 |
| 62 | Middle Africa | 657061 | 66822 | 92819 | 88929 | 37.8 | 81617 | 50.3 | 326874 | 49.7 |
| 63 | Northern Africa | 794112 | 25689 | 36565 | 15943 | 9.8 | 8749 | 10.9 | 707166 | 89.1 |
| 64 | Southern Africa | 266428 | 5058 | 1691 | 1139 | 3.0 | 1140 | 3.4 | 257400 | 96.6 |
| 65 | Western Africa | 632996 | 39369 | 57462 | 31433 | 20.3 | 14480 | 22.6 | 490252 | 77.4 |
| | | **2990071** | **180192** | **249241** | **187224** | **20.6** | **139548** | **25.3** | **2233866** | **74.7** |
| 71 | Western Asia | 432992 | 4067 | 4546 | 1406 | 2.3 | 400 | 2.4 | 422573 | 97.6 |
| 81 | Southeast. Asia | 444483 | 46474 | 32427 | 26472 | 23.7 | 41743 | 33.1 | 297367 | 66.9 |
| 82 | South Asia | 671842 | 41083 | 59752 | 36094 | 20.4 | 29522 | 24.8 | 505391 | 75.2 |
| 84 | East Asia | 1112296 | 15859 | 35809 | 34352 | 7.7 | 28610 | 10.3 | 997666 | 89.7 |
| 85 | Central Asia | 414363 | 2482 | 7167 | 1210 | 2.6 | 216 | 2.7 | 403288 | 97.3 |
| 86 | Japan | 37178 | 981 | 1643 | 1406 | 10.8 | 2235 | 16.9 | 30913 | 83.1 |
| | | **2680162** | **106879** | **136798** | **99534** | **12.8** | **102326** | **16.6** | **2234625** | **83.4** |
| | **DEVELOPING** | **8171488** | **501103** | **625937** | **446064** | **19.3** | **413805** | **24.3** | **6184579** | **75.7** |
| | **DEVELOPED** | **5228028** | **81400** | **253474** | **243752** | **11.1** | **169086** | **14.3** | **4480316** | **85.7** |
| | **WORLD TOTAL** | **13399516** | **582503** | **879411** | **689816** | **16.1** | **582891** | **20.4** | **10664895** | **79.6** |

**Table A43 Gross extents with cultivation potential for rain-fed plus irrigated pulses (1000ha) - high input level**

| REGION | NAME | TOTAL | VS | S | MS | % VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 51804 | 105813 | 67649 | 10.5 | 21936 | 11.6 | 1891296 | 88.4 |
| 21 | Eastern Europe | 170952 | 21160 | 21545 | 9713 | 30.7 | 825 | 31.1 | 117709 | 68.9 |
| 22 | Northern Europe | 172524 | 2423 | 8381 | 3724 | 8.4 | 1149 | 9.1 | 156847 | 90.9 |
| 23 | Southern Europe | 131643 | 5286 | 6762 | 1629 | 10.4 | 571 | 10.8 | 117395 | 89.2 |
| 24 | Western Europe | 109547 | 11540 | 10910 | 3270 | 23.5 | 609 | 24.0 | 83218 | 76.0 |
| 25 | Russian Fed. | 1674146 | 10717 | 66749 | 28447 | 6.3 | 3259 | 6.5 | 1564974 | 93.5 |
| | | **2258812** | **51126** | **114347** | **46783** | **9.4** | **6413** | **9.7** | **2040143** | **90.3** |
| 31 | Caribbean | 23397 | 1546 | 3203 | 2533 | 31.1 | 1617 | 38.0 | 14498 | 62.0 |
| 32 | Central America | 248353 | 8926 | 12364 | 10248 | 12.7 | 7591 | 15.8 | 209224 | 84.2 |
| | | **271750** | **10472** | **15567** | **12781** | **14.3** | **9208** | **17.7** | **223722** | **82.3** |
| 41 | South America | 1777573 | 57083 | 166909 | 216538 | 24.8 | 172698 | 34.5 | 1164345 | 65.5 |
| 51 | Oceania | 793540 | 32368 | 31241 | 14417 | 9.8 | 7141 | 10.7 | 708373 | 89.3 |
| 52 | Polynesia | 56118 | 117 | 693 | 645 | 2.6 | 3353 | 8.6 | 51310 | 91.4 |
| | | **849658** | **32485** | **31934** | **15062** | **9.4** | **10494** | **10.6** | **759683** | **89.4** |
| 61 | Eastern Africa | 639474 | 73153 | 76080 | 52769 | 31.6 | 32675 | 36.7 | 404797 | 63.3 |
| 62 | Middle Africa | 657061 | 43975 | 75421 | 82921 | 30.8 | 91154 | 44.7 | 363590 | 55.3 |
| 63 | Northern Africa | 794112 | 43551 | 32202 | 12569 | 11.1 | 8077 | 12.1 | 697713 | 87.9 |
| 64 | Southern Africa | 266428 | 5377 | 2153 | 2389 | 3.7 | 3888 | 5.2 | 252621 | 94.8 |
| 65 | Western Africa | 632996 | 38931 | 58899 | 47964 | 23.0 | 34272 | 28.4 | 452930 | 71.6 |
| | | **2990071** | **204987** | **244755** | **198612** | **21.7** | **170066** | **27.4** | **2171651** | **72.6** |
| 71 | Western Asia | 432992 | 5717 | 4532 | 822 | 2.6 | 56 | 2.6 | 421865 | 97.4 |
| 81 | Southeast. Asia | 444483 | 16986 | 37719 | 24413 | 17.8 | 30629 | 24.7 | 334736 | 75.3 |
| 82 | South Asia | 671842 | 27482 | 99578 | 56141 | 27.3 | 14910 | 29.5 | 473731 | 70.5 |
| 84 | East Asia | 1112296 | 12267 | 51950 | 33582 | 8.8 | 23433 | 10.9 | 991064 | 89.1 |
| 85 | Central Asia | 414363 | 3997 | 6417 | 2826 | 3.2 | 244 | 3.3 | 400879 | 96.7 |
| 86 | Japan | 37178 | 1327 | 2853 | 1842 | 16.2 | 1008 | 18.9 | 30148 | 81.1 |
| | | **2680162** | **62059** | **198517** | **118804** | **14.2** | **70224** | **16.8** | **2230558** | **83.2** |
| | **DEVELOPING** | **8171488** | **339108** | **628120** | **546360** | **18.5** | **424597** | **23.7** | **6233303** | **76.3** |
| | **DEVELOPED** | **5228028** | **136625** | **254254** | **130691** | **10.0** | **36498** | **10.7** | **4669960** | **89.3** |
| | **WORLD TOTAL** | **13399516** | **475733** | **882374** | **677051** | **15.2** | **461095** | **18.6** | **10903263** | **81.4** |

**Table A44 Gross extents with cultivation potential for rain-fed plus irrigated oil crops (1000ha) - high input level**

| REGION | NAME | TOTAL | VS | S | MS | % VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 55640 | 96295 | 99129 | 11.7 | 64292 | 14.7 | 1823142 | 85.3 |
| 21 | Eastern Europe | 170952 | 22320 | 24825 | 26882 | 43.3 | 19677 | 54.8 | 77248 | 45.2 |
| 22 | Northern Europe | 172524 | 4050 | 12157 | 11847 | 16.3 | 8820 | 21.4 | 135650 | 78.6 |
| 23 | Southern Europe | 131643 | 6223 | 9674 | 5836 | 16.5 | 5011 | 20.3 | 104899 | 79.7 |
| 24 | Western Europe | 109547 | 11436 | 11965 | 13479 | 33.7 | 6380 | 39.5 | 66287 | 60.5 |
| 25 | Russian Fed. | 1674146 | 32194 | 45724 | 36656 | 6.8 | 63464 | 10.6 | 1496108 | 89.4 |
| | | **2258812** | **76223** | **104345** | **94700** | **12.2** | **103352** | **16.8** | **1880192** | **83.2** |
| 31 | Caribbean | 23397 | 2651 | 2411 | 2656 | 33.0 | 1651 | 40.0 | 14028 | 60.0 |
| 32 | Central America | 248353 | 16993 | 11681 | 8234 | 14.9 | 7410 | 17.8 | 204035 | 82.2 |
| | | **271750** | **19644** | **14092** | **10890** | **16.4** | **9061** | **19.8** | **218063** | **80.2** |
| 41 | South America | 1777573 | 219467 | 315166 | 190659 | 40.8 | 144326 | 48.9 | 907955 | 51.1 |
| 51 | Oceania | 793540 | 39312 | 37353 | 23855 | 12.7 | 16386 | 14.7 | 676634 | 85.3 |
| 52 | Polynesia | 56118 | 7469 | 3365 | 2843 | 24.4 | 2575 | 29.0 | 39866 | 71.0 |
| | | **849658** | **46781** | **40718** | **26698** | **13.4** | **18961** | **15.7** | **716500** | **84.3** |
| 61 | Eastern Africa | 639474 | 88742 | 92533 | 41987 | 34.9 | 23778 | 38.6 | 392434 | 61.4 |
| 62 | Middle Africa | 657061 | 105610 | 125006 | 85252 | 48.1 | 62890 | 57.6 | 278303 | 42.4 |
| 63 | Northern Africa | 794112 | 44680 | 35965 | 16628 | 12.2 | 11494 | 13.7 | 685345 | 86.3 |
| 64 | Southern Africa | 266428 | 5821 | 2991 | 5284 | 5.3 | 5556 | 7.4 | 246776 | 92.6 |
| 65 | Western Africa | 632996 | 66895 | 59767 | 45594 | 27.2 | 33618 | 32.5 | 427122 | 67.5 |
| | | **2990071** | **311748** | **316262** | **194745** | **27.5** | **137336** | **32.1** | **2029980** | **67.9** |
| 71 | Western Asia | 432992 | 7691 | 5600 | 3408 | 3.9 | 3311 | 4.6 | 412982 | 95.4 |
| 81 | Southeast. Asia | 444483 | 58578 | 44224 | 38449 | 31.8 | 23409 | 37.0 | 279823 | 63.0 |
| 82 | South Asia | 671842 | 57465 | 94545 | 47885 | 29.8 | 15152 | 32.0 | 456795 | 68.0 |
| 84 | East Asia | 1112296 | 29765 | 30005 | 31619 | 8.2 | 25941 | 10.5 | 994966 | 89.5 |
| 85 | Central Asia | 414363 | 8726 | 4317 | 1004 | 3.4 | 1368 | 3.7 | 398948 | 96.3 |
| 86 | Japan | 37178 | 1842 | 2369 | 1685 | 15.9 | 1327 | 19.4 | 29955 | 80.6 |
| | | **2680162** | **156376** | **175460** | **120642** | **16.9** | **67197** | **19.4** | **2160487** | **80.6** |
| | **DEVELOPING** | **8171488** | **720553** | **827576** | **521502** | **25.3** | **362479** | **29.8** | **5739378** | **70.2** |
| | **DEVELOPED** | **5228028** | **173017** | **240362** | **219369** | **12.1** | **185357** | **15.6** | **4409923** | **84.4** |
| | **WORLD TOTAL** | **13399516** | **893570** | **1067938** | **740871** | **20.2** | **547836** | **24.3** | **10149301** | **75.7** |

**Table A45 Gross extents with cultivation potential for rain-fed plus irrigated sugar crops (1000ha) - high input level**

| REGION | NAME | TOTAL | VS | S | MS | % VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 51010 | 69488 | 47007 | 7.8 | 27276 | 9.1 | 1943717 | 90.9 |
| 21 | Eastern Europe | 170952 | 13882 | 11822 | 3345 | 17.0 | 312 | 17.2 | 141591 | 82.8 |
| 22 | Northern Europe | 172524 | 27 | 4350 | 5745 | 5.9 | 4390 | 8.4 | 158012 | 91.6 |
| 23 | Southern Europe | 131643 | 5431 | 5651 | 2427 | 10.3 | 579 | 10.7 | 117555 | 89.3 |
| 24 | Western Europe | 109547 | 8791 | 9780 | 3020 | 19.7 | 261 | 19.9 | 87695 | 80.1 |
| 25 | Russian Fed. | 1674146 | 3366 | 10055 | 15087 | 1.7 | 37086 | 3.9 | 1608552 | 96.1 |
| | | **2258812** | **31497** | **41658** | **29624** | **4.6** | **42628** | **6.4** | **2113405** | **93.6** |
| 31 | Caribbean | 23397 | 3956 | 2138 | 1855 | 34.0 | 594 | 36.5 | 14854 | 63.5 |
| 32 | Central America | 248353 | 9083 | 12077 | 6525 | 11.1 | 4301 | 12.9 | 216367 | 87.1 |
| | | **271750** | **13039** | **14215** | **8380** | **13.1** | **4895** | **14.9** | **231221** | **85.1** |
| 41 | South America | 1777573 | 79295 | 167301 | 273659 | 29.3 | 201086 | 40.6 | 1056232 | 59.4 |
| 51 | Oceania | 793540 | 35619 | 23750 | 10768 | 8.8 | 5529 | 9.5 | 717874 | 90.5 |
| 52 | Polynesia | 56118 | 537 | 4065 | 6719 | 20.2 | 4357 | 27.9 | 40440 | 72.1 |
| | | **849658** | **36156** | **27815** | **17487** | **9.6** | **9886** | **10.8** | **758314** | **89.2** |
| 61 | Eastern Africa | 639474 | 29639 | 27919 | 17546 | 11.7 | 24698 | 15.6 | 539672 | 84.4 |
| 62 | Middle Africa | 657061 | 58551 | 96778 | 67643 | 33.9 | 56493 | 42.5 | 377596 | 57.5 |
| 63 | Northern Africa | 794112 | 19446 | 23338 | 8901 | 6.5 | 13262 | 8.2 | 729165 | 91.8 |
| 64 | Southern Africa | 266428 | 3531 | 2394 | 828 | 2.5 | 189 | 2.6 | 259486 | 97.4 |
| 65 | Western Africa | 632996 | 16340 | 21067 | 25599 | 10.0 | 29055 | 14.5 | 540935 | 85.5 |
| | | **2990071** | **127507** | **171496** | **120517** | **14.0** | **123697** | **18.2** | **2446854** | **81.8** |
| 71 | Western Asia | 432992 | 5438 | 4875 | 1360 | 2.7 | 190 | 2.7 | 421129 | 97.3 |
| 81 | Southeast. Asia | 444483 | 7651 | 38744 | 51769 | 22.1 | 42996 | 31.8 | 303323 | 68.2 |
| 82 | South Asia | 671842 | 33324 | 47740 | 17048 | 14.6 | 14577 | 16.8 | 559153 | 83.2 |
| 84 | East Asia | 1112296 | 18279 | 37010 | 33916 | 8.0 | 18719 | 9.7 | 1004372 | 90.3 |
| 85 | Central Asia | 414363 | 5603 | 4613 | 835 | 2.7 | 198 | 2.7 | 403114 | 97.3 |
| 86 | Japan | 37178 | 1404 | 2460 | 2154 | 16.2 | 1055 | 19.0 | 30105 | 81.0 |
| | | **2680162** | **66261** | **130567** | **105722** | **11.3** | **77545** | **14.2** | **2300067** | **85.8** |
| | **DEVELOPING** | **8171488** | **290673** | **490059** | **514203** | **15.8** | **410715** | **20.9** | **6465838** | **79.1** |
| | **DEVELOPED** | **5228028** | **119530** | **137356** | **89553** | **6.6** | **76488** | **8.1** | **4805101** | **91.9** |
| | **WORLD TOTAL** | **13399516** | **410203** | **627415** | **603756** | **12.2** | **487203** | **15.9** | **11270939** | **84.1** |

**Table A46 Gross extents with cultivation potential for rain-fed plus irrigated cotton (1000ha) - high input level**

| REGION | NAME | TOTAL | VS | S | MS | % VS+S+MS | mS | % VS+S+MS+mS | NS | % NS |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | North America | 2138498 | 11400 | 13219 | 10040 | 1.6 | 6686 | 1.9 | 2097153 | 98.1 |
| 21 | Eastern Europe | 170952 | 0 | 15 | 13 | 0.0 | 0 | 0.0 | 170924 | 100.0 |
| 22 | Northern Europe | 172524 | 0 | 0 | 0 | 0.0 | 0 | 0.0 | 172524 | 100.0 |
| 23 | Southern Europe | 131643 | 534 | 1066 | 446 | 1.6 | 0 | 1.6 | 129597 | 98.4 |
| 24 | Western Europe | 109547 | 0 | 110 | 51 | 0.1 | 0 | 0.1 | 109386 | 99.9 |
| 25 | Russian Fed. | 1674146 | 0 | 720 | 761 | 0.1 | 0 | 0.1 | 1672665 | 99.9 |
| | | **2258812** | **534** | **1911** | **1271** | **0.2** | **0** | **0.2** | **2255096** | **99.8** |
| 31 | Caribbean | 23397 | 64 | 286 | 2107 | 10.5 | 3541 | 25.6 | 17399 | 74.4 |
| 32 | Central America | 248353 | 5047 | 5632 | 4868 | 6.3 | 6953 | 9.1 | 225853 | 90.9 |
| | | **271750** | **5111** | **5918** | **6975** | **6.6** | **10494** | **10.5** | **243252** | **89.5** |
| 41 | South America | 1777573 | 25006 | 45814 | 67822 | 7.8 | 135715 | 15.4 | 1503216 | 84.6 |
| 51 | Oceania | 793540 | 31204 | 24605 | 11959 | 8.5 | 4977 | 9.2 | 720795 | 90.8 |
| 52 | Polynesia | 56118 | 90 | 86 | 315 | 0.9 | 440 | 1.7 | 55187 | 98.3 |
| | | **849658** | **31294** | **24691** | **12274** | **8.0** | **5417** | **8.7** | **775982** | **91.3** |
| 61 | Eastern Africa | 639474 | 44230 | 63146 | 51314 | 24.8 | 31134 | 29.7 | 449650 | 70.3 |
| 62 | Middle Africa | 657061 | 20417 | 28153 | 40170 | 13.5 | 52109 | 21.4 | 516212 | 78.6 |
| 63 | Northern Africa | 794112 | 39385 | 31995 | 11627 | 10.5 | 9861 | 11.7 | 701244 | 88.3 |
| 64 | Southern Africa | 266428 | 1720 | 4687 | 1232 | 2.9 | 948 | 3.2 | 257841 | 96.8 |
| 65 | Western Africa | 632996 | 25471 | 47646 | 36550 | 17.3 | 34271 | 22.7 | 489058 | 77.3 |
| | | **2990071** | **131223** | **175627** | **140893** | **15.0** | **128323** | **19.3** | **2414005** | **80.7** |
| 71 | Western Asia | 432992 | 6022 | 2757 | 379 | 2.1 | 0 | 2.1 | 423834 | 97.9 |
| 81 | Southeast. Asia | 444483 | 590 | 3508 | 22690 | 6.0 | 35996 | 14.1 | 381699 | 85.9 |
| 82 | South Asia | 671842 | 59282 | 83075 | 40027 | 27.1 | 16230 | 29.6 | 473228 | 70.4 |
| 84 | East Asia | 1112296 | 7264 | 7193 | 5954 | 1.8 | 12833 | 3.0 | 1079052 | 97.0 |
| 85 | Central Asia | 414363 | 798 | 3108 | 2303 | 1.5 | 0 | 1.5 | 408154 | 98.5 |
| 86 | Japan | 37178 | 0 | 0 | 0 | 0.0 | 1152 | 3.1 | 36026 | 96.9 |
| | | **2680162** | **67934** | **96884** | **70974** | **8.8** | **66211** | **11.3** | **2378159** | **88.7** |
| | **DEVELOPING** | **8171488** | **235386** | **327086** | **287358** | **10.4** | **340031** | **14.6** | **6981627** | **85.4** |
| | **DEVELOPED** | **5228028** | **43138** | **39735** | **23270** | **2.0** | **12815** | **2.3** | **5109070** | **97.7** |
| | **WORLD TOTAL** | **13399516** | **278524** | **366821** | **310628** | **7.1** | **352846** | **9.8** | **12090697** | **90.2** |

# APPENDIX II

## PROCEDURES FOR COMPILATION OF THE TERRAIN SLOPES DATABASE

The GTOPO30 database (EROS Data Center, 1998) provides digital elevation data in a regular grid of 30 arc-seconds latitude/longitude. A distribution of terrain slope classes for each 5 arc-min grid-cell of the Digital Soil Map of the World (DSMW) has subsequently been derived from the 30 arc-second DEM and the DSMW as follows:

1. Calculation of 'quadrant' slope classes for each 30 arc-second grid-cell of GTOPO30 using 7 classes: 0-2%, 2-5%, 5-8%, 8-16%, 16-30%, 30-45%, and > 45%. Since the computation of mathematical slope angles from 30 arc-second grid-cells gives unrealistic results, exaggerating the prevalence of flat terrain, the following rule-based procedures have been applied:

   1a Determine for each 3 by 3 sub-grid the difference in altitude of the central grid-cell with regard to all neighboring grid-cells, e.g., Alt(a) – Alt(e), Alt(b) – Alt(e), etc.

   1b Select the orthogonal pair defined by the neighboring grid-cell with the largest altitude difference, i.e., a-e-i, c-e-g or b-e-h, d-e-f.

| | | |
|---|---|---|
| **a** | **b** | **c** |
| **d** | **e** | **f** |
| **g** | **h** | **i** |

   1c For the selected orthogonal pair of neighboring grid-cells and corresponding altitude differences $dAlt_j$, j=1,...,4, determine 'quadrant' slope classes according to specified ranges of elevation differences. The following thresholds were used for classification of terrain conditions in the Global AEZ study: ≤ 2m, 6m, 16m, 40m, 125m, 250m, and > 250m

2. Aggregation of the 'quadrant' slope classes by 30 arc-second respectively to: 5 arc-min latitude/longitude grid-cells of the DSMW, and to individual soil association map units.

3. Establishing 'priority' soil unit/slope relationships by defining upper limits of slope classes for each soil unit. For use in GAEZ, the soil units have been allocated to five groups with regard to maximum slopes of respectively 2% (max. 8%), 8% (max. 16%), 30%, 30-45%, and one unlimited class. For instance, it is known that the major part of the Fluvisols are related to the flat slopes (0-2%). This approach was first elaborated in South East Asia (Bruggeman and Nachtergaele, 1986) and was further refined by Sys (Sys, 1990) for China. The approach was also used for FAO's study on World Agriculture: Towards 2010 (FAO, 1995d). In GAEZ the five groups of soils for priority slope classes are defined as follows:

| CLASS | FAO '74 | FAO '90 |
|---|---|---|
| Class 1 | < 2% / max. 8%:<br>all J, G, O soils; all gleyic soil units (Zg, Sg, Hg, Mg, Bg, Lg, Dg, Pg, Ag), and miscellaneous land units ST, WR, WRs | < 2% / max. 8%:<br>all FL, GL, HS soils; ATc, all gleyic soil units, and miscellaneous land units ST, WR, WRs |
| Class 2 | < 8% / max. 16%:<br>all S, Z soils (except for gleyic units) | < 8% / max. 16%:<br>all SN, SC soils (except for gleyic units); and all stagno-gleyic soil units |
| Class 3 | < 30%:<br>all A, Q, M, L, N, D, V soils (except for gleyic units) and all luvic soil units (Ql, Yl, Xl, Kl, Cl, Hl) | < 30%:<br>all AC, AL, AR, GR, LV, LX, NT, PD, VR soils (except for gleyic and stagno-gleyic units); ATa and all luvic soil units |
| Class 4 | < 30-45%:<br>all C, E, X, Y, F, K, H, W, P soils (except for gleyic and luvic soil units); and miscellaneous unit DS | <30-45%:<br>all CH, CL, GY, FR, KS, PH, PL, PZ soils (except for gleyic, stagno-gleyic and luvic soil units); and misc. unit DS |
| Class 5 | all slopes:<br>all T, B, I, R, U soils; (except for gleyic and luvic soil units); and miscellaneous units RK and GLR | all slopes:<br>all AN, CM, LP, RG soils; ATf, ATu (except for gleyic, stagno-gleyic and luvic soil units); and miscellaneous units RK and GLR |

4. Establishing for each soil association map unit of the DSMW a consistent allocation of slope classes and soil units, accounting for:
   - slope distribution calculated in step 2 above by grid-cell and soil association map unit.
   - Slope classes as defined for the soil units in the soil association map unit expansion table of the DSMW.
   - the 'priority' slope relationships (as defined in 3 above).
5. Allocation of soil units within soil association map units to 5 min grid-cells, according to calculated slope distributions, slope 'priorities', and soil association map unit composition.

## APPENDIX III

## 1. SOIL AND TERRAIN CONSTRAINT CLASSIFICATIONS FOR SOIL UNITS ACCORDING TO FAO'74 LEGEND

*TERRAIN SLOPE CONSTRAINTS*

| | Rain-fed | Gravity irrigation* | Sprinkler irrigation |
|---|---|---|---|
| **Severe constraints** | slopes > 30% | slopes > 8% | slopes > 16% |
| **Constraints** | slopes 16-30% | slopes 5-8% | slopes 8-16% |
| **Slight constraints** | slopes 8-16% | slopes 2-5% | slopes 5-8% |
| **No constraints** | slopes 0-8% | slopes 0-2% | slopes 0-5% |

*Applicable to non-terraced land

*SOIL DEPTH CONSTRAINTS*

**Severe constraints**: All soils with depth limitations within 50 cm of the surface caused by the presence of coherent hardrock or hard-pans (shallow soils): Lithosols (I), Renzinas (E), Rankers (U), all soils with Lithic phase.

**Constraints:** All soils with depth limitations within 100 cm of the surface by presence of Petrocalcic, Petrogypsic, Petroferric and Duripan phases.

**No constraints**: Deep soils: all other soils.

*NATURAL FERTILITY CONSTRAINTS*

**Severe constraints**: Soils with low natural fertility and soils where a major land improvement is required before cultivation is possible: all other soils.

**Constraints**: Soils with moderate natural fertility: Jd, Gh, Gd, Rd, Q, Qc, Ql, T, To, Th, Xy, M, Mo, Mg, Bc, Bd, Bh, Bg, Bf, Lf, Lp, Lc, Lg, D, De,Dg, Pl, W, We, Wh, A, Ao, Ah, Nd, Nh, Fr and Fh.

**No constraints**: Soils with high natural fertility: J, Je, G, Ge, Gc, Gm, R, Re, Rc, E, Tm, V, VP, Vc, Sm, Y, Yh, Yk, Yl, X, Xh, Xk, Xl, K, Kh, Kk, Kl, C, Ch, Ck, Cl, Cg, H, Hh, Hc, Hl, Hg, B, Be, Bk, Bv, L, Lo, Lk, Lv, Wm, N and Ne.

*SOIL DRAINAGE CONSTRAINTS*

**Severe constraints**: Poorly and imperfectly drained soils: All Gleysols (G, Ge, Gc, Gd, Gm, Gh, Gp and Gx), all Planosols (W, We, Wd, Wm, Wh, Ws, Wx) and all gleyic sub-groups (Zg, Sg, Mg, Hg, Lg, Dg, Pg and Ag), except Bg.

**No constraints**: Excessively and well drained soils: all other soils.

*SOIL TEXTURE CONSTRAINTS*

**Severe constraints**: Coarse textured soils. Soils with less than 18% clay, more than 65% sand, or which have stones, boulders or rock outcrops in the surface layer or at the surface: All Arenosols (Q, Qc, Ql, Qf, Qa), all Regosols (R, Re, Rc, Rd, Rx) and Vitric Andosols (Tv) with coarse texture, and all soils with petric and stony phase.

**Constraints** Soils with heavy cracking clays: Soils with 30% or more clay to at least 50 cm deep, with cracks at least 1 cm wide and 50 cm deep at some period in most years (unless irrigated), and high bulk density between the cracks: All Vertisols (V, Vp, Vc) and vertic sub-groups (Bv and Lv).

**No constraints**: Soils with medium and fine textures: all other soils.

*SOIL CHEMICAL CONSTRAINTS*

**Severe constraints**: Soils with severe salinity, sodicity, or gypsum limitations.

(a) Soils with a high salt content or exchangeable sodium saturation within 100 cm of the surface: All Solonchaks (Z, Zo, Zm, Zt, Zg), all Solonetz (S, So, Sm, Sg) and Solodic Planosols (Ws);

(b) Soils with gypsic horizons: Gypsic Xerosols (Xy), Gypsic Yermosols (Yy);

(c) Soils with saline and sodic phases.

**No constraints**: All other soils.

*MICELLANEOUS LAND UNITS*

The miscellaneous land units of the DSMW are considered as **severe constraints.** They include: dunes, shifting sands, salt flats, rock debris, desert detritus, glaciers and snow caps.

## 2. SOIL AND TERRAIN CONSTRAINT CLASSIFICATIONS FOR SOIL UNITS ACCORDING TO FAO'90 REVISED LEGEND

*TERRAIN SLOPE CONSTRAINTS*

| | Rain-fed | Gravity irrigation * | Sprinkler irrigation |
|---|---|---|---|
| **Severe constraints** | slopes > 30% | slopes > 8% | slopes > 16% |
| **Constraints** | slopes 16-30% | slopes 5-8% | slopes 8-16% |
| **Slight constraints** | slopes 8-16% | slopes 2-5% | slopes 5-8% |
| **No constraints** | slopes 0-8% | slopes 0-2% | slopes 0-5% |

* Applicable to non-terraced land

*SOIL DEPTH CONSTRAINTS*

**Severe constraints**: All soils with depth limitations within 50 cm of the surface caused by the presence of coherent hardrock or hard-pans (shallow soils): Leptosols (LP), all soils with Lithic phase

**Constraints:** All soils with depth limitations within 100 cm of the surface by presence of Petroferric and Duripan phases.

**No constraints**: Deep soils: all other soils

*NATURAL FERTILITY CONSTRAINTS*

**No constraints**: Soils with high natural fertility: FL, FLe, FLc, FLm, FLu, GL, GLe, GLk, GLa, GLm, GLu, RG, RGe, RGc, Rgu, AN, ANm, ANh, ANu, VR, VRe, VRk, CM, CMe, CMu, CMc, CMx, CMv, KS, KSh, KSl, KSk, CH, CHh, CHk, CHl, CHw, PH, PHh, PHc, PHl, GR, GRh, LV, LVh, LVx, LVk, LVv, PD, PDe, NT, NTh, NTr, AT, ATa, Atc.

**Constraints**: Soils with moderate natural fertility: FLd, FLs, GLd, RGd, AR, ARh, ARb, ARl, ARc ARg, ANg, VRd, CMd, CMg, CMo, CL, CLh, CLl, CHg, PHg, PHj, GRg, LVf, LVa, LVg, LVj, PL, PLe, PLd, PLm, PLu, PDd, PDg, PDj, PZ, PZh, LX, LXh, AC, ACh, ACu, NTu, FR, FRh, FRr, FRu, HS, HSl, HSs, HSf, ATf.

**Severe constraints**: Soils with low natural fertility and soils where a major land improvement is required before cultivation is possible: all other soils.

*SOIL DRAINAGE CONSTRAINTS*

**Severe constraints**: Poorly and imperfectly drained soils: All Gleysols (GL, GLe, GLk, GLd, GLa, GLm, Glu, GLt, GLi), all planosols (PL, PLe, PLd, PLm, PLu, PLi) and soils with antraquic phases.

**Constraints** All soil with gleyic and stagnogleyic subgroups (ARg, ANg, CMg, SNg, SNj, SCg, CHg, PHg. PHj, GRg, LVg, LVj, PDg, PDj, PZg, LXg, LXj, ACg, ALg, ALj).

**No constraints**: Excessively and well drained soils: all other soils.

*SOIL TEXTURE CONSTRAINTS*

**Severe constraints**: Coarse textured soils, soils with less than 18% clay, more than 65% sand, or have stones, boulders or rock outcrops in the surface layer or at the surface: All Arenosols (AR, ARh, ARb, Arl, ARo, ARa, ARc, ARg), all Regosols (RG, RGe, RGc, RGy, RGd, RGu, RGi), all Podzols (PZ, PZh, PZb, PZf, PZc, PZg, PZi) and Vitric Andosols (ANz) with texture "1", and soils with skeletic, yermic, rudic, desert and Gobi phases.

**Constraints** Soils with heavy cracking clays: Soils with 30% or more clay to at least 50 cm deep, with cracks at least 1 cm wide and 50 cm deep at some period in most years (unless irrigated), and high bulk density between the cracks: All Vertisols (VR, VRe, VRd, VRk, VRy) and vertic sub-groups (CMv, LVv).

**No constraints**: Soils with medium and fine textures: all other soils.

*SOIL CHEMICAL CONSTRAINTS*

**Severe constraints**: Soils with severe salinity, sodicity, or gypsum limitations:

(a) Soils with a high salt content or exchangeable sodium saturation within 100 cm of the surface: All Solonchaks (SC, SCh, SCm, SCk, SCy, SCn, SCg, SCi), all Solonetz (SN, SNh, SNm, SNk, SNy, SNj, SNg) and Salic Fluvisols (FLs);

(b) All Gypsisols (GY, GYh, GYk, GYl, GYp) and soils with gypsic horizons: (RGy, VRy, SNy, SCy, Ksy);

(c) Soils with salic and sodic phases.

**No constraints**: All other soils.

*MICELLANEOUS LAND UNITS*

Miscellaneous land units are considered as **severe constraints.** They include: dunes, shifting sands, salt flats, rock debris, desert detritus, and glaciers/snow caps.

# APPENDIX IV

## TEMPERATURE REGIME REQUIREMENTS OF CROP/LUTs

### Notes:

**Climates:** B = Boreal; Te = Temperate; STR = Sub-tropics; WR = Winter Rainfall; SR = Summer Rainfall; Tr = Tropics

**Growth cycle:** L/Gc = Total; La = Pre-dormancy; Lb = Post-dormancy

**Temperature profile interval symbols:**

| **Temperature intervals ($^{o}$C)** | <-5 | -5-0 | 0-5 | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | >30 |
|---|---|---|---|---|---|---|---|---|---|
| **Totals** | L9 | L8 | L7 | L6 | L5 | L4 | L3 | L2 | L1 |
| **Increasing temperatures (winter to summer)** | L9a | L8a | L7a | L6a | L5a | L4a | L3a | L2a | L1a |
| **Decreasing temperatures (summer to winter)** | L9b | L8b | L7b | L6b | L5b | L4b | L3b | L2b | L1b |

**Heat Units:** TSgc = Temperature Sum during growth cycle

**Temperature Growing Period:** $LGP_{t=5}$ = Number of days with mean daily temperatures above 5$^{o}$C

# TEMPERATURE REGIME REQUIREMENTS OF CROP/LUTs

| Crop | Sub-optimal Conditions | Optimal Conditions |
|---|---|---|
| **Winter Wheat** | *Climates: B, Te, STr (WR+SR)* | *Climates: B, Te, STr (WR+SR)* |
| (Wheat I) | *L6a < 0.667*Lb* | *L6a < 0.500*Lb* |
| **Winter Barley** | *L6a+L5a > 0.167*Lb* | *L6a+L5a > 0.084*Lb* |
| (Barley I) | *L2a+L2b < 0.333*Lb* | *L2a+L2b < 0.333*Lb* |
| **Winter Rye** | *L1a+L1b = 0* | *L1a+L1b = 0* |
| (Rye I) | *L2b+L3b+L4b+L5b < 0.500*Lb* | *L2b+L3b+L4b+L5b < 0.500*Lb* |
| *L = 30 + 90* | *L3b+L4b+L5b+L6b > La* | *L3b+L4b+NLb+L6b > La* |
| *L = 35 + 105* | *TSgc>1200 ** | *TSgc> 1300 ** |
| *L = 40 + 120* | *no permafrost* | *no permafrost* |
| *L = 45 + 135* | $LGP_{t=5} < 365$ | $LGP_{t=5} < 365$ |
| | *dormancy required* | *dormancy required* |
| **Spring Wheat** | *Climates: B, Te, STr (WR+SR)* | *Climates: B, Te, STr (WR+SR)* |
| (Wheat II) | *L6a < 0.333*L* | *L6a < 0.333*L* |
| *L = 105/120/135/150* | *L6a+L5a > 0.167*Lb* | *L6a+L5a > 0.167*Lb* |
| | *L2a+L2b < 0.333*Lb* | *L2a+L2b < 0.333*Lb* |
| | *L1a+L1b = 0* | *L1a+L1b = 0* |
| | *L2b+L3b+L4b+L5b < 0.500*Lb* | *L2b+L3b+L4b+L5b < 0.500*Lb* |
| | *TSgc> 1400* | *TSgc > 1800* |
| | *no permafrost* | *no permafrost* |
| | $LGP_{t=5} < 365$ | $LGP_{t=5} < 365$ |
| **Spring Barley** | *Climates: B, Te, STr (WR+SR)* | *Climates: B, Te, STr (WR+SR)* |
| (Barley II) | *L6a < 0.333*L* | *L6a < 0.333*L* |
| **Spring Rye** | *L6a+L5a > 0.167*Lb* | *L6a+L5a > 0.167*Lb* |
| (Rye II) | *L2a+L2b < 0.333*Lb* | *L2a+L2b < 0.333*Lb* |
| *L = 90/105/120/135* | *L1a+L1b = 0* | *L1a+L1b = 0* |
| | *L2b+L3b+L4b+L5b < 0.500*Lb* | *L2b+L3b+L4b+L5b < 0.500*Lb* |
| | TSgc> 1400 | *TSgc > 1700* |
| | *no permafrost* | *no permafrost* |
| | $LGP_{t=5} < 365$ | $LGP_{t=5} < 365$ |
| **Wheat (sub-tropics)** | *Climates: STr (WR + SR)* | *Climates: STr (WR + SR)* |
| (Wheat III) | *L6a < 0.333*L* | *L6a < 0.167*L* |
| *L = 105* | *L6+L5+L4 > 0.167*Lb* | *L6+L5+L4 > 0.333*Lb* |
| *L = 120* | *L2a+L2b < 0.500*Lb* | *L2a+L2b < 0.500*Lb* |
| *L = 135* | *L1a+L1b = 0* | *L1a+L1b = 0* |
| *L = 150* | TSgc> 1500 | *TSgc > 1800* |
| | $LGP_{t=5} = 365$ | $LGP_{t=5} = 365$ |
| **Barley (sub-tropics)** | *Climates: STr (WR + SR)* | *Climates: STr (WR + SR)* |
| (Barley III) | *L6a < 0.333*L* | *L6a < 0.167*L* |
| *L = 90* | *L6+L5+L4 > 0.167*Lb* | *L6+L5+L4 > 0.333*Lb* |
| *L = 105* | *L2a+L2b < 0.500*Lb* | *L2a+L2b < 0.500*Lb* |
| *L = 120* | *L1a+L1b = 0* | *L1a+L1b = 0* |
| *L = 135* | TSgc> 1400 | *TSgc > 1700* |
| | $LGP_{t=5} = 365$ | $LGP_{t=5} = 365$ |
| **Wheat (tropics)** | *Climates: Tr* | *Climates: Tr* |
| (Wheat IV) | *L6a < 0.333*L* | *L6a < 0.167*L* |
| *L = 100 at 20.0℃* | *L6+L5+L4 > 0.167*Lb* | *L6+L5+L4 > 0.333*Lb* |
| *L = 130 at 17.5℃* | *L2a+L2b < 0.500*Lb* | *L2a+L2b < 0.500*Lb* |
| *L = 160 at 15.0℃* | *L1a+L1b = 0* | *L1a+L1b = 0* |
| *L = 190 at 12.5℃* | TSgc> 1600 | *TSgc > 2000* |
| | $LGP_{t=5} = 365$ | $LGP_{t=5} = 365$ |
| **Barley (tropics)** | *Climates: Tr* | *Climates: Tr* |
| (Barley IV) | *L6a < 0.333*L* | *L6a < 0.167*L* |
| *L = 100 at 20.0℃* | *L6+L5+L4 > 0.167*Lb* | *L6+L5+L4 > 0.333*Lb* |
| *L = 130 at 17.5℃* | *L2a+L2b < 0.500*Lb* | *L2a+L2b < 0.500*Lb* |
| *L = 160 at 15.0℃* | *L1a+L1b = 0* | *L1a+L1b = 0* |
| *L = 190 at 12.5℃* | TSgc> 1500 | *TSgc > 1900* |
| | $LGP_{t=5} = 365$ | $LGP_{t=5} = 365$ |

* applicable to post-dormancy period only

| Crop | Sub-optimal Conditions | Optimal Conditions |
|---|---|---|
| **Indica Rice (wetland)** | Climates: Tr, STr (SR+WR) | Climates: Tr, STr (SR+WR) |
| L = 105/120/135/150 | L5=L6=0 | L6=L5=L4 = 0 |
| | L3 + L2+ L1 >0.833*L | L3+L2+L1 = 1.000*L |
| | L4a < 0.167*L | L1 < 0.667*L |
| | L4b < 0.167*L | TSgc >3000 |
| | TSgc>2400 | |
| **Indica Rice (dryland)** | Climates: Tr | Climates: Tr |
| L = 105/120/135 | L5=L6=0 | L6=L5=L4 = 0 |
| | L3 + L2+ L1 >0.833*L | L3+L2+L1 = 1.000*L |
| | L4a < 0.167*L | L1 < 0.667*L (not implemented)r |
| | L4b < 0.167*L | TSgc >3000 |
| | TSgc>2400 | |
| **Japonica Rice (wetland)** | Climates: Tr, STR (SR+WR), Te | Climates: T**r**, STR (SR+WR), Te |
| L = 105/120/135/150 | L5a+L4a < 0.400*L | L5a+L4a < 0.400*L |
| | L4 >0 | |
| | L2a+L2b < 0.667*L | L2a+L2b < 0.667*L |
| | L1a+L1b < 0.200*L | L1a+L1b < 0.200*L |
| | L4b+L5b < 0.250*L | L4b+L5b < 0.250*L |
| | L6=0 | L6=0 |
| | TSgc > 1800 | TSgc> 2200 |
| **Lowland Maize and Sorghum** | Climates: Tr | Climates: Tr |
| (Maize I) | L4a+L4b < 0.167*L | L4 = 0 |
| (Sorghum I) | TSgc > 2200 | TSgc > 2500 |
| L = 90/105/120/135 | | |
| **Highland Maize and Sorghum** | Climates: Tr | Climates: Tr |
| (Maize II) | L1 = 0 | L1 = 0 |
| (Sorghum II) | L2 = 0 | L2 = 0 |
| L = 105 at 20.0°C | L5 < 0.500*L | L5 < 0.333*L |
| L = 180 at 17.5°C | L6=0 | L6=0 |
| L = 300 at 15.0°C | L3a+L3b < 0.333L | L3a+L3b < 0.333*L |
| | TSgc > 2200 | TSgc > 2500 |
| **Maize (sub-tropics, grain)** | Climates: STr (SR+WR), Te | Climates: STr (SR+WR), Te |
| (Maize III) | L5a+L5b < 0.200*L | L5 = <0.200*L |
| L = 105/120/135/150/165/180 | L6=0 | L6=0 |
| | TSgc>1900 | TSgc>2400 |
| **Maize (temperate, silage)** | Climates: STr (SR+WR), Te | Climates: STr (SR+WR), Te |
| (Maize IV) | L5 < 0.667*L | L5 < 0.667*L |
| L = 105/120/135/150/165/180 | L6=0 | L6=0 |
| | TSgc>1700 | TSgc > 1900 |
| | no permafrost | no permafrost |
| **Irish Potato** | Climates: B, Te, STr, Tr | Climates: B, Te, STr, Tr |
| L = 90/120/150/180 | L6a < 0.333*L | L6a < 0.333*L |
| | L6b < 0.167*L | L6b < 0.167*L |
| | L2 < 0.333*L | L2 < 0.333*L |
| | L1 = 0 | L1 = 0 |
| | L6+L5+L4 > 0.400*L | L6+L5+L4 > 0.400*L |
| | TSgc >1200 | TSgc>1500 |
| | no permafrost | no permafrost |
| **Pearl Millet** | Climates: Tr | Climates: Tr |
| L = 70/90 | L4a+L4b < 0.167*L | L4 = 0 |
| | L5=L6=0 | L5=L6=0 |
| | TSgc > 1600 | TSgc > 1800 |
| **Cowpea** | Climates: Tr | Climates: Tr |
| L = 80/100/120 | L4a+L4b < 0.167*L | L4 = 0 |
| | L5=L6=0 | L5=L6=0 |
| | TSgc > 1800 | TSgc > 2100 |
| **Cassava** | Climates: Tr | Climates: Tr |
| L = 12 months | L4 < 0.333*L | L4 < 0.167*L |
| | L1 < 0.667 * L | L1 < 0.667* L |
| | L5=L6=0 | L5=L6=0 |
| | TSgc> 6500 | TSgc> 7500 |

| Crop | Sub-optimal Conditions | Optimal Conditions |
|---|---|---|
| **Sweet Potato** | Climates: Tr, STr (SR) | Climates: Tr, STr (SR) |
| L = 150/180/210 | L4 < 0.333*L | L4 < 0.333 * L |
| | L5 = L6= 0 | L5=L6=0 |
| | L1< 0.500 * L | L1 < 0.500 * L |
| | TSgc > 3500 | TSgc > 4000 |
| **Foxtail Millet (Setaria)** | Climates: STr (SR+WR), Te | Climates: STr (SR+WR), Te |
| L = 75/90/105/120 | L5a+L5b < 0.167*L | L5 = 0 |
| | L3>0 | L3>0 |
| | L6=0 | L6=0 |
| | TSgc > 1500 | TSgc > 1800 |
| **Sugarcane** | Climates: Tr, STr (SR + WR) | Climates: Tr, STr (SR + WR) |
| L = 12 months | L4 + L5 < 0.667*L | L4 < 0.667*L |
| | L5 + L4+L3 >0.084*L (n.a) | L4 + L3 > 0.084*L |
| | L6 = 0 | L5 + L6 = 0 |
| | TSgc> 6250 | TSgc > 6500 |
| **Sugarbeet** | Climates: Te, STr (SR+WR) | Climates: Te, STr (SR+WR) |
| L = 150/165/180/195/210 | L6a < 0.333 * L; L6b <0.167 * L | L6a < 0.333 * L; L6b <0.167 * L |
| | L6+L5 > 0.167*L | L6+L5 > 0.167*L |
| | L2 < 0.400*L | L2 < 0.400*L |
| | L1 = 0 | L1 = 0 |
| | TSgc > 1600 | TSgc> 2000 |
| | no permafrost | no permafrost |
| **Lowland Phaseolus Bean** | Climates: Tr | Climates: Tr |
| L = 90/120/150 | L4a+L4b < 0.167*L | L4 = 0 |
| | L6+L5=0 | L6+L5=0 |
| | TSgc > 1800 | TSgc > 2400 |
| **Highland Phaseolus Bean** | Climates: Tr | Climates: Tr |
| L = 120 at 17.5 °C | L5a+L5b < 0.500*L | L5a+L5b < 0.500*L |
| L = 150 at 15.0 °C | L3a+L3b < 0.050*L | L3a+L3b < 0.050*L |
| L = 180 at 12.5 °C | L1+L2 = 0 | L1+L2 = 0 |
| | L6=0 | L6=0 |
| | TSgc > 1500 | TSgc> 1800 |
| **Phaseolus Bean (temperate)** | Climates: Te, STr (SR+WR) | Climates: Te, STr (SR+WR) |
| L = 90/120/150 | L5< 0.667*L | L5 < 0.667*L |
| | L5+L4+L3 > 0.500*L | L5+L4+L3 > 0.500*L |
| | L1 = 0 | L1 = 0 |
| | L6=0 | L6=0 |
| | TSgc > 1400 | TSgc > 1700 |
| **Chickpea (cold tolerant)** | Climates: STr (WR) | Climates: STr (WR) |
| L = 150/180 | L6a < 0.333*L | L6a < 0.333*L |
| Winter sowing (cold resistant) | L5b + L6b < 0.167*L | L5b + L6b < 0.167*L |
| (data from ICARDA) | L6a + L5a + L4a > 0.333*L | L6a + L5a + L4a > 0.333*L |
| | L4b + L3b + L2b = 0 | L4b+L3b+L2b= 0 |
| | L1 < 0.167*L | L1 < 0.167*L |
| | L3a > 0 | L3a>0 |
| | TSgc > 1700 | TSgc > 2200 |
| **Chickpea** | Climates:Tr, STr (SR+WR) | Climates:Tr, STr (SR+WR) |
| L = 90/105/120 | L6a < 0.167*L | L6 = 0.167 |
| | L1 < 0.167*L | L1 <0.167 * L |
| | L6b+L5b+L4b+L3b+L2b = 0 | L5b+L4b+L3b+L2b = 0 |
| | L6a+L5a+L4a > 0.167*L | L6a+L5a+L4a > 0.167*L |
| | L3a>0 | L3a>0 |
| | TSgc > 1500 | TSgc > 2100 |
| **Groundnut** | Climates: Tr, STr (SR+ WR), Te | Climates: Tr, STr (SR+ WR), Te |
| L = 90/105/120 | L4a+L4b < 0.167*L | L4 = 0 |
| | L5=L6=0 | L5=L6=0 |
| | TSgc > 2200 | TSgc > 2500 |
| **Soybean (tropics)** | Climates: Tr | Climates: Tr |
| L = 90/105/120 | L4a+L4b < 0.500*L | L4 < 0.333*L |
| | L5=L6=0 | L5=L6=0 |
| | TSgc > 2100 | TSgc > 2400 |

| Crop | Sub-optimal Conditions | Optimal Conditions |
|---|---|---|
| **Soybean (sub-tropics)** | Climates:STr(SR+WR), Te | Climates:STr(SR+WR), Te |
| L = 105/120/135 | L5 =0 | L5 =0 |
| | L3+L4 > 0.333*L | L6=0 |
| | L1 < 0.333*L | L3+L4 > 0.333*L |
| | TSgc > 1700 | L1 <0.333*L |
| | | TSgc > 2000 |
| **Sunflower (tropics)** | Climates:Tr | Climates:Tr |
| L= 135/150/165 | L5 + L4 + L3 > 0.500* L | L5 + L4 + L3 > 0.500* L |
| | L3 < 0.500*L | L3 < 0.500*L |
| | L4 > 0.167 * L | L4 > 0.167 * L |
| | L1 = L2 = L6 = 0 | L1 = L2 = L6 = 0 |
| | TSgc > 2200 | TSgc > 2500 |
| **Sunflower (sub-tropics)** | Climates:STr (SR+WR), Te | Climates:STr (SR+WR), Te |
| L = 135/150/165 | L5 < 0.300*L | L5 < 0.200*L |
| | L5+L4 + L3 > 0.400*L (n.a.) | L5+L4+L3 > 0.400*L (n.a.) |
| | L1 < 0.333*L | L1 < 0.333*L |
| | L6 = 0 | L6 = 0 |
| | TSgc > 2000 | TSgc > 2400 |
| **Winter Rape** | Climates: Te, STr (SR+TR) | Climates: Te, STr (SR+TR) |
| L = 35 + 105 | L6a < 0.667*Lb | L6a < 0.500*Lb |
| L = 45 + 120 | L2a+L2b < 0.400*Lb | L2a+L2b < 0.400*Lb |
| | L1a+L1b = 0 | L1a+L1b = 0 |
| | L2b+L3b+L4b+L5b < 0.500*Lb | L2b+L3b+L4b+L5b < 0.500*Lb |
| | N4b+N5b +N6b > La | N4b+N5b +N6b > La |
| | TSgc > 1200 * | TSgc > 1400 * |
| | $LGP_{t=5}$ < 365 | $LGP_{t=5}$ < 365 |
| | dormancy required | dormancy required |
| | no permafrost | no permafrost |
| **Spring Rape** | Climates: Te, STr (SR+WR) | Climates: Te, STr (SR+WR) |
| L = 135/150/165 | L6a < 0.333*L | L6a < 0.333*L |
| | L2a+L2b < 0.400*L | L2a+L2b < 0.400*L |
| | L1a+L1b = 0 | L1a+L1b = 0 |
| | L2b+L3b+L4b+L5b < 0.500*L | L2b+L3b+L4b+L5b < 0.500*L |
| | TSgc > 1400 | TSgc > 1800 |
| | $LGP_{t=5}$ < 365 | $LGP_{t=5}$ < 365 |
| | no permafrost | no permafrost |
| **Rape (rabi)** | Climates: Tr, STr (SR + WR) | Climates: Tr, STr (SR + WR) |
| L = 135/150/165 | L6a < 0.333*L | L6a < 0.333*L |
| | L2a+L2b < 0.500*L | L2a+L2b < 0.500*L |
| | L1a+L1b = 0 | L1a+L1b = 0 |
| | L6+L5+L4 > 0.167*L | L6+L5+L4 > 0.167*L |
| | TSgc > 1400 | TSgc > 1800 |
| | $LGP_{t=5}$ = 365 | $LGP_{t=5}$ = 365 |
| **Cotton (tropics)** | Climates: Tr | Climates: Tr |
| L = 135/150/165/180 | L4a+L4b < 0.250*L | L4 = 0 |
| | TSgc > 3000 | TSgc > 3400 |
| **Cotton (sub-tropics)** | Climates:STr (SR+WR), Te | Climates:STr (SR+WR), Te |
| L = 135/150/165 | L4a+L4b < 0.333*L | L4a+L4b < 0.167*L |
| | TSgc > 2700 | TSgc > 3000 |
| **Banana/Plantain** | Climate: Tr, STr (SR+WR) | Climate: Tr, STr (SR+WR) |
| L = 12 months | L5< 0.667*L | L5< 0.500*L |
| | L2+L3 >0.333*L | L2+L3 >0.400*L |
| | L1 < 0.667 * L | L1 < 0.500 * L |
| | TSgc > 6000 | TSgc > 7000 |
| **Oil Palm** | Climate: Tr, STr (SR) | Climate: Tr, STr (SR) |
| L = 12 months | L4a+L4b< 0.333*L | L4 < 0.167*L |
| | TSgc > 7500 | TSgc > 8000 |

* applicable to post-dormancy period only

| Crop | Sub-optimal Conditions | Optimal Conditions |
|---|---|---|
| **Olive** | *Climates: STr (SR+WR), Te* | *Climates: STr (SR+WR), Te* |
| *L = 12 months* | $L8 = L9 = 0$ | $L8 = L9 = 0$ |
| | $L7 + L6 + L5 + L4 > 0.400*L$ | $L7 + L6 + L5 + L4 > 0.400*L$ |
| | $L4 + L3 + L2 + L1 > 0.333*L$ | $L4 + L3 + L2 + L1 > 0.333*L$ |
| | $TSgc > 4000$ | $TSgc > 5000$ |
| **Alfalfa (Lucerne)** | *Climates: Te, STR (SR+WR)* | *Climates: Te, STR (SR+WR)* |
| $L = LGP_{t=5}$ | $Gc (L) = (LGP_{t=5}) > 120$ days . | $Gc (L) = (LGP_{t=5}) > 150$ days . |
| | $L6 < 0.500*L$ | $L6 < 0.500*L$ |
| | $L1 < 0.333*L$ | $L1 < 0.333*L$ |
| | $TSgc > 1800$ | $TSgc > 2250$ |
| **Grasses** | *Climates: Tr, STR (SR+WR), Te* | *Climates: Tr, STR (SR+WR), Te* |
| $L = LGP_{t=5}$ | $TSgc > 750$ | $TSgc > 1000$ |
| | $Gc (L) = (LGP_{t=5}) > 90$ days | $Gc (L) = (LGP_{t=5}) > 120$ days |
| **Grasses** | *Climates:Te, B* | *Climates:Te* |
| $L = LGP_{t=5}$ | $TSgc > 750$ | $TSgc > 1000$ |
| | $Gc (L) = (LGP_{t=5}) > 90$ days | $Gc (L) = (LGP_{t=5}) > 120$ days |

## APPENDIX V

## CALCULATION OF REFERENCE EVAPOTRANSPIRATION ACCORDING TO PENMAN-MONTEITH COMBINATION EQUATION

The calculation of reference evapotranspiration ($ET_o$), i.e., the rate of evapotranspiration from a hypothetic reference crop with an assumed crop height of 12 cm, a fixed canopy resistance of 70ms$^{-1}$ and an albedo of 0.23 (closely resembling the evapotranspiration from an extensive surface of green grass), is done according to the Penman-Monteith equation (Monteith, 1965, 1981; FAO, 1992b). The calculation procedure uses a standardized set of input parameters, as follows:

$T_{max}$ ... maximum daily temperature (ºC)
$T_{min}$ ... minimum daily temperature (ºC)
$RH$ ... mean daily relative humidity (%)
$U2$ ... wind speed measurement (ms$^{-1}$)
$SD$ ... bright sunshine hours per day (hours)
$A$ ... elevation (m)
$L$ ... latitude (deg)
$J$ ... Julian date, i.e., number of day in year

The *Penman-Monteith combination equation* can be written in terms of an aerodynamic and a radiation term (FAO, 1992b):

$$ET_o = ET_{ar} + ET_{ra} \tag{1}$$

where the *aerodynamic term* can be approximated by

$$ET_{ar} = \frac{\gamma}{\vartheta + \gamma^*} \cdot \frac{900}{T_a + 273} \cdot U2 \cdot (e_a - e_d) \tag{2}$$

and the *radiation term* by

$$ET_{ra} = \frac{\vartheta}{\vartheta + \gamma^*} \cdot (R_n - G) \cdot \frac{1}{\lambda} \tag{3}$$

where variables in (2) and (3) are as follows:

$\gamma$ ... psychrometric constant (kPa ºC$^{-1}$)
$\gamma^*$ .. modified psychrometric constant (kPa ºC$^{-1}$)
$\vartheta$ ... slope of vapor pressure curve (kPa ºC$^{-1}$)
$T_a$ ... average daily temperature (ºC)
$e_a$ ... saturation vapor pressure (kPa)
$e_d$ ... vapor pressure at dew point (kPa)
$(e_a - e_d)$ vapor pressure deficit (kPa)
$U2$ ... wind speed measurement (ms$^{-1}$)
$R_n$ ... net radiation flux at surface (MJ m$^{-2}$ d$^{-1}$)
$G$ ... soil heat flux (MJ m$^{-2}$ d$^{-1}$)
$\lambda$ ... latent heat of vaporization (MJ kg$^{-1}$)

In the calculation procedure for the reference crop we use the following relationships to define terms in (2):

*Average daily temperature*:

$$T_a = 0.5(T_{\max} + T_{\min}) \tag{4}$$

*Latent heat of vaporization*:

$$\lambda = 2.501 - 0.002361\, T_a \tag{5}$$

*Atmospheric pressure* (kPa) at elevation A:

$$P = 101.3\left(\frac{293 - 0.0065\, A}{293}\right)^{5.256} \tag{6}$$

*Psychrometric constant*:

$$\gamma = 0.0016286 \cdot \frac{P}{\lambda} \tag{7}$$

*Aerodynamic resistance*:

$$r_a = \frac{208}{U2} \tag{8}$$

*Crop canopy resistance*:

$$r_c = \frac{R_l}{0.5\, LAI} \tag{9}$$

where under ambient $CO_2$ concentrations the average daily stomata resistance of a single leaf, $R_l$ ($sm^{-1}$), is set to $R_l$ = 100, and leaf area index of the reference crop is assumed as $LAI = 24 \cdot 0.12 = 2.88$.

*Modified psychrometric constant*:

$$\gamma^* = \gamma\left(1 + \frac{r_c}{r_a}\right) \tag{10}$$

*Saturation vapor pressure* $e_a$ for given temperatures $T_{\min}$ and $T_{\max}$

$$e_{ax} = 0.6108 \exp\left(\frac{17.27\, T_{\max}}{237.3 + T_{\max}}\right) \tag{11}$$

$$e_{an} = 0.6108 \exp\left(\frac{17.27\, T_{\min}}{237.3 + T_{\min}}\right) \tag{12}$$

$$e_a = 0.5\,(e_{ax} + e_{an}) \tag{13}$$

*Vapor pressure* at dew point, $e_d$:

$$e_d = \frac{RH}{100} \cdot \frac{0.5}{\left(\frac{1}{e_{ax}} + \frac{1}{e_{an}}\right)} \tag{14}$$

*Slope of vapor pressure curve*, $\vartheta$, for given temperatures $T_{max}$ and $T_{min}$:

$$\vartheta_x = \frac{4096\, e_{ax}}{(237.3 + T_{max})^2} \tag{15}$$

$$\vartheta_n = \frac{4096\, e_{an}}{(237.3 + T_{min})^2} \tag{16}$$

$$\vartheta = (\vartheta_x + \vartheta_n) \tag{17}$$

Using (4)-(17) all variables in (2) can be calculated from the input parameters of the $ET_o$ computer subroutine. To determine the remaining variables $R_n$ and G used in the radiation term $ET_{ra}$ of equation (3), we proceed with the following calculation steps:

*Latitude* expressed in rad:

$$\varphi = \frac{L\pi}{180} \tag{18}$$

*Solar declination* (rad):

$$\delta = 0.4093 \cdot \sin\left(\frac{2\pi}{365} J - 1.405\right) \tag{19}$$

*Relative distance* Earth to Sun:

$$d = 1 + 0.033 \cos\left(\frac{2\pi}{365} J\right) \tag{20}$$

*Sunset hour angle* (rad):

$$\psi = arc\cos(-\tan\varphi \tan\delta) \tag{21}$$

*Extraterrestrial radiation* (MJ $m^{-2}$ $d^{-1}$):

$$R_a = 37.586\, d\, (\psi \sin\varphi \sin\delta + \cos\varphi \cos\delta \sin\psi) \tag{22}$$

*Maximum daylight hours*:

$$DL = \frac{24}{\pi}\, \psi \tag{23}$$

*Short-wave radiation* $R_s$ (MJ $m^{-2}$ $d^{-1}$)

$$R_s = \left(0.25 + 0.5\frac{SD}{DL}\right) R_a \tag{24}$$

For a reference crop with an assumed albedo coefficient $\alpha = 0.23$ *net incoming short-wave radiation* $R_{ns}$ (MJ $m^{-2}$ $d^{-1}$) is:

$$R_{ns} = 0.77\, R_s \tag{25}$$

*Net outgoing long-wave radiation* $R_{nl}$ (MJ $m^{-2}$ $d^{-1}$) is estimated using:

$$R_{nl} = 4.903 \cdot 10^{-9} \left(0.1 + 0.9\frac{SD}{DL}\right)\left(0.34 - 0.139\sqrt{e_d}\right) \frac{(273.16 + T_{max})^4 + (273.16 + T_{min})^4}{2} \tag{26}$$

Using (25) and (26), *net radiation flux* at surface, $R_n$, becomes

$$R_n = R_{ns} - R_{nl} \tag{27}$$

Finally, *soil heat flux* is approximated using

$$G = 0.14\,(T_{a,n} - T_{a,n-1}) \qquad (28)$$

where $T_{a,n}$ and $T_{a,n-1}$ are average monthly temperatures of current and previous month, respectively. With equations (5), (10), (17), (27) and (28) all variables in (3) are defined and can be calculated from the input parameters described at the beginning of this Appendix.

# APPENDIX VI

## BIOMASS AND YIELD CALCULATION

The AEZ methodology for the calculation of potential net biomass and yields is derived from Kassam (1977). This model, based on eco-physiological principles, is outlined below:

To calculate the net biomass production ($B_n$) of a crop, an estimation of the gross biomass production ($B_g$) and respiration loss ($R$) is required:

$$B_n = B_g - R \qquad (1)$$

The equation relating the rate of net biomass production ($b_n$) to the rate of gross biomass production ($b_g$) and the respiration rate ($r$) is:

$$b_n = b_g - r \qquad (2)$$

The maximum rate of net biomass production ($b_{nm}$) is reached when the crop fully covers the ground surface. The period of maximum net crop growth, i.e., the point in time when maximum net biomass increments occur, is indicated by the inflection point of the cumulative growth curve. When the first derivative of net biomass growth is plotted against time the resulting graph resembles a normal distribution curve. The model assumes that the average rate of net production ($b_{na}$) over the entire growth cycle is half the maximum growth rate, i.e., $b_{na}$ = 0.5 $b_{nm}$. The net biomass production for a crop of N days ($B_n$) is then:

$$B_n = 0.5\ b_{nm} \times N \qquad (3)$$

The maximum rate of gross biomass production ($b_{gm}$) is related to the maximum net rate of $CO_2$ exchange of leaves ($P_m$) which is dependent on temperature, the photosynthesis pathway of the crop, and the level of atmospheric $CO_2$ concentration.

For a standard crop, i.e., a crop in adaptability group I with $P_m$ = 20 kg ha$^{-1}$ hr$^{-1}$ and a leaf area index of LAI = 5, the rate of gross biomass production $b_{gm}$ is calculated from the equation:

$$b_{gm} = F \times b_o + (1 - F)\ b_c \qquad (4)$$

where:

- $F$ = the fraction of the daytime the sky is clouded, $F = (A_c - 0.5\ R_g) / (0.8\ A_c)$, where $A_c$ (or PAR) is the maximum active incoming short-wave radiation on clear days (de Wit, 1965), and $R_g$ is incoming short-wave radiation (both are measured in cal cm$^{-2}$ day$^{-1}$)
- $b_o$ = gross dry mater production rate of a standard crop for a given location and time of the year on a completely overcast day, (kg ha$^{-1}$ day$^{-1}$) (de Wit, 1965)
- $b_c$ = gross dry mater production rate of a standard crop for a given location and time of the year on a perfectly clear day, (kg ha$^{-1}$ day$^{-1}$) (de Wit, 1965)

When $P_m$ is greater than 20 kg ha$^{-1}$ hr$^{-1}$, $b_{gm}$ is given by the equation:

$$b_{gm} = F\ (0.8 + 0.01P_m)\ b_o + (1 - F)\ (0.5 + 0.025\ P_m)\ b_c \quad (5)$$

When $P_m$ is less than 20 kg ha$^{-1}$ hr$^{-1}$, $b_{gm}$ is calculated according to:

$$b_{gm} = F\ (0.5 + 0.025\ P_m)\ b_o + (1 - F)\ (0.05\ P_m)\ b_c \quad (6)$$

To calculate the maximum rate of net biomass production ($b_{nm}$), the maximum rate of gross biomass production ($b_{gm}$) and the rate of respiration ($r_m$) are required. Here, growth respiration is considered a linear function of the rate of gross biomass production (McCree, 1974), and maintenance respiration a linear function of net biomass that has already been accumulated ($B_m$) When the rate of gross biomass production is $b_{gm}$, the respiration rate $r_m$ is:

$$r_m = k\ b_{gm} + c\ B_m \quad (7)$$

where $k$ and $c$ are the proportionality constants for growth respiration and maintenance respiration respectively, and $B_m$ is the net biomass accumulated at the time of maximum rate of net biomass production. For both legume and non legume crops $k$ equals 0.28. However, $c$ is temperature dependent and differs for the two crop groups. At 30 $^oC$, factor $c_{30}$ for a legume crop equals 0.0283 and for a non-legume crop 0.0108. The temperature dependence of $c_t$ for both crop groups is modelled with a quadratic function:

$$c_t = c_{30}\ (0.0044 + 0.0019\ T + 0.0010\ T^2). \quad (8)$$

It is assumed that the cumulative net biomass $B_m$ of the crop (i.e., biomass at the inflection point of the cumulative growth curve) equals half the net biomass that would be accumulated at the end of the crop's growth cycle. Therefore, we set $B_m$ = 0.5 $B_n$, and using (3), $B_m$ for a crop of $N$ days is determined according to:

$$B_m = 0.25\ b_{nm}\ x\ N \quad (9)$$

By combining the respiration equation with the equation for the rate of gross photosynthesis, the maximum rate of net biomass production ($b_{nm}$) or the rate of net dry matter production at full cover for a crop of $N$ days becomes:

$$b_{nm} = 0.72\ b_{gm} / (1 + 0.25\ c_t\ N) \quad (10)$$

Finally, the net biomass production ($B_n$) for a crop of $N$ days, where 0.5 $b_{nm}$ is the seasonal average rate of net biomass production, can be derived as:

$$B_n = (0.36\ b_{gm}\ x\ L) / (1/N + 0.25\ c_t) \quad (11)$$

where:

$b_{gm}$ = maximum rate of gross biomass production at leaf area index (LAI) of 5

$L$ = growth ratio, equal to the ratio of $b_{gm}$ at actual LAI to $b_{gm}$ at LAI of 5

$N$ = length of normal growth cycle

$c_t$ = maintenance respiration, dependent on both crop and temperature according to equation (8)

Potential yield ($Y_p$) is estimated from net biomass ($B_n$) using the equation:

$$Y_p = H_i \; x \; B_n \tag{12}$$

where:

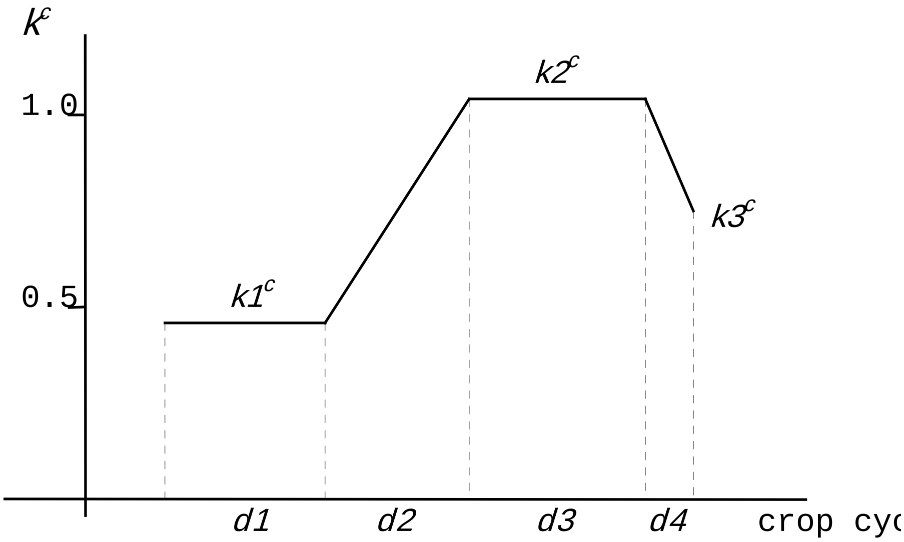
$H_i$ = harvest index, i.e., proportion of the net biomass of a crop that is economically useful

Thus, climate and crop characteristics that apply in the computation of net biomass and yield are: (a) heat and radiation regime over the crop cycle, (b) crop adaptability group to determine applicable rate of photosynthesis $P_m$, (c) length of growth cycle (from emergence to physiological maturity), (d) length of yield formation period,.(e) leaf area index at maximum growth rate, and (f) harvest index.

The calculation of moisture limited yields follows the procedures described in FAO (1992a), known as the CROPWAT method. In this approach, the crop-specific potential evapo-transpiration $ETo^c$ is related to reference evapotranspiration $ETo$ as,

$$ETo^c = k^c x\, ETo \tag{13}$$

where $k^c$ is calculated from a piecewise linear function as sketched below:




The function is paramerized by means of seven parameters. Four coefficients, *d1*, …, *d4*, relate to the characteristics of the crop cycle, denoting the length (in days) of four crop development stages, namely, initial stage, vegetative stage, reproductive stage, and maturation stage. Another three parameters, $k1^c, k2^c$ *and* $k3^c$, define relationship (13) respectively for the initial stage, the reproductive phase, and the end of the maturation stage.

Let $D_1, \ldots, D_4$ denote the days belonging to each of the four crop growth stages,

$$D_1 = \{ j \mid 1 \le j \le d1 \},$$

$$D_2 = \{ j \mid d1 < j \le d1 + d2 \},$$

$D_3 = \{ j \mid d1 + d2 < j \le d1 + d2 + d3 \}$, and
$D_4 = \{ j \mid d1 + d2 + d3 < j \le d1 + d2 + d3 + d4 \}$,

then the value of $k^c$ for a particular day $j$ is defined by:

$$k_j^c = \begin{cases} k1^c & j \in D_1 \\ k1^c + (j - d1) \cdot \dfrac{k2^c - k1^c}{d2} & j \in D_2 \\ k2^c & j \in D_3 \\ k2^c + (j - (d1 + d2 + d3)) \cdot \dfrac{k3^c - k2^c}{d4} & j \in D_4 \end{cases} \tag{14}$$

Using (13) and (14), crop-specific potential evapotranspiration over the four crop growth stages, $TETo_k^c$, and the entire crop cycle, $TETo^c$, can be calculated:

$$TETo_k^c = \sum_{j \in D_k} k_j^c \cdot ETo_j \qquad k = 1, \ldots, 4 \tag{15}$$

$$d0 = d1 + d2 + d3 + d4$$
$$TETo^c = \sum_{j=1}^{d0} k_j^c \cdot ETo_j \tag{16}$$

Similarly, applying a crop-specific soil water balance, actual evapotranspiration is calculated:

$$TETa_k^c = \sum_{j \in D_k} ETa_j^c \qquad k = 1, \ldots, 4 \tag{17}$$

$$TETa^c = \sum_{j=1}^{d0} ETa_j^c \tag{18}$$

where $ETa^c$ is determined according to (see also Chapter 3.4):

$$W_{j+1}^c = \min\left( W_j^c + P_j - ETa_j^c,\ Sa \right) \tag{19}$$

$$ETa_j^c = \begin{cases} ETo_j^c & \mathit{if}\ (W_j^c + P_j) \cdot d \ge Sa \cdot d \cdot (1 - p_j^c) \\ \rho_j \cdot ETo_j^c & \mathit{else} \end{cases} \tag{20}$$

with,

$$\rho_j = \frac{ETa_j^c}{ETo_j^c} = \frac{W_j^c + P_j}{Sa \cdot (1 - p_j^c)} \tag{21}$$

$j$ number of day in year
$Sa$ available soil moisture holding capacity (mm/m)
$d$ rooting depth (m)
$p_j^c$ soil water depletion fraction below which $ETa < ETo$
$\rho_j$ actual evapotranspiration proportionality factor.

*Sa* and *d* are defined by the respective values of the soil units in individual grid-cells. The computation of water-limited yields $Y_a$ is now easily obtained, following FAO (1979 and 1992a):

$$1-\frac{Y_a}{Y_p}=k^y\cdot(1-\frac{ETa^c}{ETo^c}) \qquad (22)$$

We evaluate (22) in two variants, first over the entire growth cycle and then according to individual growth stages. The more severe of the two conditions determines $Y_a$. The respective reduction multipliers $f_0$ and $f_1$ are defined by,

$$f_0=1-k_0^y\cdot(1-\frac{TETa^c}{TETo^c}) \qquad (23)$$

and

$$f_1=\prod_{k=1}^{4}(1-k_k^y\cdot(1-\frac{TETa_k^c}{TETo_k^c})) \qquad (24)$$

where the coefficient expressing the sensitivity of crop yield to moisture deficit, $k^y$, are based on FAO (1992a).

Applying (23) and (24) to potential yield from (12), we obtain the final results,

$$Y_a=\min(f_1,f_2)\cdot Y_p \qquad (25)$$

The parameters for lengths of crop stages, crop-specific evapotranspiration, and for sensitivity of yield to moisture deficit, used in this study, are listed in Appendix 7.

# APPENDIX VII

## PARAMETERS FOR BIOMASS AND YIELD CALCULATIONS

# PARAMETERS FOR BIOMASS AND YIELD CALCULATIONS

| CROPS | Growth cycle (GC) | Adaptability group | High Inputs | | Intermediate Inputs | | Low Inputs | | Dependence of Rate of Leaf Photosynthesis (Pm) on Temperature ($^{o}C$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | HI | Max. LAI | HI | Max. LAI | HI | Max. LAI | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
| **Wheat (winter)** | 30-90 days | C3/I | 0.45 | 4.5 | 0.35. | 3.5 | 0.25 | 2.5 | 5 | 15 | 25 | 25 | 20 | 10 | 0 | 0 | 0 |
| **Wheat (winter)** | 35-105 days | C3/I | 0.45 | 5.0 | 0.35. | 3.8 | 0.25 | 2.5 | 5 | 15 | 25 | 25 | 20 | 10 | 0 | 0 | 0 |
| **Wheat (winter)** | 40-120 days | C3/I | 0.50 | 5.5 | 0.40. | 4.0 | 0.30 | 2.5 | 5 | 15 | 25 | 25 | 20 | 10 | 0 | 0 | 0 |
| **Wheat (winter)** | 45-135 days | C3/I | 0.50 | 5.5 | 0.40. | 4.0 | 0.30 | 2.5 | 5 | 15 | 25 | 25 | 20 | 10 | 0 | 0 | 0 |
| **Wheat (spring)** | 105 days | C3/I | 0.40 | 3.5 | 0.30 | 2.6 | 0.20 | 1.8 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Wheat (spring)** | 120 days | C3/I | 0.40 | 4.0 | 0.30 | 3.0 | 0.20 | 2.0 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Wheat (spring)** | 135 days | C3/I | 0.40 | 4.5 | 0.30 | 3.4 | 0.20 | 2.3 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Wheat (spring)** | 150 days | C3/I | 0.40 | 5.0 | 0.30 | 3.8 | 0.20 | 2.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Wheat (sub-tropics)** | 105 days | C3/I | 0.45 | 4.0 | 0.35 | 3.0 | 0.25 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Wheat (sub-tropics)** | 120 days | C3/I | 0.45 | 4.5 | 0.35 | 3.3 | 0.25 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Wheat (sub-tropics)** | 135 days | C3/I | 0.45 | 5.0 | 0.35 | 3.8 | 0.25 | 2.5 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Wheat (sub-tropics)** | 150 days | C3/I | 0.45 | 5.0 | 0.35 | 3.8 | 0.25 | 2.5 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Wheat (tropics)** | 100 days | C3/I | 0.40 | 3.5 | 0.30 | 2.6 | 0.20 | 1.8 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Wheat (tropics)** | 130 days | C3/I | 0.40 | 4.5 | 0.30 | 3.4 | 0.20 | 2.3 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Wheat (tropics)** | 160 days | C3/I | 0.40 | 5.0 | 0.30 | 3.8 | 0.20 | 2.5 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Wheat (tropics)** | 190 days | C3/I | 0.40 | 5.0 | 0.30 | 3.8 | 0.20 | 2.5 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Japonica Rice (wetland)** | 105 days | C3/II | 0.40 | 5.0 | 0.35. | 3.7 | 0.30 | 2.5 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Japonica Rice (wetland)** | 120 days | C3/II | 0.40 | 5.0 | 0.35. | 4.0 | 0.30 | 2.5 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Japonica Rice (wetland)** | 135 days | C3/II | 0.40 | 5.5 | 0.35. | 4.3 | 0.30 | 3.0 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Japonica Rice (wetland)** | 150 days | C3/II | 0.40 | 6.0 | 0.35. | 4.5 | 0.30 | 3.0 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Indica Rice (wetland)** | 105 days | C3/II | 0.45 | 5.0 | 0.38. | 3.8 | 0.30 | 2.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Indica Rice (wetland)** | 120 days | C3/II | 0.45 | 5.5 | 0.38. | 4.0 | 0.30 | 2.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Indica Rice (wetland)** | 135 days | C3/II | 0.45 | 6.0 | 0.38. | 4.5 | 0.30 | 3.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Indica Rice (wetland)** | 150 days | C3/II | 0.45 | 6.5 | 0.38. | 4.8 | 0.30 | 3.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Rice (dryland)** | 105 days | C3/II | 0.30 | 3.5 | 0.23 | 2.6 | 0.15 | 1.8 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Rice (dryland)** | 120 days | C3/II | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Rice (dryland)** | 135 days | C3/II | 0.30 | 4.5 | 0.23 | 3.4 | 0.15 | 2.3 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Maize (grain) (lowland)** | 90 days | C4/III | 0.40 | 3.0 | 0.30 | 2.3 | 0.20 | 1.5 | 0 | 0 | 5 | 45 | 65 | 65 | 65 | 45 | 5 |
| **Maize (grain) (lowland)** | 105 days | C4/III | 0.40 | 3.5 | 0.30 | 2.8 | 0.20 | 2.0 | 0 | 0 | 5 | 45 | 65 | 65 | 65 | 45 | 5 |
| **Maize (grain) (lowland)** | 120 days | C4/III | 0.45 | 4.0 | 0.35 | 3.3 | 0.25 | 2.5 | 0 | 0 | 5 | 45 | 65 | 65 | 65 | 45 | 5 |
| **Maize (grain) (lowland)** | 135 days | C4/III | 0.45 | 4.5 | 0.35 | 3.3 | 0.25 | 2.5 | 0 | 0 | 5 | 45 | 65 | 65 | 65 | 45 | 5 |
| **Maize (grain) (highland)** | 105 days | C4/IV | 0.35 | 3.5 | 0.25 | 2.5 | 0.15 | 1.5 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (grain) (highland)** | 180 days | C4/IV | 0.35 | 4.0 | 0.27 | 3.0 | 0.20 | 2.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (grain) (highland)** | 300 days | C4/IV | 0.35 | 4.0 | 0.27 | 3.0 | 0.20 | 2.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |

# PARAMETERS FOR BIOMASS AND YIELD CALCULATIONS

| CROPS | Growth cycle (GC) | Adaptability group | High Inputs | | Intermediate Inputs | | Low Inputs | | Dependence of Rate of Leaf Photosynthesis (Pm) on Temperature ($^{o}$C) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | HI | Max. LAI | HI | Max. LAI | HI | Max. LAI | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
| **Maize (grain) (sub-tropics)** | 105 days | C4/IV | 0.40 | 3.0 | 0.30 | 2.3 | 0.20 | 1.5 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (grain) (sub-tropics)** | 120 days | C4/IV | 0.40 | 3.5 | 0.30 | 2.5 | 0.20 | 2.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (grain) (sub-tropics)** | 135 days | C4/IV | 0.45 | 4.0 | 0.33 | 3.0 | 0.20 | 2.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (grain) (sub-tropics)** | 150 days | C4/IV | 0.45 | 4.5 | 0.33 | 3.5 | 0.20 | 2.5 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (grain) (sub-tropics)** | 165 days | C4/IV | 0.45 | 5.0 | 0.35 | 3.8 | 0.25 | 2.5 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (grain) (sub-tropics)** | 180 days | C4/IV | 0.45 | 5.5 | 0.35 | 4.3 | 0.25 | 3.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (silage)** | 105 days | C4/IV | 0.60 | 6.0 | 0.50 | 4.5 | 0.40 | 3.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (silage)** | 120 days | C4/IV | 0.60 | 6.0 | 0.50 | 4.5 | 0.40 | 3.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (silage)** | 135 days | C4/IV | 0.60 | 6.0 | 0.50 | 4.5 | 0.40 | 3.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (silage)** | 150 days | C4/IV | 0.65 | 6.5 | 0.55 | 5.0 | 0.45 | 3.5 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (silage)** | 165 days | C4/IV | 0.65 | 6.5 | 0.55 | 5.0 | 0.45 | 3.5 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Maize (silage)** | 180 days | C4/IV | 0.65 | 7.0 | 0.55 | 5.5 | 0.45 | 4.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Barley (winter)** | 30-90 days | C3/I | 0.45 | 4.5 | 0.35. | 3.5 | 0.25 | 2.5 | 5 | 15 | 25 | 25 | 20 | 10 | 0 | 0 | 0 |
| **Barley (winter)** | 35-105 days | C3/I | 0.45 | 5.0 | 0.35. | 3.8 | 0.25 | 2.5 | 5 | 15 | 25 | 25 | 20 | 10 | 0 | 0 | 0 |
| **Barley (winter)** | 40-120 days | C3/I | 0.50 | 5.5 | 0.40. | 4.0 | 0.30 | 2.5 | 5 | 15 | 25 | 25 | 20 | 10 | 0 | 0 | 0 |
| **Barley (winter)** | 45-135 days | C3/I | 0.50 | 5.5 | 0.40. | 4.0 | 0.30 | 2.5 | 5 | 15 | 25 | 25 | 20 | 10 | 0 | 0 | 0 |
| **Barley (spring)** | 90 days | C3/I | 0.40 | 3.5 | 0.30 | 2.8 | 0.20 | 2.0 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Barley (spring)** | 105 days | C3/I | 0.40 | 3.5 | 0.30 | 2.8 | 0.20 | 2.0 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Barley (spring** | 120 days | C3/I | 0.40 | 4.0 | 0.30 | 3.3 | 0.20 | 2.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Barley (spring)** | 135 days | C3/I | 0.40 | 4.5 | 0.30 | 3.5 | 0.20 | 2.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Barley (sub-tropics)** | 90 days | C3/I | 0.45 | 4.0 | 0.35 | 3.0 | 0.25 | 2.0 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Barley (sub-tropics)** | 105 days | C3/I | 0.45 | 4.5 | 0.35 | 3.3 | 0.25 | 2.0 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Barley (sub-tropics)** | 120 days | C3/I | 0.45 | 5.0 | 0.35 | 3.8 | 0.25 | 2.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Barley (sub-tropics)** | 135 days | C3/I | 0.45 | 5.0 | 0.35 | 3.8 | 0.25 | 2.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Barley (tropics)** | 100 days | C3/I | 0.40 | 3.5 | 0.30 | 2.5 | 0.20 | 1.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Barley (tropics)** | 130 days | C3/I | 0.40 | 4.0 | 0.30 | 3.0 | 0.20 | 2.0 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Barley (tropics)** | 160 days | C3/I | 0.40 | 5.0 | 0.30 | 3.8 | 0.20 | 2.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Barley (tropics)** | 190 days | C3/I | 0.40 | 5.0 | 0.30 | 3.8 | 0.20 | 2.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Sorghum (lowland)** | 90 days | C4/III | 0.35 | 3.5 | 0.25 | 2.5 | 0.15 | 1.5 | 0 | 0 | 5 | 45 | 65 | 65 | 65 | 45 | 5 |
| **Sorghum (lowland)** | 105 days | C4/III | 0.35 | 4.0 | 0.25 | 3.0 | 0.15 | 2.0 | 0 | 0 | 5 | 45 | 65 | 65 | 65 | 45 | 5 |
| **Sorghum (lowland)** | 120 days | C4/III | 0.35 | 4.5 | 0.25 | 3.3 | 0.15 | 2.0 | 0 | 0 | 5 | 45 | 65 | 65 | 65 | 45 | 5 |
| **Sorghum (lowland)** | 135 days | C4/III | 0.35 | 4.5 | 0.25 | 3.3 | 0.15 | 2.0 | 0 | 0 | 5 | 45 | 65 | 65 | 65 | 45 | 5 |
| **Sorghum (highland)** | 105 days | C4/IV | 0.20 | 3.5 | 0.16 | 2.5 | 0.12 | 1.5 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Sorghum (highland)** | 180 days | C4/IV | 0.20 | 4.0 | 0.16 | 3.0 | 0.12 | 2.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Sorghum (highland)** | 300 days | C4/IV | 0.20 | 4.0 | 0.16 | 3.0 | 0.12 | 2.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |

# PARAMETERS FOR BIOMASS AND YIELD CALCULATIONS

| CROPS | Growth cycle (GC) | Adaptability group | High Inputs | | Intermediate inputs | | Low Inputs | | Dependence of Rate of Leaf Photosynthesis (Pm) on Temperature ($^{o}$C) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | HI | Max. LAI | HI | Max. LAI | HI | Max. LAI | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
| **Rye (winter)** | 30-90 days | C3/I | 0.35 | 3.5 | 0.28 | 2.8 | 0.20 | 2.0 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Rye (winter)** | 35-105 days | C3/I | 0.35 | 4.0 | 0.28 | 3.0 | 0.20 | 2.0 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Rye (winter)** | 40-120 days | C3/I | 0.35 | 4.0 | 0.28 | 3.0 | 0.20 | 2.0 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Rye (winter)** | 45-135 days | C3/I | 0.35 | 4.5 | 0.28 | 3.5 | 0.20 | 2.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Rye (spring)** | 90 days | C3/I | 0.35 | 3.0 | 0.25 | 2.3 | 0.15 | 1.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Rye (spring)** | 105 days | C3/I | 0.35 | 3.5 | 0.25 | 2.5 | 0.15 | 1.8 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Rye (spring)** | 120 days | C3/I | 0.35 | 4.0 | 0.25 | 3.0 | 0.15 | 2.0 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Rye (spring)** | 135 days | C3/I | 0.35 | 4.0 | 0.25 | 3.0 | 0.15 | 2.0 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Pearl Millet** | 70 days | C4/III | 0.25 | 3.0 | 0.18 | 2.3 | 0.12 | 1.5 | 0 | 0 | 5 | 45 | 65 | 65 | 65 | 45 | 5 |
| **Pearl Millet** | 90 days | C4/III | 0.25 | 3.5 | 0.18 | 2.8 | 0.12 | 2.0 | 0 | 0 | 5 | 45 | 65 | 65 | 65 | 45 | 5 |
| **Foxtail Millet** | 75 days | C4/IV | 0.30 | 3.5 | 0.25 | 2.6 | 0.15 | 1.5 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Foxtail Millet** | 90 days | C4/IV | 0.30 | 4.0 | 0.25 | 3.0 | 0.15 | 2.0 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Foxtail Millet** | 105 days | C4/IV | 0.35 | 4.5 | 0.28 | 3.5 | 0.20 | 2.5 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **Foxtail Millet** | 120 days | C4/IV | 0.35 | 5.0 | 0.28 | 3.8 | 0.20 | 2.5 | 0 | 5 | 40 | 50 | 50 | 50 | 40 | 5 | 0 |
| **White Potato** | 90 days | C3/I | 0.60 | 3.5 | 0.45 | 2.8 | 0.30 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **White Potato** | 120 days | C3/I | 0.60 | 4.5 | 0.45 | 3.2 | 0.30 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **White Potato** | 150 days | C3/I | 0.60 | 5.0 | 0.45 | 3.7 | 0.30 | 2.5 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **White Potato** | 180 days | C3/I | 0.60 | 5.5 | 0.45 | 4.0 | 0.30 | 2.5 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Cassava** | ≤ 365 days | C3/II | 0.50 | 3.0 | 0.40 | 2.3 | 0.30 | 1.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Sweet Potato** | 120 days | C3/II | 0.55 | 4.0 | 0.42 | 3.0 | 0.30 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Sweet Potato** | 150 days | C3/II | 0.55 | 4.0 | 0.42 | 3.0 | 0.30 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Sweet Potato** | 180 days | C3/II | 0.55 | 4.5 | 0.42 | 3.5 | 0.30 | 2.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Sugarcane** | ≤ 365 days | C4/III | 0.15 | 7.0 | 0.12 | 5.3 | 0.10 | 3.5 | 0 | 0 | 5 | 45 | 65 | 65 | 65 | 45 | 5 |
| **Sugarbeet** | 150 days | C3/I | 0.15 | 5.0 | 0.10 | 3.5 | 0.08 | 2.0 | 5 | 15 | 20 | 25 | 25 | 25 | 25 | 5 | 0 |
| **Sugarbeet** | 165 days | C3/I | 0.15 | 5.5 | 0.10 | 4.0 | 0.08 | 2.5 | 5 | 15 | 20 | 25 | 25 | 25 | 25 | 5 | 0 |
| **Sugarbeet** | 180 days | C3/I | 0.15 | 5.5 | 0.10 | 4.0 | 0.08 | 2.5 | 5 | 15 | 20 | 25 | 25 | 25 | 25 | 5 | 0 |
| **Sugarbeet** | 195 days | C3/I | 0.15 | 6.0 | 0.10 | 4.5 | 0.08 | 3.0 | 5 | 15 | 20 | 25 | 25 | 25 | 25 | 5 | 0 |
| **Sugarbeet** | 210 days | C3/I | 0.15 | 6.0 | 0.10 | 4.5 | 0.08 | 3.0 | 5 | 15 | 20 | 25 | 25 | 25 | 25 | 5 | 0 |
| **Phaseolus Bean (lowland)** | 90 days | C3/II | 0.30 | 3.5 | 0.23 | 2.6 | 0.15 | 1.8 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Phaseolus Bean (lowland)** | 120 days | C3/II | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Phaseolus Bean (lowland)** | 150 days | C3/II | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Phaseolus Bean (highland)** | 120 days | C3/I | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Phaseolus Bean (highland)** | 150 days | C3/I | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Phaseolus Bean (highland)** | 180 days | C3/I | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Phaseolus Bean (temperate)** | 90 days | C3/I | 0.30 | 3.0 | 0.23 | 2.3 | 0.15 | 1.5 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Phaseolus Bean (temperate)** | 120 days | C3/I | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Phaseolus Bean (temperate)** | 150 days | C3/I | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |

# PARAMETERS FOR BIOMASS AND YIELD CALCULATIONS

| CROPS | Growth cycle (GC) | Adaptability group | High Inputs | | Intermediate Inputs | | Low Inputs | | Dependence of Rate of Leaf Photosynthesis (Pm) on Temperature (°C) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | HI | Max. LAI | HI | Max. LAI | HI | Max. LAI | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
| **Chickpea** | 90 days | C3/I | 0.30 | 3.0 | 0.23 | 2.3 | 0.15 | 1.5 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Chickpea** | 105 days | C3/I | 0.30 | 3.5 | 0.23 | 2.7 | 0.15 | 1.8 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Chickpea** | 120 days | C3/I | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Chickpea (CR)** | 150 days | C3/I | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Chickpea (CR)** | 180 days | C3/I | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Cowpea** | 80 days | C3/II | 0.30 | 3.0 | 0.23 | 2.3 | 0.15 | 1.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Cowpea** | 100 days | C3/II | 0.30 | 3.5 | 0.23 | 2.7 | 0.15 | 1.8 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Cowpea** | 120 days | C3/II | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Groundnut** | 90 days | C3/II | 0.30 | 3.0 | 0.23 | 2.3 | 0.15 | | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Groundnut** | 105 days | C3/II | 0.30 | 3.5 | 0.23 | 2.7 | 0.15 | 1.8 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Groundnut** | 120 days | C3/II | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Soybean (tropics)** | 90 days | C3/II | 0.30 | 3.0 | 0.23 | 2.3 | 0.15 | 1.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Soybean (tropics)** | 105 days | C3/II | 0.30 | 3.5 | 0.23 | 2.7 | 0.15 | 1.8 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Soybean (tropics)** | 120 days | C3/II | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Soybean (sub-tropics)** | 105 days | C3/II | 0.30 | 3.5 | 0.23 | 2.7 | 0.15 | 1.8 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Soybean (sub-tropics)** | 120 days | C3/II | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Soybean (sub-tropics)** | 135 days | C3/II | 0.30 | 4.0 | 0.23 | 3.0 | 0.15 | 2.0 | 0 | 5 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Sunflower (tropics)** | 135 days | C3/II | 0.25 | 4.0 | 0.20 | 3.0 | 0.15 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Sunflower (tropics)** | 150 days | C3/II | 0.25 | 4.5 | 0.20 | 3.5 | 0.15 | 2.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Sunflower (tropics)** | 165 days | C3/II | 0.25 | 5.0 | 0.20 | 3.8 | 0.15 | 2.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Sunflower (sub tropics)** | 135 days | C3/I | 0.25 | 4.0 | 0.20 | 3.0 | 0.15 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Sunflower (sub tropics)** | 150 days | C3/I | 0.25 | 4.5 | 0.20 | 3.5 | 0.15 | 2.5 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Sunflower (sub tropics)** | 165 days | C3/I | 0.25 | 5.0 | 0.20 | 3.8 | 0.15 | 2.5 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Rape (winter)** | 35-105 days | C3/I | 0.25 | 3.5 | 0.18 | 2.5 | 0.12 | 1.5 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Rape (winter)** | 45-120 days | C3/I | 0.25 | 4.0 | 0.18 | 3.0 | 0.12 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Rape (spring)** | 135 days | C3/I | 0.25 | 3.5 | 0.18 | 2.5 | 0.12 | 1.5 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Rape (spring)** | 150 days | C3/I | 0.25 | 4.0 | 0.18 | 3.0 | 0.12 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Rape (spring)** | 165 days | C3/I | 0.25 | 4.0 | 0.18 | 3.0 | 0.12 | 2.0 | 5 | 15 | 25 | 25 | 20 | 15 | 5 | 0 | 0 |
| **Rape (sub-tropics/tropics)** | 135 days | C3/I | 0.25 | 3.5 | 0.18 | 2.5 | 0.12 | 1.5 | 5 | 15 | 20 | 25 | 25 | 25 | 25 | 5 | 0 |
| **Rape (sub-tropics/tropics)** | 150 days | C3/I | 0.25 | 4.0 | 0.18 | 3.0 | 0.12 | 2.0 | 5 | 15 | 20 | 25 | 25 | 25 | 25 | 5 | 0 |
| **Rape (sub-tropics/tropics)** | 165 days | C3/I | 0.25 | 4.0 | 0.18 | 3.0 | 0.12 | 2.0 | 5 | 15 | 20 | 25 | 25 | 25 | 25 | 5 | 0 |
| **Oil palm** | ≤ 365 days | C3/II | 0.20 | 6.0 | 0.15 | 4.5 | 0.10 | 3.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Olive** | ≤ 365 days | C3/I | 0.20 | 3.5 | 0.15 | 2.5 | 0.10 | 1.5 | 5 | 15 | 20 | 25 | 25 | 25 | 25 | 5 | 0 |
| **Banana/Plantain** | ≤ 365 days | C3/II | 0.25 | 6.0 | 0.20 | 4.5 | 0.15 | 3.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |

# PARAMETERS FOR BIOMASS AND YIELD CALCULATIONS

| CROPS | Growth cycle (GC) | Adaptability group | High Inputs | | Intermediate Inputs | | Low Inputs | | Dependence of Rate of Leaf Photosynthesis (Pm) on Temperature (°C) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | HI | Max. LAI | HI | Max. LAI | HI | Max. LAI | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
| **Cotton (tropics)** | 135 days | C3/II | 0.07 | 2.5 | 0.05 | 2.0 | 0.03 | 1.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Cotton (tropics)** | 150 days | C3/II | 0.07 | 2.5 | 0.05 | 2.0 | 0.03 | 1.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Cotton (tropics)** | 165 days | C3/II | 0.07 | 3.0 | 0.05 | 2.5 | 0.03 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Cotton (tropics)** | 180 days | C3/II | 0.07 | 3.0 | 0.05 | 2.5 | 0.03 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Cotton (sub-tropics)** | 135 days | C3/II | 0.07 | 2.5 | 0.05 | 2.0 | 0.03 | 1.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Cotton (sub-tropics** | 150 days | C3/II | 0.07 | 2.5 | 0.05 | 2.0 | 0.03 | 1.5 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Cotton (sub-tropics** | 165 days | C3/II | 0.07 | 3.0 | 0.05 | 2.5 | 0.03 | 2.0 | 0 | 0 | 15 | 30 | 35 | 35 | 30 | 5 | 0 |
| **Alfalfa** | ≤ 365 days | C3/I | 0.65 | 6.0 | 0.45 | 4.5 | 0.25 | 3.0 | 5 | 15 | 20 | 25 | 25 | 25 | 25 | 5 | 0 |
| **Grass + Legume (temp.)** | ≤ 365 days | C3/I | 0.65 | 4.0 | 0.40 | 3.0 | 0.30 | 2.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Grass + Legume (tropics)** | ≤ 365 days | C3/II | 0.65 | 4.0 | 0.40 | 3.0 | 0.30 | 2.5 | 2.5 | 10 | 20 | 25 | 25 | 20 | 10 | 5 | 0 |
| **Grasses (temp.)** | ≤ 365 days | C3/I | 0.65 | 4.0 | 0.40 | 3.0 | 0.30 | 2.5 | 5 | 15 | 20 | 20 | 15 | 5 | 0 | 0 | 0 |
| **Grasses (tropics)** | ≤ 365 days | C3/II | 0.65 | 4.0 | 0.40 | 3.0 | 0.30 | 2.5 | 0 | 2.5 | 15 | 35 | 37.5 | 37.5 | 30 | 5 | 0 |
| **Grasses (temp.)** | ≤ 365 days | C4/IV | 0.65 | 4.0 | 0.40 | 3.0 | 0.30 | 2.5 | 2.5 | 15 | 37.5 | 50 | 50 | 37.5 | 25 | 10 | 0 |
| **Grassess (tropics)** | ≤ 365 days | C4/III | 0.65 | 4.0 | 0.40 | 3.0 | 0.30 | 2.5 | 0 | 2.5 | 30 | 40 | 47.5 | 50 | 47.5 | 40 | 5 |


**Main Sources:**

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**Notes:**

When the growth cycle is curtailed due to the growing period being shorter, both harvest index *and* maximum leaf area index are to be reduced proportionately relative to the normal yield formation period.

It is assumed that yield formation periods relate to growth cycles as follows: cereals 33%; roots and tubers 66%; legumes 50%; oil crops except for olive and oil palm 50%; fiber crops 50%. sugar crops 66%; and pastures 100%. The yield formation period of winter crops is relative to the post-winter (dormancy) part of the growth cycle.

## PARAMETERS FOR CALCULATION OF WATER-LIMITED YIELDS

| CROPS | Length of Crop Stage (% of growth cycle) | | | | Crop water requirements relative to reference evapotranspiration | | | | Yield loss factors | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $d1$ | $d2$ | $d3$ | $d4$ | $k1^c$ | $k2^c$ | $k3^c$ | $k0^c$ | $k_1^y$ | $k_2^y$ | $k_3^y$ | $k_4^y$ | $k_0^y$ |
| **Wheat (winter)** | 10 | 30 | 35 | 25 | 0.40 | 1.10 | 0.40 | 0.85 | 0.20 | 0.60 | 0.75 | 0.50 | 1.05 |
| **Wheat (spring)** | 10 | 20 | 45 | 25 | 0.40 | 1.10 | 0.40 | 0.85 | 0.20 | 0.65 | 0.80 | 0.55 | 1.15 |
| **Rice (wetland)** | 10 | 30 | 30 | 30 | 1.10 | 1.20 | 1.00 | 1.10 | 1.00 | 2.00 | 2.50 | 1.00 | 2.00 |
| **Rice (dryland)** | 10 | 30 | 30 | 30 | 0.50 | 1.20 | 0.60 | 0.90 | 0.40 | 0.90 | 1.50 | 0.50 | 1.25 |
| **Maize /grain)** | 15 | 30 | 35 | 20 | 0.40 | 1.10 | 0.60 | 0.85 | 0.40 | 0.90 | 1.50 | 0.50 | 1.25 |
| **Barley (winter)** | 10 | 30 | 35 | 25 | 0.40 | 1.10 | 0.40 | 0.85 | 0.20 | 0.60 | 0.75 | 0.50 | 1.05 |
| **Barley (spring)** | 10 | 20 | 45 | 25 | 0.40 | 1.10 | 0.40 | 0.85 | 0.20 | 0.65 | 0.80 | 0.55 | 1.15 |
| **Sorghum** | 10 | 25 | 40 | 25 | 0.40 | 1.05 | 0.55 | 0.80 | 0.20 | 0.60 | 0.90 | 0.50 | 0.90 |
| **Rye (winter)** | 10 | 30 | 35 | 25 | 0.40 | 1.10 | 0.40 | 0.85 | 0.20 | 0.60 | 0.75 | 0.50 | 1.05 |
| **Rye (spring)** | 10 | 20 | 45 | 25 | 0.40 | 1.10 | 0.40 | 0.85 | 0.20 | 0.65 | 0.80 | 0.55 | 1.15 |
| **Pearl Millet** | 10 | 25 | 40 | 25 | 0.35 | 1.05 | 0.40 | 0.80 | 0.20 | 0.60 | 0.80 | 0.50 | 0.90 |
| **Foxtail Millet** | 10 | 25 | 40 | 25 | 0.40 | 1.05 | 0.40 | 0.85 | 0.20 | 0.60 | 0.80 | 0.50 | 1.00 |
| **White Potato** | 20 | 25 | 35 | 20 | 0.50 | 1.10 | 0.75 | 0.85 | 0.50 | 0.80 | 0.80 | 0.70 | 1.10 |
| **Sweet Potato** | 20 | 25 | 35 | 20 | 0.50 | 1.10 | 0.75 | 0.85 | 0.50 | 0.80 | 0.80 | 0.70 | 1.10 |
| **Sugarbeet** | 15 | 30 | 35 | 20 | 0.50 | 1.10 | 0.70 | 0.85 | 1.00 | 1.00 | 1.00 | 0.50 | 1.10 |
| **Phaseolous Bean** | 20 | 33 | 33 | 14 | 0.40 | 1.10 | 0.90 | 0.85 | 0.20 | 0.60 | 1.10 | 0.75 | 1.15 |
| **Chickpea** | 20 | 33 | 33 | 14 | 0.40 | 1.10 | 0.70 | 0.85 | 0.20 | 0.60 | 1.10 | 0.75 | 1.15 |
| **Cowpea** | 20 | 33 | 33 | 14 | 0.40 | 1.10 | 0.70 | 0.85 | 0.20 | 0.60 | 1.10 | 0.75 | 1.15 |
| **Groundnut** | 20 | 30 | 30 | 20 | 0.50 | 1.05 | 0.60 | 0.80 | 0.20 | 0.80 | 0.80 | 0.60 | 0.70 |
| **Soybean** | 15 | 20 | 45 | 20 | 0.40 | 1.10 | 0.50 | 0.85 | 0.20 | 0.80 | 1.00 | 0.80 | 0.85 |
| **Sunflower** | 17 | 28 | 35 | 20 | 0.40 | 1.10 | 0.40 | 0.80 | 0.25 | 0.60 | 1.00 | 0.80 | 0.95 |
| **Rape** | 15 | 25 | 40 | 20 | 0.50 | 1.10 | 0.50 | 0.80 | 0.20 | 0.80 | 1.00 | 0.80 | 0.85 |
| **Cotton** | 15 | 30 | 30 | 25 | 0.50 | 1.15 | 0.70 | 0.85 | 0.20 | 0.50 | 0.75 | 0.50 | 0.85 |

**Notes**: The coefficients *d1*, …, *d4* relate to the characteristics of the crop growth cycle, denoting here the relative length (in percent) of four crop development stages, namely, initial stage, vegetative stage, reproductive stage, and maturation stage. Parameters $k1^c$, $k2^c$, and $k3^c$ define crop water requirements respectively for the initial stage, the reproductive phase, and the end of the maturation stage. Coefficient $k0^c$ indicates water requirements relative to reference evapotranspiration over the entire growth cycle. Finally, factors $k^y$ quantify the expected yield loss in relation to a crop evapotranspiration deficit, by crop stage and for the entire growth cycle, respectively. For calculation details, see Appendix 6.

# APPENDIX VIII

## AGRO-CLIMATIC CONSTRAINT RATINGS

Agro-climatic constraints cause direct or indirect losses in the yield and quality of produce. Yields losses in a rain-fed crop due to agro-climatic constraints have been formulated based on principles and procedures proposed in FAO1978-81a. Details of the conditions that are influencing yield losses are listed below.

*(i) How well the crop growth cycle fits within the length of growing period*

When the growing period is shorter than the growth cycle of the crop, from sowing to full maturity, there is loss of yield. The biomass and yield calculations account for direct losses by appropriately adjusting LAI and harvest index (see section 4.3.2). However, the loss in the marketable value of the produce due to poor quality of the yield as influenced by incomplete yield formation (e.g., incomplete grain filling in grain crops resulting in shriveled grains or yield of a lower grade, incomplete bulking in root and tuber leading to a poor grade of ware), is not accounted for in the biomass and yield calculations. This loss is to be considered as an agro-climatic constraint in addition to the quantitative yield loss due to curtailment of the yield formation period. Yield losses can also occur when the length of the growing period is much longer than the length of the growth cycles. These losses operate through yield and quality reducing effects of (i) pests, diseases and weeds, (ii) climatic factors affecting yield components and yield formation, and (iii) climatic conditions affecting the efficiency of farming operations.

*(ii) The degree of water-stress during the growing period*

Water-stress generally affects crop growth, yield formation and quality of produce. The yield reducing effects of water-stress varies from crop to crop. The total yield impact can be considered in terms of (i) the effect on growth of the whole crop, and (ii) the effect on yield formation and quality of produce. For some crops, the latter effect can be more severe than the former, particularly where the yield is a reproductive part (e.g., cereals) and yield formation depends on the sensitivity of floral parts and fruit set to water-stress (e.g., silk drying in maize).

*(iii) Pests, diseases and weeds*

To assess the agro-climatic constraints of pest, disease and weed complex, it is convenient to separate the effects on yields that operate through loss in crop growth potential (e.g., pest and diseases affecting vegetative parts in grain crops) from effects on yield that operate directly on yield formation and quality of produce (e.g., cotton stainer affecting lint quality, grain mould in sorghum affecting both yield and grain quality).

*(iv) Climatic factors directly or indirectly reducing yield and quality of produce*

These include problems of poor seed set and/or maturity under cool or low temperature conditions, problems of seed germination in the panicle due to wet conditions at the end of grain filling, problems of poor quality lint due to wet conditions during the time of boll opening period in cotton, problems of poor seed set in wet conditions at the time of flowering in some grain crops, and problems of excessive vegetative growth and poor harvest index due to high night-time temperature or low diurnal range in temperature.

*(v) Climatic factors affecting the efficiency of farming operations and costs of production*

Farming operations include those related to land preparation, sowing, cultivation and crop protection during crop growth, and harvesting (including operations related to handling the produce during harvest and the effectiveness of being able to dry the produce). Agro-climatic constraints in this category are essentially workability constraints, which primarily account for excessive wetness conditions. Limited workability can cause direct losses in yield and quality of produce, and/or impart a degree of relative unsuitability to an area for a given crop from the point of view of how effectively crop cultivation and produce handling can be conducted at a given level of inputs.

*(vi) Frost hazard and extreme temperature events*

The risk of occurrence of late and early frost increases substantially when mean temperatures drop below 10°C. Hence, length of the thermal growing period with temperatures above 10°C (LGPT10) in a grid-cell has been compared with growth cycle length of frost sensitive crops. When the crop growth cycle is slightly shorter than LGPT10 the constraints related to frost risk are adjudged moderate, when the growth cycle is very close or equal to LGPT10, the constraints have been adjudged as severe.

The agro-climatic constraints described above are closely related to prevailing climate conditions. For convenience they have been arranged in five groups as follows:

(a) yield losses due to water-stress constraints on crop growth (e.g., rainfall variability);
(b) yield losses due to the effect of pests, diseases and weed constraints on crop growth;
(c) yield losses due to water stress, pest and diseases constraints on yield components and yield formation of produce (e.g., affecting quality of produce);
(d) yield losses due to workability constraints (e.g., wetness rendering produce handling difficulties), and
(e) yield losses due to occurrence of early or late frosts.

At the stage of computing potential biomass and yields, no account is taken of the effects of climatic conditions operating through pests and diseases, and workability. Such effects need to be included to arrive at realistic attainable crop yields. Precise estimates of their impacts are very difficult to obtain for a global study. Here it has been achieved by semi-quantifying the constraints in terms of reduction ratings, according to the different constraints and their severity for each crop, in each length of growing period zone and by level of inputs. The latter subdivision is necessary to take account of the fact that some constraints, such as bollworm on cotton, are present under low input conditions but are controllable under high input conditions in certain growing period zones. While some constraints are common to all input levels, others (e.g., poor workability through excess moisture) are more applicable to high input conditions with mechanized cultivation.

Although the constraints of group ‘d’ are not direct yield losses in reality, such constraints do mean, for example, that the high input level mechanized cultivator cannot get onto the land to carry out operations. In practice, these results in yield reductions. Similarly for the low input cultivator, for example, excessive wetness could mean that the produce is too wet to handle and remove, and again losses would be incurred even though the produce may be standing in the field. Also included in this group are constraints due to the cultivator having to use longer duration cultivars to enable harvesting in dry conditions. The use of such cultivars incurs yield restrictions, and such circumstances under wet conditions have therefore been incorporated in the severity ratings of agro-climatic constraints in group ‘d’.

In general, with increasing length of growing period and wetness, constraints due to pests and diseases (groups ‘b’ and ‘c’) become increasingly severe particularly to low input cultivators. As the length of growing period gets very long, even the high input level cultivator cannot keep these constraints under control and they become severe yield reducing factors at all three levels of inputs. Other factors, such as poor pod set in soybean or poor quality in short lengths of growing period zones, are of similar severity for all three levels of inputs. Difficulties in lifting root crops under dry soil conditions (short lengths of growing periods group ‘d’) are rated more severely under the high level of inputs (mechanized) than under intermediate and low level of inputs. For irrigated production the ‘c’ constraint is applied only at the wet end, i.e., above 300 days in the example of Table 9 (in Chapter 4).

**Input level:**

1 = low inputlevel, 2 = intermediate input level, 3 = high input level

**Constraint type:**

1 = ‘a’ constraint, yield losses due to water-stress constraints on crop growth (e.g., rainfall variability);

2 = ‘b’ constraint, yield losses due to the effect of pests, diseases and weed constraints on crop growth;

3 = ‘c’ constraint, yield losses due to water-stress, pest and diseases constraints on yield components and yield formation of produce;

4 = ‘d’ constraint, yield losses due to workability constraints (e.g., wetness rendering produce handling difficulties);

5 = ‘e’ constraint, yield losses due to occurrence of early or late frosts.

# AGRO-CLIMATIC CONSTRAINTS

| **Crop** | **Growth cycle** | **Input level** | **Con-straint** | **Length of Growing Period** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| WINTER WHEAT | 30+90 d | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 30+90 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 30+90 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 30+90 d | 1 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 30+90 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 30+90 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 30+90 d | 2 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 30+90 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 30+90 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 30+90 d | 3 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 35+105 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 35+105 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 35+105 d | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 35+105 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 35+105 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 35+105 d | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 35+105 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 35+105 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 35+105 d | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 40+120 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 40+120 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 40+120 d | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 40+120 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 40+120 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 40+120 d | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 40+120 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 40+120 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 40+120 d | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input level | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| WINTER WHEAT | 45+135 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 45+135 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 45+135 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 45+135 d | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 45+135 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 45+135 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 45+135 d | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 45+135 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 45+135 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 45+135 d | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SPRING WHEAT | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 1 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 2 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 105 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 105 days | 3 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 120 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input level | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SPRING WHEAT | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 135 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 150 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 150 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 150 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WHEAT, SUB-TROPICS | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 1 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 2 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 105 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 105 days | 3 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input Levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| WHEAT, SUB-TROPICS | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 120 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 135 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 150 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 150 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 150 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | 15 | 45 | 75 | 105 | 135 | 165 | 195 | 225 | 255 | 285 | 315 | 345 | 365- | 365+ |
| WHEAT, TROPICS | 100 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 100 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 100 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 100 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 100 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 100 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 100 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 100 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 100 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 100 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 100 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 100 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 130 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 130 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 130 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 130 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 130 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 130 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 130 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 130 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 130 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 130 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 130 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 130 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 160 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 160 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 160 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 160 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 160 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 160 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 160 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 160 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 160 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 160 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 160 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 160 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 190 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 190 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 190 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 190 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 190 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 190 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 190 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 190 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 190 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 190 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 190 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 190 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| RICE, JAPONICA | 105 days | 1 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 105 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | 135 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| RICE, JAPONICA | 150 days | 1 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RICE, INDICA | 105 days | 1 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 135 days | 1 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | 135 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |

| Crop | Growth cycle | Input levels | Con- straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| RICE, INDICA | 135 days | 3 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 25 | 25 | 25 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| RICE, DRYLAND | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | 135 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | 15 | 45 | 75 | 105 | 135 | 165 | 195 | 225 | 255 | 285 | 315 | 345 | 365- | 365+ |
| RICE, DRYLAND | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| MAIZE (GRAIN), TROPICAL LOWLAND | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 90 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 90 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 90 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 135 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 25 | 50 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 135 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| MAIZE (GRAIN), TROPICAL LOWLAND | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 135 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| MAIZE (GRAIN), TROPICAL HIGHLAND | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 180 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 180 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 180 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 180 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 180 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 180 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 300 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 |
| | 300 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 300 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 25 | 25 | 50 |
| | 300 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 300 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 |
| | 300 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 300 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 25 | 25 | 50 |
| | 300 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 300 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 |
| | 300 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 300 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 25 | 25 | 50 |
| | 300 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| MAIZE (GRAIN), SUBTROP./ TEMPER. | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 1 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| MAIZE (GRAIN), SUBTROP./ TEMPER.. | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 2 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 3 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 135 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 135 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 135 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 150 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| MAIZE (GRAIN), SUBTROP./ TEMPER. | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 165 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 165 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 165 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 165 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 165 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 165 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 165 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 180 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 180 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 180 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 180 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 180 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 180 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 180 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MAIZE (SILAGE) | 105 days | 1 | 1 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 1 | 5 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 2 | 5 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| MAIZE (SILAGE) | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 3 | 5 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 135 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 135 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 135 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 150 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| MAIZE (SILAGE) | 165 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 165 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 165 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 165 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 165 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 165 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 165 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 165 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 165 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 165 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 180 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 180 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 180 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 180 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 180 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 180 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 180 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | 180 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 180 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WINTER BARLEY | 30+90 d | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 30+90 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 30+90 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 30+90 d | 1 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 30+90 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 30+90 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 30+90 d | 2 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 30+90 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 30+90 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 30+90 d | 3 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| WINTER BARLEY | 35+105 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 35+105 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 35+105 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 35+105 d | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 35+105 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 35+105 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 35+105 d | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 35+105 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 35+105 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 35+105 d | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 40+120 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 40+120 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 40+120 d | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 40+120 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 40+120 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 40+120 d | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 40+120 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 40+120 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 40+120 d | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 45+135 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 45+135 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 45+135 d | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 45+135 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 45+135 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 45+135 d | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 45+135 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 45+135 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 45+135 d | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SPRING BARLEY | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 90 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 1 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 90 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 2 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 90 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 90 days | 3 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 105 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 105 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 120 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| **Crop** | **Growth cycle** | **Input levels** | **Con-straint** | **Length of Growing Period** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SPRING BARLEY | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 135 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BARLEY, SUB-TROPICS | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 90 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 1 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 90 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 2 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 90 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 90 days | 3 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 105 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 105 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| BARLEY, SUB-TROPICS | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 120 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 135 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BARLEY, TROPICS | 100 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 100 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 100 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 100 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 100 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 100 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 100 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 100 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 100 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 100 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 100 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 100 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | 15 | 45 | 75 | 105 | 135 | 165 | 195 | 225 | 255 | 285 | 315 | 345 | 365- | 365+ |
| BARLEY, TROPICS | 130 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 130 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 130 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 130 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 130 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 130 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 130 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 130 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 130 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 130 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 130 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 130 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 160 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 160 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 160 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 160 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 160 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 160 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 160 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 160 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 160 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 160 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 160 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 160 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 190 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 190 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 190 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 190 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 190 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 190 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 190 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 190 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 190 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 190 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 190 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 190 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| SORGHUM, LOWLAND | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | 15 | 45 | 75 | 105 | 135 | 165 | 195 | 225 | 255 | 285 | 315 | 345 | 365- | 365+ |
| SORGHUM, LOWLAND | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 2 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 1 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| SORGHUM, HIGHLAND | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SORGHUM, HIGHLAND | 180 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 180 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 300 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 |
| | 300 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 300 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 300 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 300 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 |
| | 300 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 300 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 300 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 300 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 |
| | 300 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 300 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 300 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| WINTER RYE | 30+90 d | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 30+90 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 30+90 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 30+90 d | 1 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 30+90 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 30+90 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 30+90 d | 2 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30+90 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 30+90 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 30+90 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 30+90 d | 3 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 35+105 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 35+105 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 35+105 d | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 35+105 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| WINTER RYE | 35+105 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 35+105 d | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 35+105 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 35+105 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 35+105 d | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 40+120 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 40+120 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 40+120 d | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 40+120 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 40+120 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 40+120 d | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 40+120 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 40+120 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 40+120 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 40+120 d | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 45+135 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 45+135 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 45+135 d | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 45+135 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 45+135 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 45+135 d | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+135 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 45+135 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 45+135 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 45+135 d | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SPRING RYE | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 90 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 1 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 90 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 2 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SPRING RYE | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 90 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 90 days | 3 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 105 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 105 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 105 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 120 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 120 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 |
| | 135 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SPRING RYE | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 |
| | 135 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PEARL MILLET | 70 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 70 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 70 days | 1 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 70 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 70 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 70 days | 2 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 70 days | 2 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 70 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 70 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 70 days | 3 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 70 days | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 70 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| FOXTAIL MILLET | 75 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 75 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 75 days | 1 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 75 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 75 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 75 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 75 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 75 days | 2 | 3 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 75 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 75 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 75 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 75 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 75 days | 3 | 3 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 75 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 75 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| FOXTAIL MILLET | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 90 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 3 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 3 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 105 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Periods | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| WHITE POTATO | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 90 days | 1 | 5 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 5 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 5 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 25 | 25 | 50 | 25 | 50 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| WHITE POTATO | 180 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CASSAVA | <= 365 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 1 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| | <= 365 d | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | <= 365 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| | <= 365 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | <= 365 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | <= 365 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | <= 365 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| SWEET POTATO | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 180 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 |
| | 180 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 180 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SWEET POTATO | 180 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 180 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 210 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 210 days | 1 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 210 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 210 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 |
| | 210 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 210 days | 2 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 210 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 210 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 210 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 210 days | 3 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 210 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 210 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| SUGAR-CANE | <= 365 d | 1 | 1 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 1 | 3 | 0 | 0 | 0 | 0 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | <= 365 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 1 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 3 | 0 | 0 | 0 | 0 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | <= 365 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 1 | 100 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 3 | 0 | 0 | 0 | 0 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | <= 365 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SUGAR-BEET | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 165 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SUGAR-BEET | 165 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 165 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 165 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 165 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 180 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 180 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 180 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 195 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 195 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 195 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 195 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 195 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 195 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 195 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 195 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 195 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 195 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 195 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 195 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 195 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 195 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 195 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 210 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 210 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 210 days | 1 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 210 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 210 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SUGAR-BEET | 210 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 210 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 210 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 210 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 210 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 210 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 210 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 210 days | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 210 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 210 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PHASEOL. BEAN, LOWLAND | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 90 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 90 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 150 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| PHASEOL. BEAN, HIGHLAND | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 150 days | 2 | 3 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 180 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 180 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 180 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| PHASEOL. BEAN, TEMPER. | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 90 days | 1 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 90 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| PHASEOL. BEAN, TEMPER. | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 90 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 150 days | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CHICKPEA | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 3 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 90 days | 1 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 90 days | 2 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| CHICKPEA | 90 days | 3 | 1 | 100 | 100 | 100 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 5 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CHICKPEA (CR) | 150 days | 1 | 1 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con- straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| CHICKPEA (CR) | 150 days | 3 | 1 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 1 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 3 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 1 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 1 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 50 | 50 | 50 |
| | 180 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| COWPEA | 80 days | 1 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 80 days | 1 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 80 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 80 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 80 days | 2 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 80 days | 2 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 80 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 80 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 80 days | 3 | 1 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 80 days | 3 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 80 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 80 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 100 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 100 days | 1 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 100 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 100 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |
| | 100 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 100 days | 2 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 100 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 100 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 100 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 100 days | 3 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 100 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 100 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| COWPEA | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| GROUND-NUT | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 90 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 90 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 90 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 50 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SOYBEAN, TROPICS | 90 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 90 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 90 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 90 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 90 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 90 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 90 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 90 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 90 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| SOYBEAN, SUB-TROPICS | 105 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 105 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 105 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SOYBEAN, SUB-TROPICS | 105 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 105 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 105 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 105 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 105 days | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 120 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 120 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 120 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 120 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 120 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 135 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 135 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SUN-FLOWER, TROPICS | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | 15 | 45 | 75 | 105 | 135 | 165 | 195 | 225 | 255 | 285 | 315 | 345 | 365- | 365+ |
| SUN-FLOWER, TROPICS | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| SUN-FLOWER, SUB-TROPICS | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 135 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 135 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con- straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SUN-FLOWER, SUB-TROPICS | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 2 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 165 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 165 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WINTER RAPE | 35+105 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 35+105 d | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 35+105 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 35+105 d | 1 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 35+105 d | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 35+105 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 35+105 d | 2 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35+105 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 35+105 d | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 35+105 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 35+105 d | 3 | 5 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+120 d | 1 | 1 | 100 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+120 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 45+120 d | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 45+120 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 45+120 d | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+120 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+120 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 45+120 d | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 45+120 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 45+120 d | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| WINTER RAPE | 45+120 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 45+120 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 45+120 d | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 45+120 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 45+120 d | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SPRING RAPE | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 135 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 135 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 150 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 165 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 165 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |

| **Crop** | **Growth cycle** | **Input levels** | **Con-straint** | **Length of Growing Period** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| SPRING RAPE | 165 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 165 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RAPE, SUB-TROP./ TROPICS | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 135 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 135 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 150 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 150 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 165 days | 2 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 165 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 |
| | 165 days | 3 | 3 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | 165 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| COTTON, TROPICS | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 3 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con- straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| COTTON, TROPICS | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 2 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 3 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 1 | 2 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 3 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 180 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 180 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 180 days | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 180 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| COTTON, SUB-TROPICS | 135 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 1 | 2 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 3 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | 15 | 45 | 75 | 105 | 135 | 165 | 195 | 225 | 255 | 285 | 315 | 345 | 365- | 365+ |
| COTTON, SUB-TROPICS | 135 days | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 135 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 135 days | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 135 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 1 | 2 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 3 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 150 days | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 150 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 1 | 2 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 3 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 165 days | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 50 | 50 | 50 |
| | 165 days | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 | 50 | 50 |
| | 165 days | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | 165 days | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BANANA/ PLANTAIN | <= 365 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 1 | 2 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | <= 365 d | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 |
| | <= 365 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 2 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 25 |
| | <= 365 d | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 25 | 25 |
| | <= 365 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| BANANA/ PLANTAIN | <= 365 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 2 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 25 |
| | <= 365 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OILPALM | <= 365 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 1 | 2 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 1 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 0 | 0 | 25 | 25 |
| | <= 365 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 2 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 0 | 0 | 0 | 25 |
| | <= 365 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 2 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 3 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OLIVE | <= 365 d | 1 | 1 | 100 | 100 | 50 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 |
| | <= 365 d | 1 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | <= 365 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | <= 365 d | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 1 | 100 | 100 | 100 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | <= 365 d | 2 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | <= 365 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | <= 365 d | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 1 | 100 | 100 | 100 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | <= 365 d | 3 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | <= 365 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 | 50 |
| | <= 365 d | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ALFALFA | <= 365 d | 1 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 1 | 2 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | <= 365 d | 1 | 3 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | <= 365 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 |
| | <= 365 d | 1 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | <= 365 d | 2 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | <= 365 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | <= 365 d | 2 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 1 | 100 | 100 | 100 | 50 | 50 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 |
| | <= 365 d | 3 | 3 | 25 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 50 | 50 |
| | <= 365 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 50 | 50 | 50 | 50 | 50 |
| | <= 365 d | 3 | 5 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Crop | Growth cycle | Input levels | Con-straint | Length of Growing Period | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **0** | **15** | **45** | **75** | **105** | **135** | **165** | **195** | **225** | **255** | **285** | **315** | **345** | **365-** | **365+** |
| PASTURE | <= 365 d | 1 | 1 | 100 | 100 | 50 | 50 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | <= 365 d | 2 | 1 | 100 | 100 | 50 | 50 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| | <= 365 d | 3 | 1 | 100 | 100 | 50 | 50 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | <= 365 d | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |

# APPENDIX IX

## CROP SUITABILITY OF WATER COLLECTING SITES

### Short-term dryland crops I

This group includes some short duration crops (wheat, barley, rye, dryland rice, foxtail millet, chickpea, rape, and forage legumes which are somewhat tolerant to excess moisture. For LGPs less than 30 days it is assumed there is on the average insufficient water to bring these crops to maturation and yield, especially since the contribution from rainfall is also almost non-existent. At LGPs longer than 120 days these crops will grow irrespective additional water. It has been assumed that the Fluvisols are too wet in LGPs over 300 days. Most of these crops are marginal to not suitable in humid areas. Agro-climatic constraints alone will render these long LGPs already marginal to not suitable.

| Suit-ability class | Percentage of water-collecting sites suitable per LGP class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1-29 | 30-59 | 60-89 | 90-119 | 120-149 | 150-179 | 180-209 | 210-239 | 240-269 | 270-299 | 300-329 | 330-364 | 365- | 365+ |
| VS | | | | | | 33 | 33 | 33 | 33 | 33 | 33 | | | | |
| S | | | | | 33 | | | | | | | | | | |
| MS | | | | 33 | | 33 | 33 | 33 | 33 | 33 | 33 | | | | |
| mS | | | 33 | | 33 | | | | | | | | | | |
| NS | 100 | 100 | 67 | 67 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 100 | 100 | 100 | 100 |

### Short-term dryland crops II

The crops in this group (sorghum, pearl millet, cowpea) have either a shorter duration than Group I (pearl millet and cowpea) or tolerance to both drought as well as to excess water (sorghum). Therefore for some parts of the Fluvisols in 1-29 days growing periods some modest yield may be expected (though not in all years). At the wet end of the LGPs these crops are treated similarly to Group I.

| Suit-ability class | Percentage of water-collecting sites suitable per LGP class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1-29 | 30-59 | 60-89 | 90-119 | 120-149 | 150-179 | 180-209 | 210-239 | 240-269 | 270-299 | 300-329 | 330-364 | 365- | 365+ |
| VS | | | | | 33 | 33 | 33 | 33 | 33 | 33 | 33 | | | | |
| S | | | | 33 | | | | | | | | | | | |
| MS | | | 33 | | 33 | 33 | 33 | 33 | 33 | 33 | 33 | | | | |
| mS | | 33 | | 33 | | | | | | | | | | | |
| NS | 100 | 67 | 67 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 100 | 100 | 100 | 100 |

### Short-term dryland crops III

The crops in Group III include maize, phaseolus bean, soybean, and sunflower. They are more sensitive to excess water (especially water-logging) than Group I and II crops. Therefore, they are not considered to be suitable in areas where LGP exceeds 270 days. Their water requirements are similar or somewhat higher than Group I crops.

| Suit-ability class | Percentage of water-collecting sites suitable per LGP class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1-29 | 30-59 | 60-89 | 90-119 | 120-149 | 150-179 | 180-209 | 210-239 | 240-269 | 270-299 | 300-329 | 330-364 | 365- | 365+ |
| VS | | | | | | 33 | 33 | 33 | 33 | | | | | | |
| S | | | | | 33 | | | | | | | | | | |
| MS | | | | 33 | | 33 | 33 | 33 | 33 | 33 | | | | | |
| mS | | | 33 | | 33 | | | | | | | | | | |
| NS | 100 | 100 | 67 | 67 | 34 | 34 | 34 | 34 | 34 | 67 | 100 | 100 | 100 | 100 | 100 |

### Short-term dryland crops IV

Root crops (white potato, sweet potato, sugarbeet) are all sensitive to high groundwater levels and water-logging. Cotton and groundnut are also very sensitive to excess moisture. These crops can only be grown on the rarely flooded parts of the Fluvisols, provided they are well drained. Apart from groundnut the growth cycles of the crops in this group are slightly longer than the crops in Group I-III. This makes crops in Group IV slightly more vulnerable.

| Suit-ability class | Percentage of water-collecting sites suitable per LGP class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1-29 | 30-59 | 60-89 | 90-119 | 120-149 | 150-179 | 180-209 | 210-239 | 240-269 | 270-299 | 300-329 | 330-364 | 365- | 365+ |
| VS | | | | | | | | | | | | | | | |
| S | | | | | | | | | | | | | | | |
| MS | | | | | | 33 | 33 | 33 | 33 | | | | | | |
| mS | | | | | 33 | 33 | 33 | 33 | 33 | 33 | | | | | |
| NS | 100 | 100 | 100 | 100 | 67 | 34 | 34 | 34 | 34 | 67 | 100 | 100 | 100 | 100 | 100 |

### Wetland rice

Wetland Rice is difficult to grow under rainfed conditions. In particular the water management is problematic. Yields obtained from purely rainfed paddy is generally low. 2-3 t/ha is already good. Flood water supply comes in the semiarid areas in an erratic fashion; too little too late or too much too soon. In the sub-humid and humid areas the flood hazard makes management difficult (submerging and flood damage by flowing water). LGPs less than 150 days have been considered insufficient to obtain yield. Very long LGPs are assumed to be associated with high flood risks (submerging, flowing water, high water levels during maturing and harvest).

| Suit-ability class | Percentage of water-collecting sites suitable per LGP class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1-29 | 30-59 | 60-89 | 90-119 | 120-149 | 150-179 | 180-209 | 210-239 | 240-269 | 270-299 | 300-329 | 330-364 | 365- | 365+ |
| VS | | | | | | | | | | | | | | | |
| S | | | | | | | | 33 | 33 | 33 | | | | | |
| MS | | | | | | | 33 | | | | 33 | 33 | 33 | | |
| mS | | | | | | 33 | | | | | | | | 33 | |
| NS | 100 | 100 | 100 | 100 | 100 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 100 |

### Cassava

Cassava is preferably *not grown* on Fluvisols because of its sensitivity for excessive wetness in the soil. On the higher parts of Fluvisols short duration cassava can be found (e.g., LGP of 180-270 days in Ghana). Since cassava is not really benefiting from extra moisture, the best

LGPs are those where also rainfed cassava would do reasonably well. Towards the wetter end of the LGPs (more than 240-270 days) cassava is not anymore to be considered on Fluvisols.

| Suit-ability class | Percentage of water-collecting sites suitable per LGP class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1-29 | 30-59 | 60-89 | 90-119 | 120-149 | 150-179 | 180-209 | 210-239 | 240-269 | 270-299 | 300-329 | 330-364 | 365- | 365+ |
| VS | | | | | | | | | | | | | | | |
| S | | | | | | | | | | | | | | | |
| MS | | | | | | | | 33 | 33 | | | | | | |
| mS | | | | | | | 33 | | | 33 | | | | | |
| NS | 100 | 100 | 100 | 100 | 100 | 100 | 67 | 67 | 67 | 67 | 100 | 100 | 100 | 100 | 100 |

### Sugarcane

Sugarcane is fairly tolerant to flooding and water-logging (e.g., see FAO, 1988). The water from rainfall and whatever comes from the Fluvisols must meet full crop water requirements for 8 to 9 months. It is assumed that the contribution through additional water from Fluvisols sufficiently extends the growing period starting from LGP 180- 210 days onwards. At harvest presence of excess moisture is less favorable for both yield and management of the crop. There need be a predictable period during which the Fluvisol environment provides at least 2 months of dryer conditions.

| Suit-ability class | Percentage of water-collecting sites suitable per LGP class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1-29 | 30-59 | 60-89 | 90-119 | 120-149 | 150-179 | 180-209 | 210-239 | 240-269 | 270-299 | 300-329 | 330-364 | 365- | 365+ |
| VS | | | | | | | | | | | | | | | |
| S | | | | | | | | | | 33 | 33 | | | | |
| MS | | | | | | | | | 33 | | | 33 | | | |
| mS | | | | | | | | 33 | | | | | | | |
| NS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 67 | 67 | 67 | 67 | 67 | 100 | 100 | 100 |

### Banana/plantain, oil palm

Banana/plantain and oil palm prefer humid conditions. Banana is somewhat tolerant to water-logging, oil palm somewhat less. High groundwater tables are not tolerated. Both perennials require at least eight months during which full water requirements are met. Fluvisols occurring in LGPs of more than 300 days are assumed to be associated with longer periods with high groundwater levels and are therefore unsuited for oil palm and banana/plantain.

| Suit-ability class | Percentage of water-collecting sites suitable per LGP class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1-29 | 30-59 | 60-89 | 90-119 | 120-149 | 150-179 | 180-209 | 210-239 | 240-269 | 270-299 | 300-329 | 330-364 | 365- | 365+ |
| VS | | | | | | | | | | | | | | | |
| S | | | | | | | | | | | | | | | |
| MS | | | | | | | | 33 | 33 | 33 | | | | | |
| mS | | | | | | | 33 | | | | 33 | | | | |
| NS | 100 | 100 | 100 | 100 | 100 | 100 | 67 | 67 | 67 | 67 | 67 | 100 | 100 | 100 | 100 |

**Olives**

Olives tolerate neither high groundwater tables nor water-logging and flooding or inundation. Therefore, olives are not considered for cultivation on Fluvisols.

| Suit-ability class | Percentage of water-collecting sites suitable per LGP class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1-29 | 30-59 | 60-89 | 90-119 | 120-149 | 150-179 | 180-209 | 210-239 | 240-269 | 270-299 | 300-329 | 330-364 | 365- | 365+ |
| VS | | | | | | | | | | | | | | | |
| S | | | | | | | | | | | | | | | |
| MS | | | | | | | | | | | | | | | |
| mS | | | | | | | | | | | | | | | |
| NS | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Pastures**

Natural pastures are well adapted to wet conditions. Normally the species mix is fine-tuned to the environmental conditions. Artificial (sown) pastures might grow unevenly on Fluvisols depending on both local differences of soil fertility and water supply. The total period of water availability on Fluvisols can be considered an adequate measure of the productivity regarding pastures (of course, periods of water-logging, flooding and inundation are to be subtracted).

| Suit-ability class | Percentage of water-collecting sites suitable per LGP class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1-29 | 30-59 | 60-89 | 90-119 | 120-149 | 150-179 | 180-209 | 210-239 | 240-269 | 270-299 | 300-329 | 330-364 | 365- | 365+ |
| VS | | | | | | 33 | 33 | 33 | 67 | 67 | 67 | 33 | | | |
| S | | | | 33 | 33 | | 33 | 33 | 33 | 33 | 33 | | 33 | | |
| MS | | | 33 | | 33 | 33 | | 34 | | | | 33 | | 33 | |
| mS | | 33 | | 33 | | | 34 | | | | | | 33 | 33 | 33 |
| NS | 100 | 67 | 67 | 34 | 34 | 34 | | | | | | 34 | 34 | 34 | 67 |

## APPENDIX X

## FAO '74 SOIL UNIT RATINGS FOR RAINFED CONDITIONS (at HIGH INPUT LEVEL)

| Soil | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **G** | **001** | 6 | 1 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Ge** | **002** | 6 | 1 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Gc** | **003** | 6 | 1 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 1 |
| **Gd** | **004** | 6 | 1 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Gm** | **005** | 6 | 1 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Gh** | **006** | 6 | 1 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Gp** | **007** | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Gx** | **008** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **R** | **009** | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Re** | **010** | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Rc** | **011** | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 6 | 3 | 1 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 1 | 1 | 2 | 6 | 1 | 3 | 1 |
| **Rd** | **012** | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Rx** | **013** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **I** | **014** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **Q** | **015** | 6 | 4 | 4 | 2 | 2 | 2 | 6 | 1 | 2 | 3 | 2 | 6 | 6 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 6 | 6 | 6 | 2 | 3 | 2 | 6 |
| **Qc** | **016** | 6 | 4 | 4 | 2 | 2 | 2 | 6 | 1 | 2 | 3 | 2 | 6 | 6 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 6 | 6 | 6 | 2 | 3 | 2 | 6 |
| **Ql** | **017** | 6 | 4 | 4 | 2 | 2 | 2 | 6 | 1 | 2 | 3 | 2 | 6 | 6 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 6 | 6 | 6 | 2 | 3 | 2 | 2 |
| **Qf** | **018** | 4 | 4 | 4 | 6 | 2 | 6 | 4 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 2 | 6 | 6 | 2 |
| **Qa** | **019** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **E** | **020** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 1 |
| **U** | **021** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 |
| **T** | **022** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| **To** | **023** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| **Tm** | **024** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| **Th** | **025** | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 1 |
| **Tv** | **026** | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 6 | 6 | 2 | 6 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 6 |
| **V** | **027** | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 3 | 3 | 6 | 2 | 3 | 6 | 1 | 1 | 6 | 4 | 4 | 1 | 6 |
| **Vp** | **028** | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 3 | 3 | 6 | 2 | 3 | 6 | 1 | 1 | 6 | 4 | 4 | 1 | 6 |
| **Vc** | **029** | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 3 | 3 | 6 | 2 | 3 | 6 | 1 | 1 | 6 | 4 | 4 | 1 | 6 |

| Soil | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **Z** | **030** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Zo** | **031** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Zm** | **032** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Zt** | **033** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Zg** | **034** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **S** | **035** | 6 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **So** | **036** | 6 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Sm** | **037** | 6 | 4 | 4 | 4 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 2 |
| **Sg** | **038** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Y** | **039** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 2 |
| **Yh** | **040** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 2 |
| **Yk** | **041** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 2 |
| **Yy** | **042** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **Yl** | **043** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 2 |
| **Yt** | **044** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **X** | **045** | 1 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 4 | 4 | 4 | 4 | 2 | 1 | 1 |
| **Xh** | **046** | 1 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 4 | 4 | 4 | 4 | 2 | 1 | 1 |
| **Xk** | **047** | 1 | 4 | 4 | 3 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 1 | 3 | 4 | 4 | 4 | 4 | 4 | 6 | 3 | 1 |
| **Xy** | **048** | 6 | 4 | 4 | 4 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Xl** | **049** | 1 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 | 4 | 2 | 1 | 1 |
| **K** | **050** | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 4 | 1 | 1 | 1 |
| **Kh** | **051** | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 4 | 1 | 1 | 1 |
| **Kk** | **052** | 1 | 3 | 4 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 6 | 3 | 1 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 1 | 1 | 2 | 4 | 2 | 3 | 1 |
| **Kl** | **053** | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 3 | 1 | 1 | 5 | 4 | 1 | 1 | 1 |
| **C** | **054** | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 6 | 4 | 1 | 1 | 1 |
| **Ch** | **055** | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 6 | 4 | 1 | 1 | 1 |
| **Ck** | **056** | 1 | 3 | 4 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 6 | 3 | 1 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 1 | 1 | 6 | 4 | 2 | 3 | 1 |
| **Cl** | **057** | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 6 | 4 | 1 | 1 | 1 |
| **Cg** | **058** | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 3 | 1 | 1 | 2 | 4 | 1 | 1 | 1 |
| **H** | **059** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Hh** | **060** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Hc** | **061** | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 6 | 3 | 1 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 1 | 1 | 6 | 4 | 1 | 3 | 1 |
| **Hl** | **062** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| Soil | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **Hg** | **063** | 6 | 1 | 1 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 6 | 2 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 2 | 4 | 6 | 6 | 4 | 6 | 1 |
| **M** | **064** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Mo** | **065** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Mg** | **066** | 6 | 1 | 1 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 6 | 2 | 6 | 6 | 6 | 6 | 4 | 3 | 6 | 2 | 4 | 6 | 6 | 4 | 6 | 1 |
| **B** | **067** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 |
| **Be** | **068** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 |
| **Bd** | **069** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| **Bh** | **070** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Bg** | **071** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **Bx** | **072** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **Bk** | **073** | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 6 | 3 | 1 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 1 | 1 | 6 | 6 | 1 | 3 | 1 |
| **Bc** | **074** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Bv** | **075** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 2 | 4 | 1 | 1 | 1 |
| **Bf** | **076** | 2 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 6 | 6 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 6 | 3 | 2 | 2 | 1 |
| **L** | **077** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Lo** | **078** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Lc** | **079** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Lk** | **080** | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 1 | 1 | 2 | 2 | 1 | 3 | 1 |
| **Lv** | **081** | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 1 | 3 | 3 | 1 | 1 | 2 | 4 | 1 | 1 | 1 |
| **Lf** | **082** | 3 | 6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 6 | 6 | 6 | 3 | 3 | 3 | 3 | 6 | 1 | 3 | 6 | 3 | 3 | 6 | 1 | 2 | 3 | 1 |
| **La** | **083** | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 4 | 1 | 1 | 4 | 2 | 1 | 3 | 2 | 4 | 1 | 1 |
| **Lp** | **084** | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 2 |
| **Lg** | **085** | 6 | 1 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 6 | 2 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 2 | 4 | 6 | 6 | 4 | 6 | 1 |
| **D** | **086** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **De** | **087** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Dd** | **088** | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |
| **Dg** | **089** | 6 | 1 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 4 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 6 | 4 | 6 | 1 |
| **P** | **090** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Po** | **091** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Pl** | **092** | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 4 | 2 | 2 |
| **Pf** | **093** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Ph** | **094** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Pp** | **095** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |

| Soil | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **Pg** | **096** | 4 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **W** | **097** | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 3 | 2 | 1 |
| **We** | **098** | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 3 | 2 | 1 |
| **Wd** | **099** | 6 | 1 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 6 | 6 | 6 | 2 | 6 | 1 |
| **Wm** | **100** | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 3 | 2 | 1 |
| **Wh** | **101** | 6 | 1 | 2 | 2 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 1 |
| **Ws** | **102** | 4 | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 6 | 4 | 4 | 4 | 4 | 2 |
| **Wx** | **103** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **A** | **104** | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 1 |
| **Ao** | **105** | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 1 |
| **Af** | **106** | 3 | 6 | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 4 | 3 | 1 |
| **Ah** | **107** | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 1 |
| **Ap** | **108** | 6 | 3 | 5 | 6 | 6 | 5 | 6 | 5 | 5 | 6 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 4 | 6 | 2 |
| **Ag** | **109** | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 1 |
| **N** | **110** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Ne** | **111** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Nd** | **112** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| **Nh** | **113** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| **F** | **114** | 2 | 2 | 1 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 1 |
| **Fo** | **115** | 2 | 2 | 1 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 1 |
| **Fx** | **116** | 2 | 2 | 1 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 4 | 2 | 1 |
| **Fr** | **117** | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 1 |
| **Fh** | **118** | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 1 |
| **Fa** | **119** | 4 | 4 | 6 | 6 | 4 | 2 | 4 | 2 | 2 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 2 |
| **Fp** | **120** | 6 | 2 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 2 |
| **O** | **121** | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Oe** | **122** | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Od** | **123** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 2 |
| **Ox** | **124** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **IA** | **125** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **IB** | **126** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **IC** | **127** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **ID** | **128** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

| Soil | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **IE** | **129** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **IF** | **130** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **J** | **146** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 1 | 1 |
| **Je** | **147** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 1 | 1 |
| **Jc** | **148** | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 4 | 4 | 3 | 1 |
| **Jd** | **149** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 1 | 1 |
| **Jt** | **150** | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |

Note: 1 = 100% S1, 2 = 100% S2, 3 = 50% S1 and 50% S2, 4 = 100% NS, 5 = 50% S1 and 50% NS, 6 = 50% S2 and 50% NS

# APPENDIX X

## FAO '74 SOIL UNIT RATINGS FOR RAINFED CONDITIONS (at LOW INPUT LEVEL)

| Soil | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **G** | **001** | 6 | 1 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Ge** | **002** | 6 | 1 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Gc** | **003** | 6 | 1 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 1 |
| **Gd** | **004** | 4 | 3 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Gm** | **005** | 6 | 1 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Gh** | **006** | 6 | 1 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Gp** | **007** | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Gx** | **008** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **R** | **009** | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Re** | **010** | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Rc** | **011** | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 6 | 3 | 1 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 1 | 1 | 2 | 6 | 1 | 3 | 1 |
| **Rd** | **012** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| **Rx** | **013** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **I** | **014** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **Q** | **015** | 4 | 4 | 4 | 4 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 6 | 6 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 6 | 6 | 4 | 2 | 4 | 6 |
| **Qc** | **016** | 4 | 4 | 4 | 4 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 6 | 6 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 6 | 6 | 4 | 2 | 4 | 6 |
| **Ql** | **017** | 4 | 4 | 4 | 4 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 6 | 6 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 6 | 6 | 4 | 2 | 4 | 2 |
| **Qf** | **018** | 4 | 4 | 4 | 4 | 2 | 6 | 4 | 2 | 6 | 6 | 2 | 6 | 6 | 4 | 6 | 6 | 6 | 2 | 6 | 6 | 6 | 4 | 4 | 4 | 6 | 4 | 2 |
| **Qa** | **019** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **E** | **020** | 6 | 4 | 4 | 4 | 6 | 2 | 6 | 6 | 2 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 6 | 4 | 4 | 4 | 2 | 4 | 1 |
| **U** | **021** | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1 |
| **T** | **022** | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 2 | 2 | 1 |
| **To** | **023** | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 2 | 2 | 1 |
| **Tm** | **024** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| **Th** | **025** | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 6 | 2 | 1 |
| **Tv** | **026** | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 6 | 6 | 2 | 6 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 6 | 6 | 6 | 4 | 4 | 6 |
| **V** | **027** | 6 | 2 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 4 | 2 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 2 | 2 | 2 | 4 | 4 | 6 | 6 |
| **Vp** | **028** | 6 | 2 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 4 | 2 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 2 | 2 | 2 | 4 | 4 | 6 | 6 |
| **Vc** | **029** | 6 | 2 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 4 | 2 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 2 | 2 | 6 | 4 | 4 | 6 | 6 |

| Soil | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **Z** | **030** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Zo** | **031** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Zm** | **032** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Zt** | **033** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Zg** | **034** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **S** | **035** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **So** | **036** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Sm** | **037** | 6 | 4 | 4 | 4 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 2 |
| **Sg** | **038** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Y** | **039** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 2 |
| **Yh** | **040** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 2 |
| **Yk** | **041** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 2 |
| **Yy** | **042** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **Yl** | **043** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 2 |
| **Yt** | **044** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **X** | **045** | 1 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 4 | 4 | 4 | 4 | 2 | 1 | 1 |
| **Xh** | **046** | 1 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 4 | 4 | 4 | 4 | 2 | 1 | 1 |
| **Xk** | **047** | 1 | 4 | 4 | 2 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 4 | 1 | 2 | 4 | 4 | 4 | 4 | 4 | 6 | 2 | 1 |
| **Xy** | **048** | 6 | 4 | 4 | 4 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Xl** | **049** | 1 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 4 | 4 | 2 | 1 | 1 |
| **K** | **050** | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 4 | 1 | 1 | 1 |
| **Kh** | **051** | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 4 | 1 | 1 | 1 |
| **Kk** | **052** | 1 | 2 | 4 | 2 | 1 | 1 | 1 | 1 | 1 | 4 | 6 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 4 | 4 | 2 | 2 | 1 |
| **Kl** | **053** | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 3 | 1 | 1 | 5 | 4 | 1 | 1 | 1 |
| **C** | **054** | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 6 | 4 | 1 | 1 | 1 |
| **Ch** | **055** | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 6 | 4 | 1 | 1 | 1 |
| **Ck** | **056** | 1 | 2 | 4 | 2 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 4 | 4 | 2 | 2 | 1 |
| **Cl** | **057** | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 6 | 4 | 1 | 1 | 1 |
| **Cg** | **058** | 1 | 2 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 3 | 1 | 1 | 2 | 4 | 1 | 1 | 1 |
| **H** | **059** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Hh** | **060** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Hc** | **061** | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 4 | 4 | 1 | 2 | 1 |
| **Hl** | **062** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| Soil | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **Hg** | **063** | 6 | 1 | 1 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 6 | 2 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 2 | 4 | 6 | 6 | 4 | 6 | 1 |
| **M** | **064** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Mo** | **065** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Mg** | **066** | 6 | 1 | 1 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 6 | 2 | 6 | 6 | 6 | 6 | 4 | 3 | 6 | 2 | 4 | 6 | 6 | 4 | 6 | 1 |
| **B** | **067** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 |
| **Be** | **068** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 |
| **Bd** | **069** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| **Bh** | **070** | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 |
| **Bg** | **071** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **Bx** | **072** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **Bk** | **073** | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 4 | 4 | 1 | 2 | 1 |
| **Bc** | **074** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Bv** | **075** | 2 | 1 | 2 | 3 | 2 | 2 | 2 | 6 | 2 | 6 | 6 | 6 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 4 | 2 | 3 | 1 |
| **Bf** | **076** | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 6 | 6 | 1 |
| **L** | **077** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Lo** | **078** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Lc** | **079** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Lk** | **080** | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 4 | 4 | 1 | 2 | 1 |
| **Lv** | **081** | 2 | 1 | 2 | 3 | 2 | 2 | 2 | 6 | 2 | 6 | 6 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 6 | 4 | 2 | 3 | 1 |
| **Lf** | **082** | 2 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 6 | 6 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 6 | 2 | 2 | 6 | 1 | 6 | 2 | 1 |
| **La** | **083** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 4 | 2 | 1 |
| **Lp** | **084** | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 2 |
| **Lg** | **085** | 6 | 1 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 6 | 2 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 2 | 4 | 6 | 6 | 4 | 6 | 1 |
| **D** | **086** | 2 | 1 | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 2 | 3 | 1 |
| **De** | **087** | 2 | 1 | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 2 | 3 | 1 |
| **Dd** | **088** | 4 | 2 | 2 | 2 | 4 | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 1 |
| **Dg** | **089** | 6 | 1 | 6 | 6 | 4 | 6 | 6 | 6 | 6 | 4 | 6 | 4 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 6 | 4 | 6 | 6 | 4 | 6 | 1 |
| **P** | **090** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Po** | **091** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Pl** | **092** | 6 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 1 | 4 | 6 | 2 |
| **Pf** | **093** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Ph** | **094** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Pp** | **095** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **Pg** | **096** | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **W** | **097** | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 1 |
| **We** | **098** | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 1 |
| **Wd** | **099** | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 1 |
| **Wm** | **100** | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 2 | 1 |
| **Wh** | **101** | 6 | 2 | 2 | 6 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 1 |
| **Ws** | **102** | 4 | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 6 | 4 | 4 | 4 | 4 | 2 |
| **Wx** | **103** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **A** | **104** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 1 |
| **Ao** | **105** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 1 |
| **Af** | **106** | 2 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 1 |
| **Ah** | **107** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 1 |
| **Ap** | **108** | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 2 |
| **Ag** | **109** | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 1 |
| **N** | **110** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| **Ne** | **111** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| **Nd** | **112** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| **Nh** | **113** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| **F** | **114** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 1 |
| **Fo** | **115** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 1 |
| **Fx** | **116** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 1 |
| **Fr** | **117** | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| **Fh** | **118** | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 1 |
| **Fa** | **119** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Fp** | **120** | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 2 |
| **O** | **121** | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Oe** | **122** | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 1 |
| **Od** | **123** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Ox** | **124** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **IA** | **125** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **IB** | **126** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **IC** | **127** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **ID** | **128** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

| Soil | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **IE** | **129** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **IF** | **130** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **J** | **146** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 1 | 1 |
| **Je** | **147** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 1 | 1 |
| **Jc** | **148** | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 4 | 4 | 3 | 1 |
| **Jd** | **149** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 2 | 1 |
| **Jt** | **150** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |

Note: 1 = 100% S1, 2 = 100% S2, 3 = 50% S1 and 50% S2, 4 = 100% NS, 5 = 50% S1 and 50% NS, 6 = 50% S2 and 50% NS

## APPENDIX X

## FAO ‘74 SOIL UNIT MODIFICATION RATINGS FOR GRAVITY IRRIGATION (at HIGH INPUT LEVEL)

| Soil | | CROPS | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **Q** | **015** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Qc** | **016** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Ql** | **017** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Qf** | **018** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Qa** | **019** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **E** | **020** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Tv** | **026** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Yy** | **042** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Yl** | **043** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Xy** | **048** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Xl** | **049** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Kk** | **052** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Kl** | **053** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Ck** | **056** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Cl** | **057** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Bk** | **073** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **P** | **090** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Po** | **091** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **all** | **092** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Pf** | **093** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Ph** | **094** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Pp** | **095** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Pg** | **096** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **A** | **104** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Ao** | **105** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Af** | **106** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Ah** | **107** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Ap** | **108** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Ag** | **109** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **N** | **110** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |

| Soil | | CROPS | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **Ne** | **111** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Nd** | **112** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Nh** | **113** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **F** | **114** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Fo** | **115** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Fx** | **116** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Fr** | **117** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Fh** | **118** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Fa** | **119** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Fp** | **120** | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **O** | **121** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Oe** | **122** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Od** | **123** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Ox** | **124** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

Note: 1 = 100% S1, 2 = 100% S2, 3 = 50% S1 and 50% S2, 4 = 100% NS, 5 = 50% S1 and 50% NS, 6 = 50% S2 and 50% NS

## APPENDIX X

## FAO '74 SOIL UNIT RATINGS FOR DRAINED SOILS UNDER RAINFED CONDITIONS (at HIGH INPUT LEVEL)

| Soil | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | **Code** | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **G** | **001** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **Ge** | **002** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **Gc** | **003** | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 6 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 1 | 2 | 6 | 6 | 2 | 3 | 1 |
| **Gd** | **004** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 1 |
| **Gm** | **005** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **Gh** | **006** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **Gp** | **007** | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 2 |
| **Gx** | **008** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **Zg** | **034** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **Sg** | **038** | 6 | 4 | 4 | 4 | 6 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Hg** | **063** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **Mg** | **066** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **Bg** | **071** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **Lg** | **085** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **Dg** | **089** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **Pg** | **096** | 4 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| **Ag** | **109** | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 1 | 2 | 3 | 1 |

Note: 1 = 100% S1, 2 = 100% S2, 3 = 50% S1 and 50% S2, 4 = 100% NS, 5 = 50% S1 and 50% NS, 6 = 50% S2 and 50% NS

## APPENDIX XI

## FAO '74 SOIL PHASE RATINGS FOR RAINFED CONDITIONS (at HIGH INPUT LEVEL)

| Soil Phase | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **STONY** | **1** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 6 | 4 | 4 |
| **LITHIC** | **2** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **PETRIC** | **3** | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| **PETROCALCIC** | **4** | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| **PETROGYPSIC** | **5** | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| **PETROFERRIC** | **6** | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| **PHREATIC** | **7** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 |
| **FRAGIPAN** | **8** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| **DURIPAN** | **9** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 6 | 3 | 3 | 1 |
| **SALINE** | **10** | 6 | 4 | 4 | 6 | 3 | 6 | 4 | 6 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3 |
| **SODIC** | **11** | 3 | 3 | 4 | 3 | 3 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3 |
| **SHIFTING** | **12** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **ROCK DEB** | **13** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **OUTCROPS** | **14** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **DUNES** | **15** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **SALT/FLS** | **16** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **LAKES** | **17** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **ICE CAPS** | **18** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

Note: 1 = 100% S1, 2 = 100% S2, 3 = 50% S1 and 50% S2, 4 = 100% NS, 5 = 50% S1 and 50% NS, 6 = 50% S2 and 50% NS

## APPENDIX XI

## FAO ‘74 SOIL PHASE RATINGS FOR RAINFED CONDITIONS (at LOW INPUT LEVEL)

| **Soil Phase** | | **Crops** | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **STONY** | **1** | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 |
| **LITHIC** | **2** | 6 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 4 | 6 | 6 | 2 |
| **PETRIC** | **3** | 1 | 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 1 | 3 | 3 | 3 | 3 | 1 | 3 | 1 |
| **PETROCALCIC** | **4** | 3 | 6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 3 | 6 | 6 | 6 | 6 | 6 | 6 | 3 | 6 | 3 |
| **PETROGYPSIC** | **5** | 3 | 6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 3 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 3 |
| **PETROFERRIC** | **6** | 3 | 6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 3 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 3 |
| **PHREATIC** | **7** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 |
| **FRAGIPAN** | **8** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| **DURIPAN** | **9** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 6 | 3 | 3 | 1 |
| **SALINE** | **10** | 6 | 4 | 4 | 6 | 3 | 6 | 4 | 6 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3 |
| **SODIC** | **11** | 3 | 3 | 4 | 3 | 3 | 3 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3 |
| **SHIFTING** | **12** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **ROCK DEB** | **13** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **OUTCROPS** | **14** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **DUNES** | **15** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **SALT/FLS** | **16** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **LAKES** | **17** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **ICE CAPS** | **18** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

Note: 1 = 100% S1, 2 = 100% S2, 3 = 50% S1 and 50% S2, 4 = 100% NS, 5 = 50% S1 and 50% NS, 6 = 50% S2 and 50% NS

## APPENDIX XI

## FAO ‘74 SOIL PHASE RATINGS FOR GRAVITY IRRIGATION (at HIGH INPUT LEVEL)

| Soil Phase | | Crops | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **wh** | **wr** | **dr** | **mz** | **by** | **sg** | **ry** | **pm** | **fx** | **wp** | **ca** | **sp** | **su** | **sb** | **pb** | **ch** | **cw** | **gn** | **sy** | **sf** | **rp** | **ct** | **ba** | **op** | **ol** | **al** | **gr** |
| **STONY** | **1** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **LITHIC** | **2** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **PETRIC** | **3** | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 1 |
| **PETROCALCIC** | **4** | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| **PETROGYPSIC** | **5** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 |
| **PETROFERRIC** | **6** | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| **PHREATIC** | **7** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 | 1 |
| **FRAGIPAN** | **8** | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 1 |
| **DURIPAN** | **9** | 6 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 1 |
| **SALINE** | **10** | 6 | 4 | 4 | 6 | 2 | 6 | 4 | 6 | 4 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 4 | 4 | 4 | 3 |
| **SODIC** | **11** | 2 | 3 | 4 | 2 | 2 | 2 | 4 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 4 | 4 | 4 | 3 |
| **SHIFTING** | **12** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **ROCK DEB** | **13** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **OUTCROPS** | **14** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **DUNES** | **15** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **SALT/FLS** | **16** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **LAKES** | **17** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| **ICE CAPS** | **18** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

Note: 1 = 100% S1, 2 = 100% S2, 3 = 50% S1 and 50% S2, 4 = 100% NS, 5 = 50% S1 and 50% NS, 6 = 50% S2 and 50% NS

# APPENDIX XII

## FALLOW PERIOD REQUIREMENTS

| **Thermal Regime (Annual mean temperature)** | | **> 25°C** | | | | | **20-25°C** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Moisture Regime (LGP, days)** | | **<90** | **90-120** | **120-180** | **180-270** | **>270** | **<90** | **90-120** | **120-180** | **180-270** | **>270** |
| **FAO Soil Units** | **Crop Groups** | | | | | | | | | | |
| J, Je, Jc | Cereals | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Legumes | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Roots/Tubers | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Long term Annuals and Perennials | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| G, Ge, Gc, Gm, Gh | Cereals | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| | Legumes | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| | Roots/Tubers | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| | Long term Annuals and Perennials | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| R, Re, Rc, E, Tm, Th, V, Vp, Vc, K, Kh, Kk, Kl, C, Ch, Ck, Cl, Cg, H, Hh, Hc, Hl, Hg, M, Mo, Mg, B, Be, Bh, Bg, Bx, Bk, Bc, Bv, L, Lo, Lc, Lk, Lv, Lg, D, De, Wh, Ah, N, Ne, Nh, Fh | Cereals | 75 | 70 | 65 | 65 | 75 | 70 | 65 | 60 | 60 | 70 |
| | Legumes | 75 | 70 | 65 | 65 | 75 | 70 | 65 | 60 | 60 | 70 |
| | Roots/Tubers | 75 | 70 | 65 | 65 | 75 | 70 | 65 | 60 | 60 | 70 |
| | Long term Annuals and Perennials | 75 | 70 | 65 | 65 | 75 | 70 | 65 | 60 | 60 | 70 |
| Z, Zo, Zm, Zg, S, So, Sm, Sg, Y, Yh, Yk, Yy, Yt | Cereals | 80 | 75 | 70 | 70 | 80 | 75 | 70 | 65 | 65 | 75 |
| | Legumes | 80 | 75 | 70 | 70 | 80 | 75 | 70 | 65 | 65 | 75 |
| | Roots/Tubers | 80 | 75 | 70 | 70 | 80 | 75 | 70 | 65 | 65 | 75 |
| | Long term Annuals and Perennials | 80 | 75 | 70 | 70 | 80 | 75 | 70 | 65 | 65 | 75 |
| X, Xh, Xk, Xl | Cereals | 80 | 75 | 70 | 70 | 80 | 75 | 70 | 65 | 65 | 75 |
| | Legumes | 80 | 75 | 70 | 70 | 80 | 75 | 70 | 65 | 65 | 75 |
| | Roots/Tubers | 85 | 80 | 75 | 75 | 85 | 80 | 75 | 70 | 70 | 80 |
| | Long term Annuals and Perennials | 90 | 85 | 80 | 80 | 90 | 85 | 80 | 75 | 75 | 85 |
| T, To Bd, Lf, La, Dd, Dg, W, We, Wm, A, Ao, Af, Ag, Nd, F, Fo, Fx, Fr, Jd, Jt | Cereals | 85 | 80 | 75 | 75 | 85 | 80 | 75 | 70 | 70 | 80 |
| | Legumes | 85 | 80 | 75 | 75 | 85 | 80 | 75 | 70 | 70 | 80 |
| | Roots/Tubers | 85 | 80 | 75 | 75 | 85 | 80 | 75 | 70 | 70 | 80 |
| | Long term Annuals and Perennials | 85 | 80 | 75 | 75 | 85 | 80 | 75 | 70 | 70 | 80 |
| Q, Qc, Ql, Bf | Cereals | 85 | 80 | 75 | 75 | 85 | 80 | 75 | 70 | 70 | 80 |
| | Legumes | 85 | 80 | 75 | 75 | 85 | 80 | 75 | 70 | 70 | 80 |
| | Roots/Tubers | 90 | 85 | 80 | 80 | 90 | 85 | 80 | 75 | 75 | 85 |
| | Long term Annuals and Perennials | 90 | 85 | 80 | 80 | 90 | 85 | 80 | 75 | 75 | 85 |
| Gd, Gp, Gx, Rd, Rx, I, Qf, Qa, U, Tv, Xy, Lp, P, Po, Pl, Pf, Ph, Pp, Pg, Wd, Ws, Wx, Ap, Fa, Fp, O, Oe, Od, Ox | Cereals | 90 | 85 | 80 | 80 | 90 | 85 | 80 | 75 | 75 | 85 |
| | Legumes | 90 | 85 | 80 | 80 | 90 | 85 | 80 | 75 | 75 | 85 |
| | Roots/Tubers | 90 | 85 | 80 | 80 | 90 | 85 | 80 | 75 | 75 | 85 |
| | Long term Annuals and Perennials | 90 | 85 | 80 | 80 | 90 | 85 | 80 | 75 | 75 | 85 |

| **Thermal Regime (Annual mean temperature)** | | **15-20°C** | | | | | **<15°C** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Moisture Regime (LGP days)** | | **<90** | **90-120** | **120-180** | **180-270** | **>270** | **<90** | **90-120** | **120-180** | **180-270** | **>270** |
| **FAO Soil Units** | **Crop Groups** | | | | | | | | | | |
| J, Je, Jc | Cereals | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Legumes | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Roots/Tubers | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | Long term Annuals and Perennials | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| G, Ge, Gc, Gm, Gh | Cereals | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| | Legumes | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| | Roots/Tubers | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| | Long term Annuals and Perennials | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| R, Re, Rc, E, Tm, Th, V, Vp, Vc, K, Kh, Kk, Kl, C, Ch, Ck, Cl, Cg, H, Hh, Hc, Hl, Hg, M, Mo, Mg, B, Be, Bh, Bg, Bx, Bk, Bc, Bv, L, Lo, Lc, Lk, Lv, Lg, D, De, Wh, Ah, N, Ne, Nh, Fh | Cereals | 70 | 65 | 60 | 60 | 70 | 75 | 70 | 65 | 65 | 75 |
| | Legumes | 70 | 65 | 60 | 60 | 70 | 75 | 70 | 65 | 65 | 75 |
| | Roots/Tubers | 70 | 65 | 60 | 60 | 70 | 75 | 70 | 65 | 65 | 75 |
| | Long term Annuals and Perennials | 70 | 65 | 60 | 60 | 70 | 75 | 70 | 65 | 65 | 75 |
| Z, Zo, Zm, Zg, S, So, Sm, Sg, Y, Yh, Yk, Yy, Yt | Cereals | 75 | 70 | 65 | 65 | 75 | 80 | 75 | 70 | 70 | 80 |
| | Legumes | 75 | 70 | 65 | 65 | 75 | 80 | 75 | 70 | 70 | 80 |
| | Roots/Tubers | 75 | 70 | 65 | 65 | 75 | 80 | 75 | 70 | 70 | 80 |
| | Long term Annuals and Perennials | 75 | 70 | 65 | 65 | 75 | 80 | 75 | 70 | 70 | 80 |
| X, Xh, Xk, Xl | Cereals | 75 | 70 | 65 | 65 | 75 | 80 | 75 | 70 | 70 | 80 |
| | Legumes | 75 | 70 | 65 | 65 | 75 | 80 | 75 | 70 | 70 | 80 |
| | Roots/Tubers | 80 | 75 | 70 | 70 | 80 | 85 | 80 | 75 | 75 | 85 |
| | Long term Annuals and Perennials | 85 | 80 | 75 | 75 | 85 | 90 | 85 | 80 | 80 | 90 |
| T, To Bd, Lf, La, Dd, Dg, W, We, Wm, A, Ao, Af, Ag, Nd, F, Fo, Fx, Fr, Jd, Jt | Cereals | 80 | 75 | 70 | 70 | 80 | 85 | 80 | 75 | 75 | 85 |
| | Legumes | 80 | 75 | 70 | 70 | 80 | 85 | 80 | 75 | 75 | 85 |
| | Roots/Tubers | 80 | 75 | 70 | 70 | 80 | 85 | 80 | 75 | 75 | 85 |
| | Long term Annuals and Perennials | 80 | 75 | 70 | 70 | 80 | 85 | 80 | 75 | 75 | 85 |
| Q, Qc, Ql, Bf | Cereals | 80 | 75 | 70 | 70 | 80 | 85 | 80 | 75 | 75 | 85 |
| | Legumes | 80 | 75 | 70 | 70 | 80 | 85 | 80 | 75 | 75 | 85 |
| | Roots/Tubers | 85 | 80 | 75 | 75 | 85 | 90 | 85 | 80 | 80 | 90 |
| | Long term Annuals and Perennials | 85 | 80 | 75 | 75 | 85 | 90 | 85 | 80 | 80 | 90 |
| Gd, Gp, Gx, Rd, Rx, I, Qf, Qa, U, Tv, Xy, Lp, P, Po, Pl, Pf, Ph, Pp, Pg, Wd, Ws, Wx, Ap, Fa, Fp, O, Oe, Od, Ox | Cereals | 85 | 80 | 75 | 75 | 85 | 90 | 85 | 80 | 80 | 90 |
| | Legumes | 85 | 80 | 75 | 75 | 85 | 90 | 85 | 80 | 80 | 90 |
| | Roots/Tubers | 85 | 80 | 75 | 75 | 85 | 90 | 85 | 80 | 80 | 90 |
| | Long term Annuals and Perennials | 85 | 80 | 75 | 75 | 85 | 90 | 85 | 80 | 80 | 90 |

# APPENDIX XIII

## SOIL MOISTURE STORAGE CAPACITY FOR THE SOIL UNITS OF THE SOIL MAP OF THE WORLD

The growing period for most crops continues beyond the rainy season and, to a greater or lesser extent, crops mature on moisture stored in the soil profile. However, the amount of soil moisture stored in the soil profile, and available to a crop, varies, e.g., with depth of the soil profile, the soil physical characteristics, and the rooting pattern of the crop. Depletion of soil moisture reserves causes the actual evapotranspiration to fall short of the potential rate. Soil moisture storage capacity of soils (*Smax*) depends on soil physical and chemical characteristics, but above all on effective soil depth or volume. For the soil units of the Legend of the Soil Map of the World (FAO, 1974), FAO has developed procedures for the estimation of *Smax* (FAO, 1995c).

As a first step the soil group and soil units are grouped in eight sets which reflect fundamental differences in soil depth, textural changes with depth, influence of parent material or seasonal flooding conditions. These sets are:

1. *Histosols, Fluvisols and Gleysols*: which are considered as wetlands or water collecting sites.
2. *Andosols*: which due to parent material influence have a very high *Smax* (except Vitric Andosols).
3. *Vertisols*: specific characteristics set this group of soils apart.
4. *Lithosols and miscellaneous land units*: Lithosols and ‘rock’ units are characterized by a very limited soil depth.
5. *Rendzinas and Rankers*: both these soil groups are shallow by definition.
6. *Soil groups and soil units with no implied clay increase with depth*: this group combines soils in which the topsoil texture is considered representative of the whole profile. These are: Solonchaks, Regosols, Podzols, Cambisols, Arenosols, Vitric Andosols, Greyzems and the non-luvic soil units of the Xerosols, Yermosols, Kastanozems, Chernozems and Phaeozems.
7. *Soil groups and soil units with an implied clay increase with depth*: this set combines soils in which subsoil texture is finer than the topsoil texture. These are Solonetz, Podzoluvisols, Nitisols, Acrisols, Ferralsols and luvic units of the Xerosols, Yermosols, Kastanozems, Chernozems and Phaeozems.
8. *Planosols*: This soil group is considered to have a fine textured subsoil regardless of the topsoil texture which separates these soils from those discussed under 6 and 7.

Water availability to plants grown on Histosols, Gleysols and Fluvisols is mainly a function of groundwater or surface water levels and flooding. Although an *Smax* value can be deduced for these soils, this is largely irrelevant for practical purposes. Hence these soil groups are considered here as ‘water collecting sites’ and no *Smax* is determined for them. For tropical soils (Ferralsols, Acrisols, Nitisols, Ferralic Cambisols and Ferric Luvisols) *Smax* is decreased by 10% as compared to similar textural classes for other soils.

Gravel, stones, boulders and rock fragments when present in the profile reduce considerably the capacity of a soil to store moisture. The Legend of the Soil Map of the World uses this criterion when defining the stony phase reflecting the presence of coarse fragments in the surface layers or at the surface to an extent that it makes the use of mechanized equipment impracticable. Soil groups and units such as Vitric Andosols, Rendzinas and Lithosols generally contain a significant amount of gravel, while in other soils such as Ferralsols (stone line), Regosols, Acrisols, and soils with a petrocalcic or petrogypsic phase gravel occurrence is more common but largely dependent on local conditions. In the present general approach it is suggested to reduce *Smax* by 50% when a stony or petric phase is present in a mapping unit of the DSMW. These adjustments are location specific and modify the evaluation of the respective soil units listed in the tables below (see Table 6 in Chapter 3).

**Soil moisture storage capacity (*Smax*) classes derived for FAO soil units of Legend ’74**

| FAO Legend ‘74 Soil Unit | SLU | coarse | | medium | | fine | | FAO Legend ‘74 Soil Unit | SLU | coarse | | medium | | fine | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mm | CL | mm | CL | mm | CL | | | mm | CL | mm | CL | mm | CL |
| Eutric Gleysols | Ge | n.a. | 1 | n.a. | 1 | n.a. | 1 | Eutric Cambisols | Be | 106 | 3 | 180 | 1 | 165 | 1 |
| Calcaric Gleysols | Gc | n.a. | 1 | n.a. | 1 | n.a. | 1 | Dystric Cambisols | Bd | 106 | 3 | 180 | 1 | 165 | 1 |
| Dystric Gleysols | Gd | n.a. | 1 | n.a. | 1 | n.a. | 1 | Humic Cambisols | Bh | 106 | 3 | 180 | 1 | 165 | 1 |
| Mollic Gleysols | Gm | n.a. | 1 | n.a. | 1 | n.a. | 1 | Gleyic Cambisols | Bg | 106 | 3 | 180 | 1 | 165 | 1 |
| Humic Gleysols | Gh | n.a. | 1 | n.a. | 1 | n.a. | 1 | Gelic Cambisols | Bx | 106 | 3 | 180 | 1 | 165 | 1 |
| Plinthic Gleysols | Gp | n.a. | 1 | n.a. | 1 | n.a. | 1 | Calcic Cambisols | Bk | 106 | 3 | 180 | 1 | 165 | 1 |
| Gelic Gleysols | Gx | n.a. | 1 | n.a. | 1 | n.a. | 1 | Chromic Cambisols | Bc | 106 | 3 | 180 | 1 | 165 | 1 |
| Eutric Regosols | Re | 106 | 3 | 180 | 1 | 165 | 1 | Vertic Cambisols | Bv | 106 | 3 | 180 | 1 | 165 | 1 |
| Calcaric Regosols | Rc | 106 | 3 | 180 | 1 | 165 | 1 | Ferralic Cambisols | Bf | 95 | 3 | 162 | 1 | 148 | 1 |
| Dystric Regosols | Rd | 106 | 3 | 180 | 1 | 165 | 1 | Orthic Luvisols | Lo | 162 | 1 | 180 | 1 | 175 | 1 |
| Gelic Regosols | Rx | 106 | 3 | 180 | 1 | 165 | 1 | Chromic Luvisols | Lc | 162 | 1 | 180 | 1 | 175 | 1 |
| Lithosols | I | 13 | 6 | 19 | 6 | 18 | 6 | Calcic Luvisols | Lk | 162 | 1 | 180 | 1 | 175 | 1 |
| Cambic Arenosols | Qc | 106 | 3 | 180 | 1 | 165 | 1 | Vertic Luvisols | Lv | 162 | 1 | 180 | 1 | 175 | 1 |
| Luvic Arenosols | Ql | 106 | 3 | 180 | 1 | 165 | 1 | Ferric Luvisols | Lf | 146 | 1 | 162 | 1 | 157 | 1 |
| Ferralic Arenosols | Qf | 106 | 3 | 180 | 1 | 165 | 1 | Albic Luvisols | La | 162 | 1 | 180 | 1 | 175 | 1 |
| Albic Arenosols | Qa | 106 | 3 | 180 | 1 | 165 | 1 | Plinthic Luvisols | Lp | 162 | 1 | 180 | 1 | 175 | 1 |
| Rendzinas | E | 39 | 5 | 57 | 5 | 53 | 5 | Gleyic Luvisols | Lg | 162 | 1 | 180 | 1 | 175 | 1 |
| Rankers | U | 39 | 5 | 57 | 5 | 53 | 5 | Eutric Podzoluvisols | De | 162 | 1 | 180 | 1 | 175 | 1 |
| Ochric Andosols | To | 200 | 1 | 200 | 1 | 200 | 1 | Dystric Podzoluvisol | Dd | 162 | 1 | 180 | 1 | 175 | 1 |
| Mollic Andosols | Tm | 200 | 1 | 200 | 1 | 200 | 1 | Gleyic Podzoluvisols | Dg | 162 | 1 | 180 | 1 | 175 | 1 |
| Humic Andosols | Th | 200 | 1 | 200 | 1 | 200 | 1 | Orthic Podzols | Po | 106 | 3 | 180 | 1 | 165 | 1 |
| Vitric Andosols | Tv | 200 | 1 | 200 | 1 | 200 | 1 | Leptic Podzols | Pl | 106 | 3 | 180 | 1 | 165 | 1 |
| Pellic Vertisols | Vp | 135 | 2 | 135 | 2 | 135 | 2 | Ferric Podzols | Pf | 106 | 3 | 180 | 1 | 165 | 1 |
| Chromic Vertisols | Vc | 135 | 2 | 135 | 2 | 135 | 2 | Humic Podzols | Ph | 106 | 3 | 180 | 1 | 165 | 1 |
| Orthic Solonchaks | Zo | 106 | 3 | 180 | 1 | 165 | 1 | Placic Podzols | Pp | 106 | 3 | 180 | 1 | 165 | 1 |
| Mollic Solonchaks | Zm | 106 | 3 | 180 | 1 | 165 | 1 | Gleyic Podzols | Pg | 106 | 3 | 180 | 1 | 165 | 1 |
| Takyric Solonchaks | Zt | 106 | 3 | 180 | 1 | 165 | 1 | Eutric Planosols | We | 152 | 1 | 169 | 1 | 165 | 1 |
| Gleyic Solonchaks | Zg | 106 | 3 | 180 | 1 | 165 | 1 | Dystric Planosols | Wd | 152 | 1 | 169 | 1 | 165 | 1 |
| Orthic Solonetz | So | 106 | 3 | 180 | 1 | 165 | 1 | Mollic Planosols | Wm | 152 | 1 | 169 | 1 | 165 | 1 |
| Mollic Solonetz | Sm | 106 | 3 | 180 | 1 | 165 | 1 | Humic Planosols | Wh | 152 | 1 | 169 | 1 | 165 | 1 |
| Gleyic Solonetz | Sg | 106 | 3 | 180 | 1 | 165 | 1 | Sodic Planosols | Ws | 152 | 1 | 169 | 1 | 165 | 1 |
| Haplic Yermosols | Yh | 106 | 3 | 180 | 1 | 165 | 1 | Gelic Planosols | Wx | 152 | 1 | 169 | 1 | 165 | 1 |
| Calcic Yermosols | Yk | 106 | 3 | 180 | 1 | 165 | 1 | Orthic Acrisols | Ao | 146 | 1 | 162 | 1 | 157 | 1 |
| Gypsic Yermosols | Yy | 106 | 3 | 180 | 1 | 165 | 1 | Ferric Acrisols | Af | 146 | 1 | 162 | 1 | 157 | 1 |
| Luvic Yermosols | Yl | 162 | 1 | 180 | 1 | 175 | 1 | Humic Acrisols | Ah | 146 | 1 | 162 | 1 | 157 | 1 |
| Takyric Yermosols | Yt | 106 | 3 | 180 | 1 | 165 | 1 | Plinthic Acrisols | Ap | 146 | 1 | 162 | 1 | 157 | 1 |
| Haplic Xerosols | Xh | 106 | 3 | 180 | 1 | 165 | 1 | Gleyic Acrisols | Ag | 146 | 1 | 162 | 1 | 157 | 1 |
| Calcic Xerosols | Xk | 106 | 3 | 180 | 1 | 165 | 1 | Eutric Nitosols | Ne | 146 | 1 | 162 | 1 | 157 | 1 |
| Gypsic Xerosols | Xy | 106 | 3 | 180 | 1 | 165 | 1 | Dystric Nitosols | Nd | 146 | 1 | 162 | 1 | 157 | 1 |
| Luvic Xerosols | Xl | 162 | 1 | 180 | 1 | 175 | 1 | Humic Nitosols | Nh | 146 | 1 | 162 | 1 | 157 | 1 |
| Haplic Kastanozems | Kh | 106 | 3 | 180 | 1 | 165 | 1 | Orthic Ferralsols | Fo | 146 | 1 | 162 | 1 | 148 | 1 |
| Calcic Kastanozems | Kk | 106 | 3 | 180 | 1 | 165 | 1 | Xanthic Ferralsols | Fx | 146 | 1 | 162 | 1 | 148 | 1 |
| Luvic Kastanozems | Kl | 162 | 1 | 180 | 1 | 175 | 1 | Rhodic Ferralsols | Fr | 146 | 1 | 162 | 1 | 148 | 1 |
| Haplic Chernozems | Ch | 106 | 3 | 180 | 1 | 165 | 1 | Humic Ferralsols | Fh | 146 | 1 | 162 | 1 | 148 | 1 |
| Calcic Chernozems | Ck | 106 | 3 | 180 | 1 | 165 | 1 | Acric Ferralsols | Fa | 146 | 1 | 162 | 1 | 148 | 1 |
| Luvic Chernozems | Cl | 162 | 1 | 180 | 1 | 175 | 1 | Plinthic Ferralsols | Fp | 146 | 1 | 162 | 1 | 148 | 1 |
| Glossic Chernozems | Cg | 106 | 3 | 180 | 1 | 165 | 1 | Eutric Histosols | Oe | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Haplic Phaeozems | Hh | 106 | 3 | 180 | 1 | 165 | 1 | Dystric Histosols | Od | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Calcaric Phaeozems | Hc | 106 | 3 | 180 | 1 | 165 | 1 | Gelic Histosols | Ox | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Luvic Phaeozems | Hl | 162 | 1 | 180 | 1 | 175 | 1 | Eutric Fluvisols | Je | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Gleyic Phaeozems | Hg | 106 | 3 | 180 | 1 | 165 | 1 | Calcaric Fluvisols | Jc | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Orthic Greyzems | Mo | 106 | 3 | 180 | 1 | 165 | 1 | Dystric Fluvisols | Jd | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Gleyic Greyzems | Mg | 106 | 3 | 180 | 1 | 165 | 1 | Thionic Fluvisols | Jt | n.a. | 1 | n.a. | 1 | n.a. | 1 |

## Soil moisture storage capacity classes derived for FAO soil units of Revised Legend '90

| FAO Legend '90 | SLU | coarse | | medium | | fine | | FAO Legend '90 | SLU | coarse | | medium | | fine | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Unit | | mm | CL | mm | CL | mm | CL | Soil Unit | | mm | CL | mm | CL | mm | CL |
| Ferric Acrisols | ACf | 146 | 1 | 162 | 1 | 157 | 1 | Eutric Gleysols | GLe | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Gleyic Acrisols | ACg | 146 | 1 | 162 | 1 | 157 | 1 | Gelic Gleysols | GLi | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Haplic Acrisols | ACh | 146 | 1 | 162 | 1 | 157 | 1 | Calcic Gleysols | GLk | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Plinthic Acrisols | ACp | 146 | 1 | 162 | 1 | 157 | 1 | Mollic Gleysols | GLm | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Humic Acrisols | ACu | 146 | 1 | 162 | 1 | 157 | 1 | Thionic Gleysols | GLt | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Ferric Alisols | ALf | 146 | 1 | 162 | 1 | 157 | 1 | Umbric Gleysols | GLu | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Gleyic Alisols | ALg | 146 | 1 | 162 | 1 | 157 | 1 | Gleyic Greyzems | GRg | 106 | 3 | 180 | 1 | 165 | 1 |
| Haplic Alisols | ALh | 146 | 1 | 162 | 1 | 157 | 1 | Haplic Greyzems | GRh | 106 | 3 | 180 | 1 | 165 | 1 |
| Stagnic Alisols | ALj | 146 | 1 | 162 | 1 | 157 | 1 | Haplic Gypsisols | GYh | 106 | 3 | 180 | 1 | 165 | 1 |
| Plinthic Alisols | ALp | 146 | 1 | 162 | 1 | 157 | 1 | Calcic Gypsisols | GYk | 106 | 3 | 180 | 1 | 165 | 1 |
| Humic Alisols | ALu | 146 | 1 | 162 | 1 | 157 | 1 | Luvic Gypsisols | GYl | 162 | 1 | 180 | 1 | 175 | 1 |
| Gleyic Andosols | ANg | 200 | 1 | 200 | 1 | 200 | 1 | Petric Gypsisols | GYp | 79 | 4 | 135 | 2 | 123 | 2 |
| Haplic Andosols | ANh | 200 | 1 | 200 | 1 | 200 | 1 | Fibric Histosols | HSf | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Gelic Andosols | ANi | 200 | 1 | 200 | 1 | 200 | 1 | Gelic Histosols | HSi | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Mollic Andosols | ANm | 200 | 1 | 200 | 1 | 200 | 1 | Folic Histosols | HSl | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Umbric Andosols | ANu | 200 | 1 | 200 | 1 | 200 | 1 | Terric Histosols | HSs | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Vitric Andosols | ANz | 200 | 1 | 200 | 1 | 200 | 1 | Thionic Histosols | HSt | n.a. | 1 | n.a. | 1 | n.a. | 1 |
| Albic Arenosols | ARa | 106 | 3 | 180 | 1 | 165 | 1 | Haplic Kastanozems | KSh | 106 | 3 | 180 | 1 | 165 | 1 |
| Cambic Arenosols | ARb | 106 | 3 | 180 | 1 | 165 | 1 | Calcic Kastanozems | KSk | 106 | 3 | 180 | 1 | 165 | 1 |
| Calcaric Arenosols | ARc | 106 | 3 | 180 | 1 | 165 | 1 | Luvic Kastanozems | KSl | 162 | 1 | 180 | 1 | 175 | 1 |
| Gleyic Arenosols | ARf | 106 | 3 | 180 | 1 | 165 | 1 | Gypsic Kastanozems | KSy | 106 | 3 | 180 | 1 | 165 | 1 |
| Haplic Arenosols | ARg | 106 | 3 | 180 | 1 | 165 | 1 | Dystric Leptosols | LPd | 13 | 6 | 19 | 6 | 18 | 6 |
| Luvic Arenosols | ARl | 106 | 3 | 180 | 1 | 165 | 1 | Eutric Leptosols | LPe | 13 | 6 | 19 | 6 | 18 | 6 |
| Ferralic Arenosols | ARo | 106 | 3 | 180 | 1 | 165 | 1 | Gelic Leptosols | LPi | 13 | 6 | 19 | 6 | 18 | 6 |
| Aric Anthrosols | ATa | 200 | 1 | 200 | 1 | 200 | 1 | Rendzic Leptosols | LPk | 39 | 5 | 57 | 5 | 53 | 5 |
| Cumulic Anthrosols | ATc | 250 | 1 | 250 | 1 | 250 | 1 | Mollic Leptosols | LPm | 13 | 6 | 19 | 6 | 18 | 6 |
| Fimic Anthrosols | ATf | 200 | 1 | 200 | 1 | 200 | 1 | Lithic Leptosols | LPq | 13 | 6 | 19 | 6 | 18 | 6 |
| Urbic Anthrosols | ATu | 200 | 1 | 200 | 1 | 200 | 1 | Umbric Leptosols | LPu | 13 | 6 | 19 | 6 | 18 | 6 |
| Gleyic Chernozems | CHg | 106 | 3 | 180 | 1 | 165 | 1 | Albic Luvsiols | LVa | 162 | 1 | 180 | 1 | 175 | 1 |
| Haplic Chernozems | CHh | 106 | 3 | 180 | 1 | 165 | 1 | Ferric Luvisols | LVf | 146 | 1 | 162 | 1 | 157 | 1 |
| Calcic Chernozems | CHk | 106 | 3 | 180 | 1 | 165 | 1 | Gleyic Luvisols | LVg | 162 | 1 | 180 | 1 | 175 | 1 |
| Luvic Chernozems | CHl | 162 | 1 | 180 | 1 | 175 | 1 | Haplic Luvisols | LVh | 162 | 1 | 180 | 1 | 175 | 1 |
| Glossic Chernozems | CHw | 106 | 3 | 180 | 1 | 165 | 1 | Stagnic Luvisols | LVj | 162 | 1 | 180 | 1 | 175 | 1 |
| Haplic Calcisols | CLh | 106 | 3 | 180 | 1 | 165 | 1 | Calcic Luvisols | LVk | 162 | 1 | 180 | 1 | 175 | 1 |
| Luvic Calcisols | CLl | 162 | 1 | 180 | 1 | 175 | 1 | Vertic Luvisols | LVv | 162 | 1 | 180 | 1 | 175 | 1 |
| Petric Calcisols | CLp | 79 | 4 | 135 | 2 | 123 | 2 | Chromic Luvisols | LVx | 162 | 1 | 180 | 1 | 175 | 1 |
| Calcaric Cambisols | CMc | 106 | 3 | 180 | 1 | 165 | 1 | Albic Lixisols | LXa | 146 | 1 | 162 | 1 | 157 | 1 |
| Dystric Cambisols | CMd | 106 | 3 | 180 | 1 | 165 | 1 | Ferric Lixisols | LXf | 146 | 1 | 162 | 1 | 157 | 1 |
| Eutric Cambisols | CMe | 106 | 3 | 180 | 1 | 165 | 1 | Gleyic Lixisols | LXg | 146 | 1 | 162 | 1 | 157 | 1 |
| Gleyic Cambisols | CMg | 106 | 3 | 180 | 1 | 165 | 1 | Haplic Lixisols | LXh | 146 | 1 | 162 | 1 | 157 | 1 |
| Gelic Cambisols | CMi | 106 | 3 | 180 | 1 | 165 | 1 | Stagnic Lixisols | LXj | 146 | 1 | 162 | 1 | 157 | 1 |
| Ferralic Cambisols | CMo | 95 | 3 | 162 | 1 | 148 | 1 | Plinthic Lixisols | LXp | 146 | 1 | 162 | 1 | 157 | 1 |
| Humic Cambisols | CMu | 106 | 3 | 180 | 1 | 165 | 1 | Haplic Nitisols | NTh | 146 | 1 | 162 | 1 | 157 | 1 |
| Vertic Cambisols | CMv | 106 | 3 | 180 | 1 | 165 | 1 | Rhodic Nitisols | NTr | 146 | 1 | 162 | 1 | 157 | 1 |
| Chromic Cambisols | CMx | 106 | 3 | 180 | 1 | 165 | 1 | Humic Nitisols | NTu | 146 | 1 | 162 | 1 | 157 | 1 |
| Calcaric Fluvisols | FLc | n.a. | 1 | n.a. | 1 | n.a. | 1 | Dystric Podzoluvisol | PDd | 162 | 1 | 180 | 1 | 175 | 1 |
| Dystric Fluvisols | FLd | n.a. | 1 | n.a. | 1 | n.a. | 1 | Eutric Podzoluvisols | PDe | 162 | 1 | 180 | 1 | 175 | 1 |
| Eutric Fluvisols | FLe | n.a. | 1 | n.a. | 1 | n.a. | 1 | Gleyic Podzoluvisols | PDg | 162 | 1 | 180 | 1 | 175 | 1 |
| Mollic Fluvisols | FLm | n.a. | 1 | n.a. | 1 | n.a. | 1 | Gelic Podzoluvisols | PDi | 162 | 1 | 180 | 1 | 175 | 1 |
| Salic Fluviosls | FLs | n.a. | 1 | n.a. | 1 | n.a. | 1 | Stagnic Podzoluvisol | PDj | 162 | 1 | 180 | 1 | 175 | 1 |
| Thionic Fluvisols | FLt | n.a. | 1 | n.a. | 1 | n.a. | 1 | Calcaric Phaeozems | PHc | 106 | 3 | 180 | 1 | 165 | 1 |
| Umbric Fluvisols | FLu | n.a. | 1 | n.a. | 1 | n.a. | 1 | Gleyic Phaeozems | PHg | 106 | 3 | 180 | 1 | 165 | 1 |
| Geric Ferralsols | FRg | 146 | 1 | 162 | 1 | 148 | 1 | Haplic Phaeozems | PHh | 106 | 3 | 180 | 1 | 165 | 1 |
| Haplic Ferralsols | FRh | 146 | 1 | 162 | 1 | 148 | 1 | Stagnic Phaeozems | PHj | 106 | 3 | 180 | 1 | 165 | 1 |
| Plinthic Ferralsols | FRp | 146 | 1 | 162 | 1 | 148 | 1 | Luvic Phaeozems | PHl | 162 | 1 | 180 | 1 | 175 | 1 |
| Rhodic Ferralsols | FRr | 146 | 1 | 162 | 1 | 148 | 1 | Dystric Planosols | PLd | 152 | 1 | 169 | 1 | 165 | 1 |
| Humic Ferralsols | FRu | 146 | 1 | 162 | 1 | 148 | 1 | Eutric Planosols | PLe | 152 | 1 | 169 | 1 | 165 | 1 |
| Xanthic Ferralsols | FRx | 146 | 1 | 162 | 1 | 148 | 1 | Gelic Planosols | PLi | 152 | 1 | 169 | 1 | 165 | 1 |
| Andic Gleysols | GLa | n.a. | 1 | n.a. | 1 | n.a. | 1 | Mollic Planosols | PLm | 152 | 1 | 169 | 1 | 165 | 1 |
| Dystric Gleysols | GLd | n.a. | 1 | n.a. | 1 | n.a. | 1 | Umbric Planosols | PLu | 152 | 1 | 169 | 1 | 165 | 1 |

**Soil moisture storage capacity classes derived for FAO soil units of Revised Legend '90 (continued)**

| FAO Legend '90 Soil Unit | SLU | coarse mm | coarse CL | medium mm | medium CL | fine mm | fine CL |
|---|---|---|---|---|---|---|---|
| Albic Plinthosols | PTa | 95 | 3 | 162 | 1 | 148 | 1 |
| Dystric Plinthosols | PTd | 95 | 3 | 162 | 1 | 148 | 1 |
| Eutric Plinthosols | PTe | 95 | 3 | 162 | 1 | 148 | 1 |
| Humic Plinthosols | PTu | 95 | 3 | 162 | 1 | 148 | 1 |
| Cambic Podzols | PZb | 106 | 3 | 180 | 1 | 165 | 1 |
| Carbic Podzols | PZc | 106 | 3 | 180 | 1 | 165 | 1 |
| Ferric Podzols | PZf | 106 | 3 | 180 | 1 | 165 | 1 |
| Gleyic Podzols | PZg | 106 | 3 | 180 | 1 | 165 | 1 |
| Haplic Podzols | PZh | 106 | 3 | 180 | 1 | 165 | 1 |
| Gelic Podzols | PZi | 106 | 3 | 180 | 1 | 165 | 1 |
| Calcaric Regosols | RGc | 106 | 3 | 180 | 1 | 165 | 1 |
| Dystric Regosols | RGd | 106 | 3 | 180 | 1 | 165 | 1 |
| Eutric Regosols | RGe | 106 | 3 | 180 | 1 | 165 | 1 |
| Gelic Regosols | RGi | 106 | 3 | 180 | 1 | 165 | 1 |
| Umbric Regosols | RGu | 106 | 3 | 180 | 1 | 165 | 1 |
| Gypsic Regosols | RGy | 106 | 3 | 180 | 1 | 165 | 1 |

| FAO Legend '90 Soil Unit | SLU | coarse mm | coarse CL | medium mm | medium CL | fine mm | fine CL |
|---|---|---|---|---|---|---|---|
| Gleyic Solonchaks | SCg | 106 | 3 | 180 | 1 | 165 | 1 |
| Haplic Solonchaks | SCh | 106 | 3 | 180 | 1 | 165 | 1 |
| Gelic Solonchaks | SCi | 106 | 3 | 180 | 1 | 165 | 1 |
| Calcic Solonchaks | SCk | 106 | 3 | 180 | 1 | 165 | 1 |
| Mollic Solonchaks | SCm | 106 | 3 | 180 | 1 | 165 | 1 |
| Sodic Solonchaks | SCn | 106 | 3 | 180 | 1 | 165 | 1 |
| Gypsic Solonchaks | SCy | 106 | 3 | 180 | 1 | 165 | 1 |
| Gleyic Solonetz | SNg | 106 | 3 | 180 | 1 | 165 | 1 |
| Haplic Solonetz | SNh | 106 | 3 | 180 | 1 | 165 | 1 |
| Stagnic Solonetz | SNj | 106 | 3 | 180 | 1 | 165 | 1 |
| Calcic Solonetz | SNk | 106 | 3 | 180 | 1 | 165 | 1 |
| Mollic Solonetz | SNm | 106 | 3 | 180 | 1 | 165 | 1 |
| Gypsic Solonetz | SNy | 106 | 3 | 180 | 1 | 165 | 1 |
| Dystric Vertisols | VRd | 135 | 2 | 135 | 2 | 135 | 2 |
| Eutric Vertisols | VRe | 135 | 2 | 135 | 2 | 135 | 2 |
| Calcic Vertisols | VRk | 135 | 2 | 135 | 2 | 135 | 2 |
| Gypsic Vertisols | VRy | 135 | 2 | 135 | 2 | 135 | 2 |

# APPENDIX XIV

## Table 1 Terrain slope ratings for rain-fed conditions (Fm: 1300-1800)

### High Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | | 100 | | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | 100 | | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 |

### Intermediate Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 100 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | 100 | | | 25 | 75 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 |

### Low Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 100 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | 100 | | | 25 | 75 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 |

**Modified Fournier index**: $Fm = 12 \sum_{i=1}^{12} \frac{p_i^2}{Pann}$ where: $p_i$ = rainfall of month i and Pann = annual rainfall total

## Table 2 Terrain slope ratings for rain-fed conditions (Fm: 1800-2200)

### High Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | | 25 | 75 | | | 100 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 | | | 100 |

### Intermediate Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 100 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 |

### Low Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 100 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 |

**Modified Fournier index**: $Fm = 12\sum_{i=1}^{12}\frac{p_i^2}{Pann}$ where: $p_i$ = rainfall of month i and Pann = annual rainfall total

## Table 3 Terrain slope ratings for rain-fed conditions (Fm: 2200-2500)

### High Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | | | 100 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | | 100 | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | | | 100 | | | 100 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |

### Intermediate Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 100 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | | 100 | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | | 100 | | | 25 | 75 | | | 100 | | | 100 |

### Low Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | | 100 | | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 100 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | | 100 | | 50 | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | | 100 | | | 25 | 75 | | | 100 | | | 100 |

**Modified Fournier index**: $Fm = 12\sum_{i=1}^{12}\frac{p_i^2}{Pann}$ where: $p_i$ = rainfall of month i and Pann = annual rainfall total

## Table 4 Terrain slope ratings for rain-fed conditions (Fm: 2500-2700)

### High Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | | | 100 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | | 100 | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | | 25 | 75 | | | 100 | | | 100 | | | 100 |

### Intermediate Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 100 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | | 100 | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | | 25 | 75 | | | 100 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |

### Low Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 100 | | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 100 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 100 | | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 100 | | | | | 100 | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | | 25 | 75 | | | 100 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |

**Modified Fournier index**: $Fm = 12 \sum_{i=1}^{12} \frac{p_i^2}{Pann}$ where: $p_i$ = rainfall of month i and Pann = annual rainfall total

## Table 5 Terrain slope ratings for rain-fed conditions (Fm > 2700)

### High Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |

### Intermediate Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 |

### Low Inputs

| Slope Gradient Classes | 0-2 % | | | 2-5% | | | 5-8% | | | 8-16% | | | 16-30% | | | 30-45% | | | > 45% | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Crop Groups** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** | **S1** | **S2** | **N** |
| Annual 1 | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 |
| Annual 2 | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Wetland Rice | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 | | | 100 |
| Sugarcane | 100 | | | 100 | | | 25 | 50 | 25 | | | 100 | | | 100 | | | 100 | | | 100 |
| Olive | 100 | | | 100 | | | 50 | 50 | | | 25 | 75 | | | 100 | | | 100 | | | 100 |
| Perennials | 100 | | | 100 | | | 50 | 50 | | | | 100 | | | 100 | | | 100 | | | 100 |
| Pasture | 100 | | | 100 | | | 100 | | | 100 | | | | 50 | 50 | | | 100 | | | 100 |
| Forage Legumes | 100 | | | 100 | | | 50 | 50 | | | 50 | 50 | | | 100 | | | 100 | | | 100 |

**Crop Groups**: Annual 1: wheat, barley, rye
Annual 2: (maize, sorghum, pearl millet, foxtail millet, white potato, sweet potato, phaseolus bean, chickpea, cowpea, soybean and groundnut, sunflower, cotton, sugar beet, rape
Perennials: cassava, oil palm, banana, plantain

## APPENDIX XV

## Plates with selected results of the Global AEZ assessment

**Plate 1. Average annual precipitation**

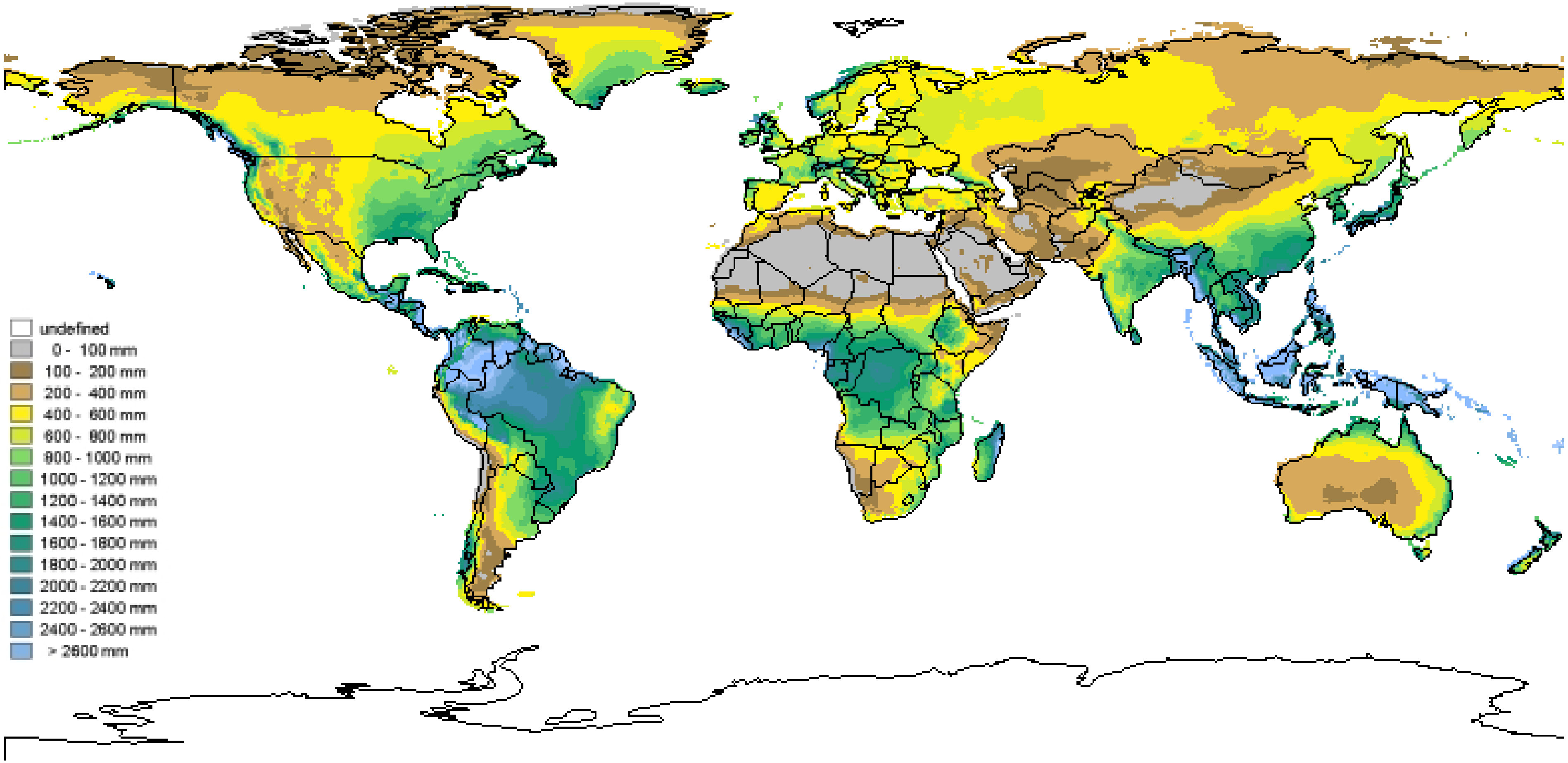
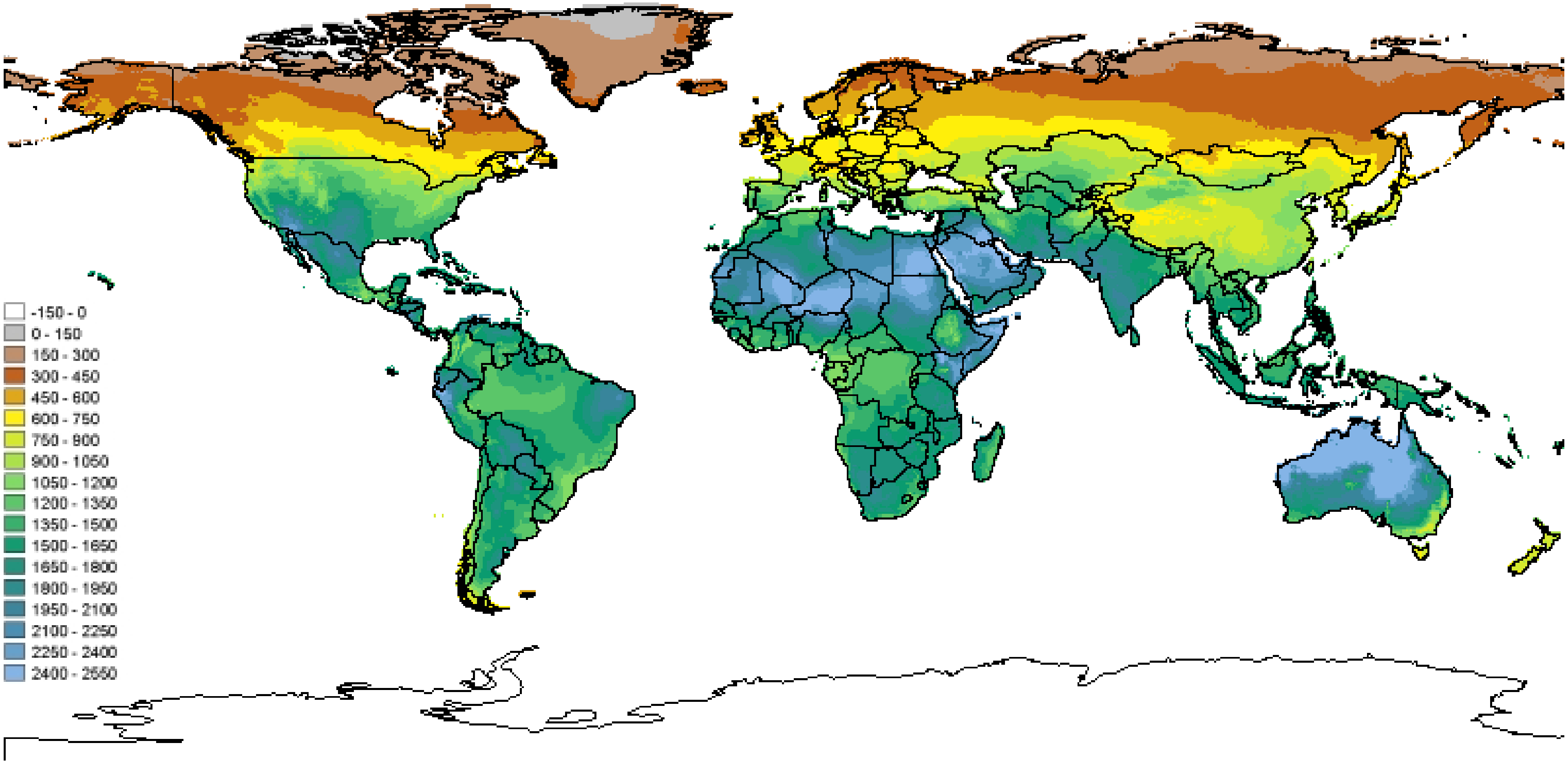


**Plate 2. Average annual reference evapotranspiration (Penman-Monteith)**



## Plate 3. Thermal climates

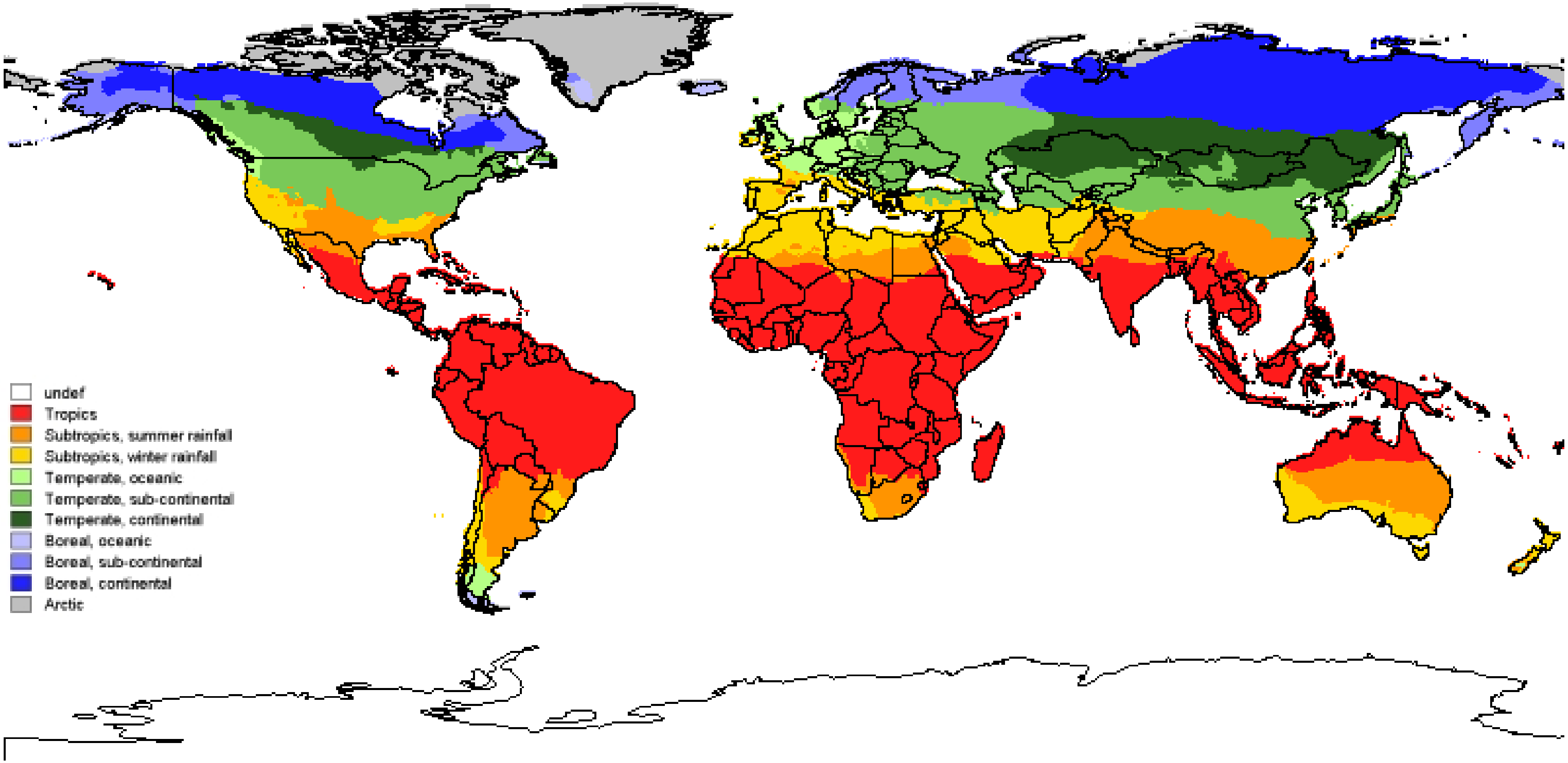


**Plate 4. Temperature growing periods ($LGP_{t=5}$)**

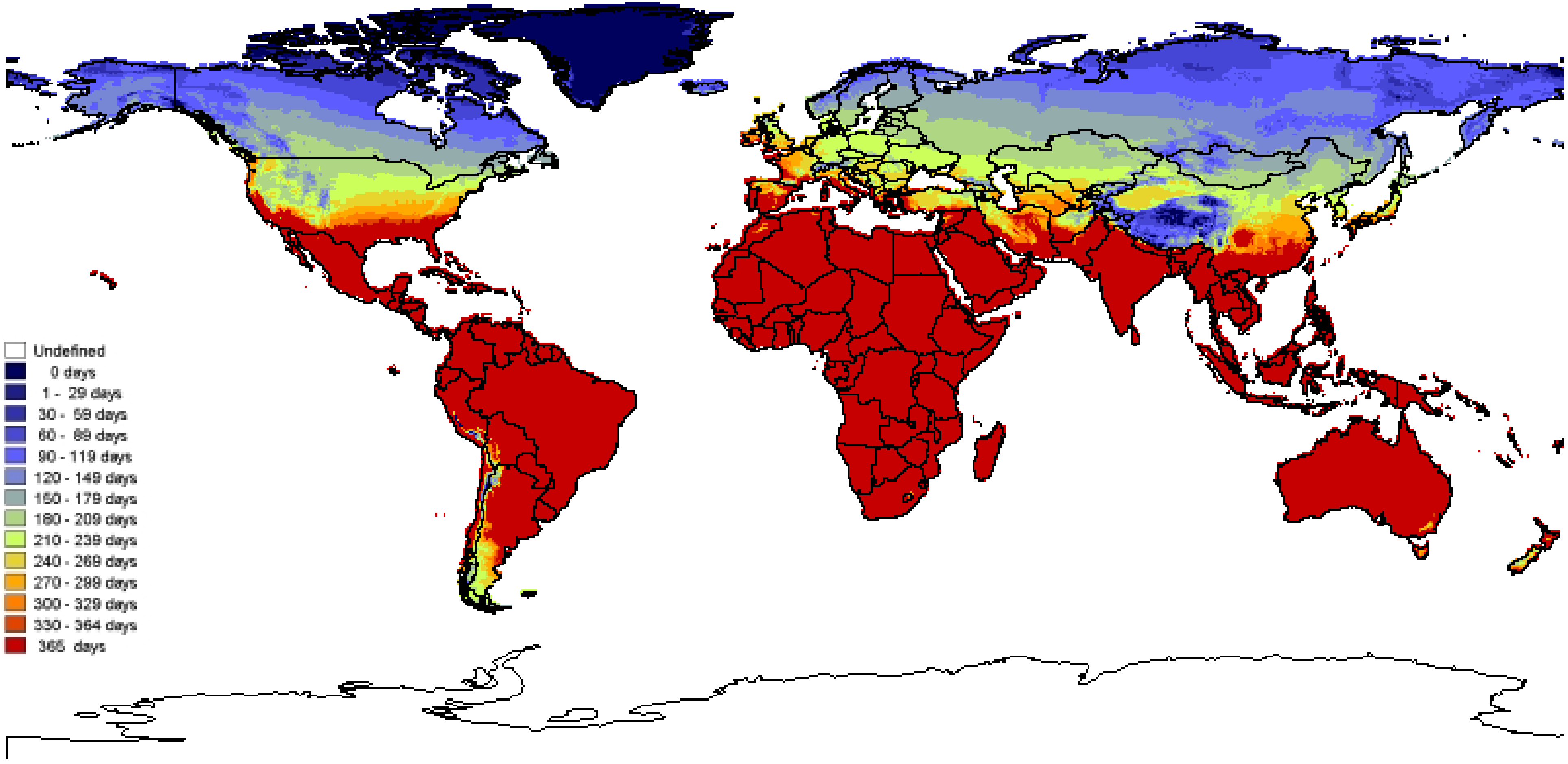


**Plate 5. Frost-free periods (LGP$_{t=10}$)**

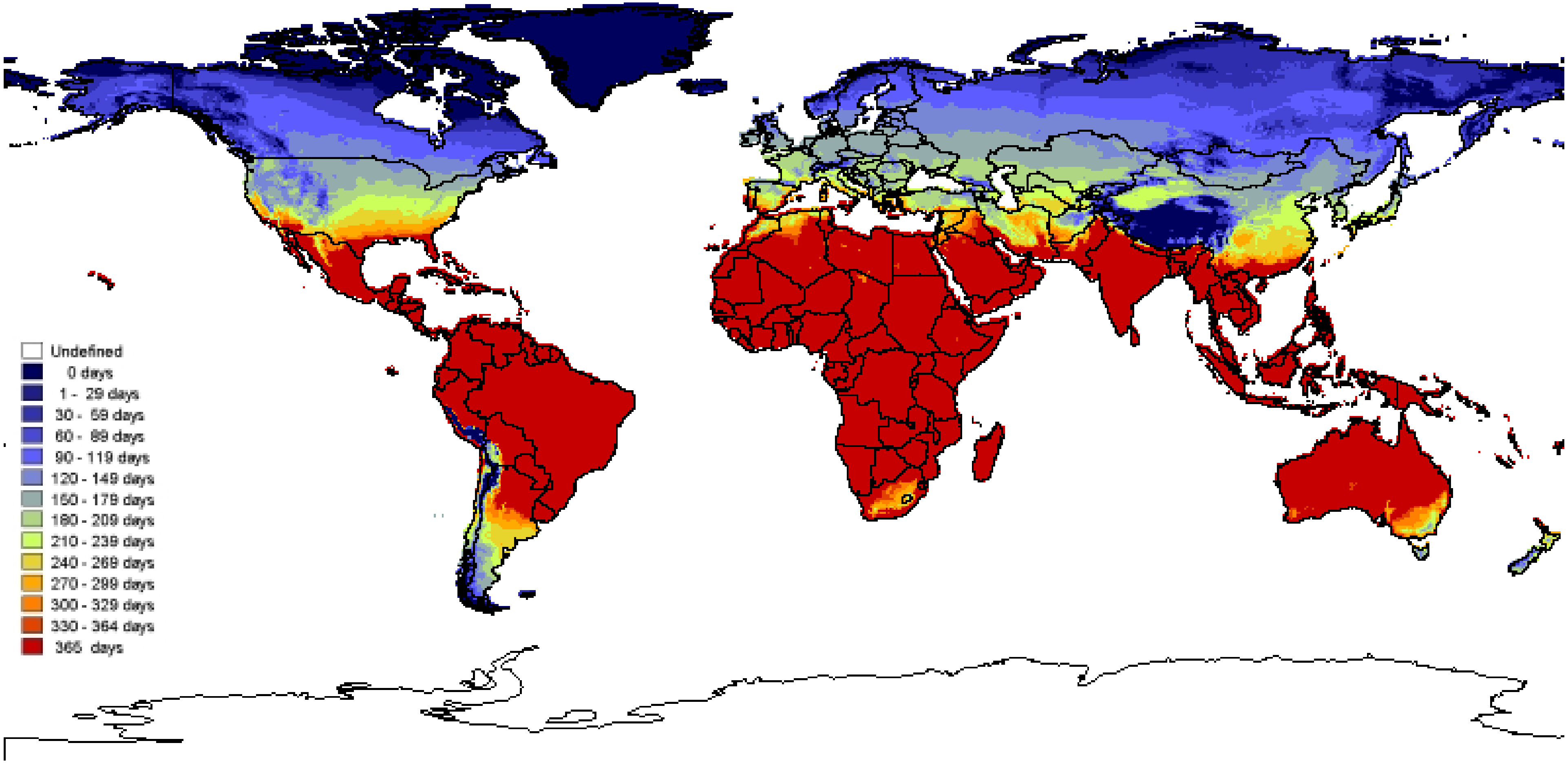


**Plate 6. Accumulated temperatures (Tmean > $0^oC$)**

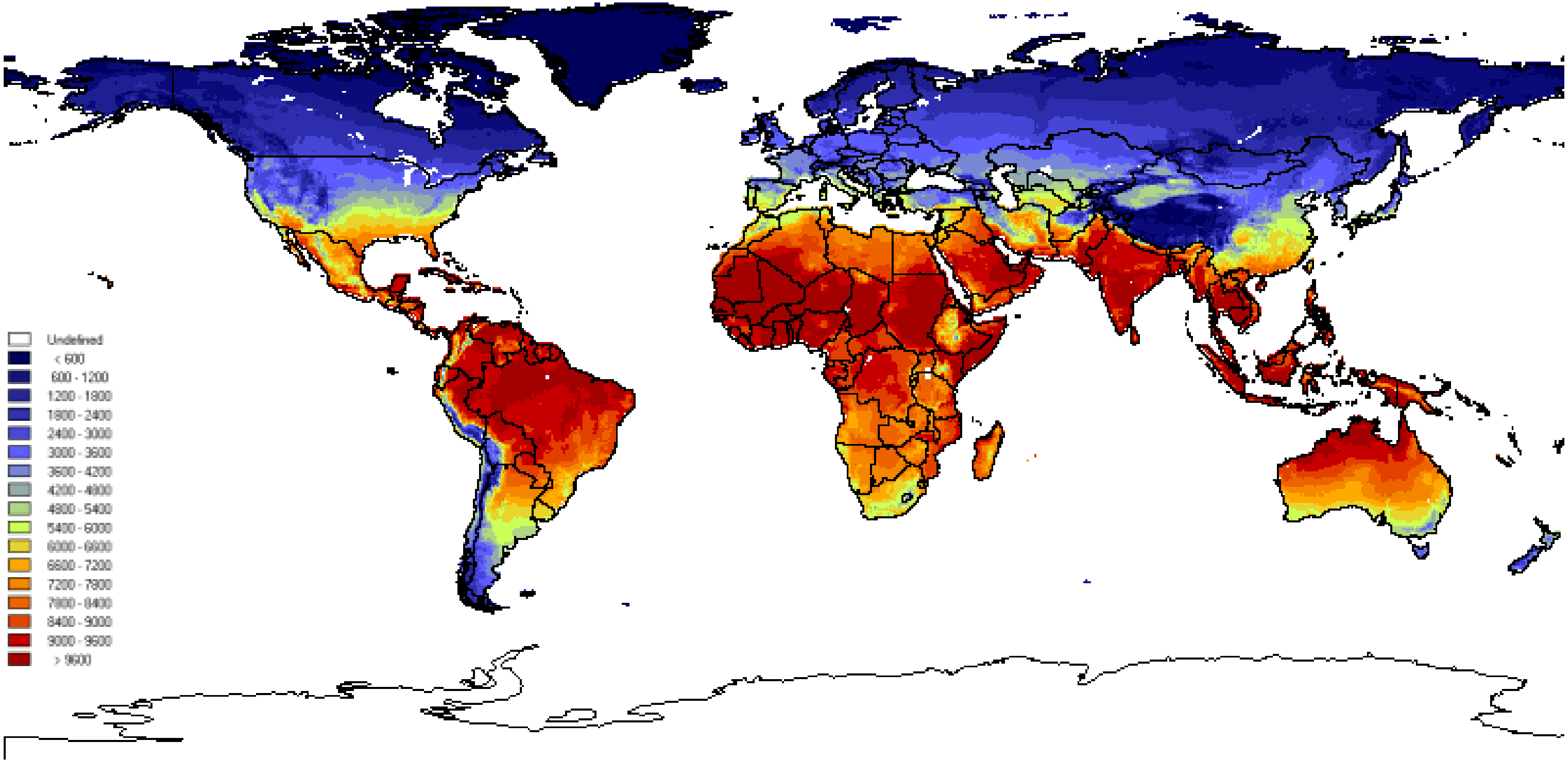


**Plate 7. Total length of growing periods**

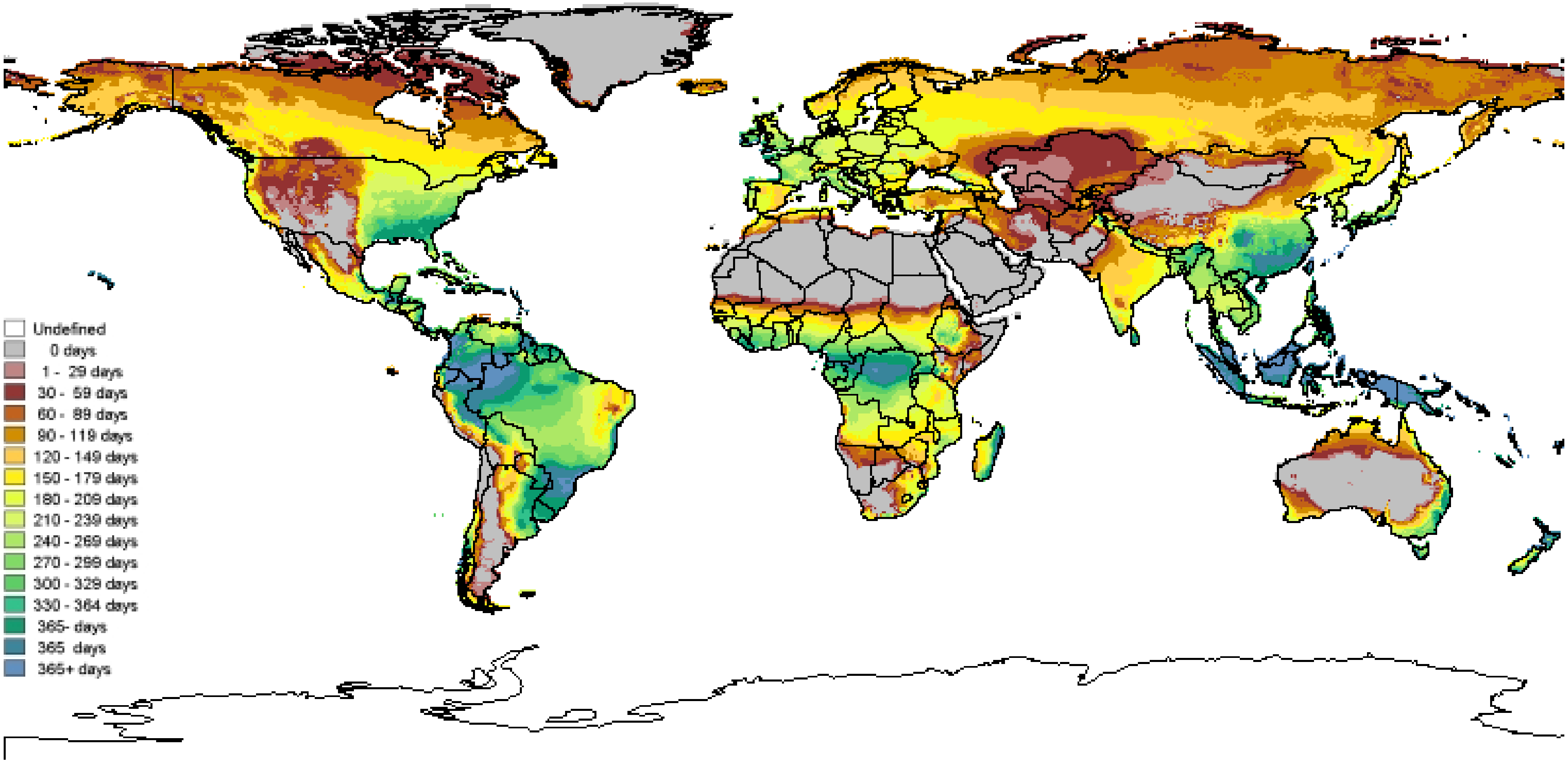


**Plate 8. Growing period patterns**

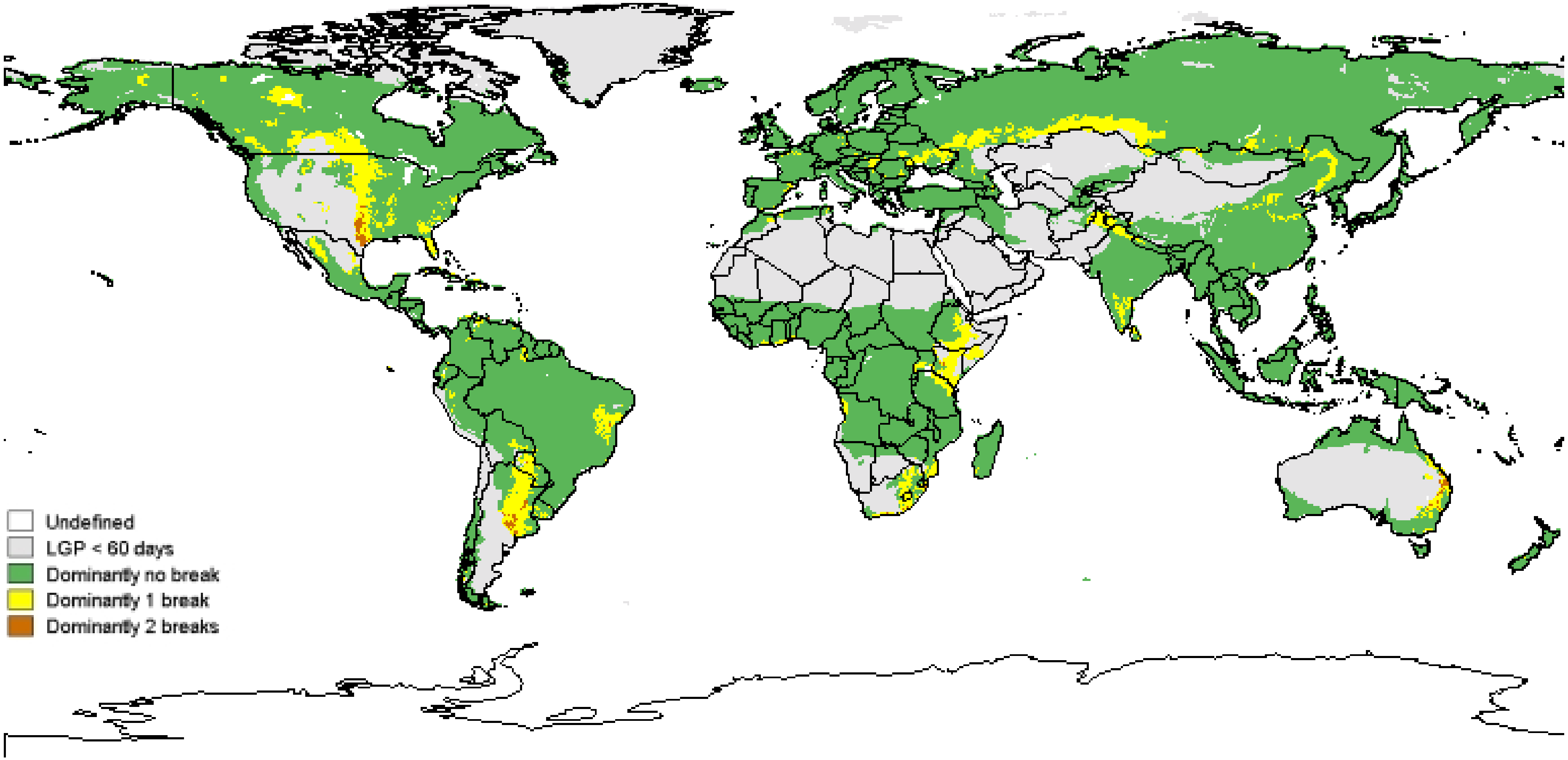


**Plate 9. Median of terrain slopes derived from GTOPO30**

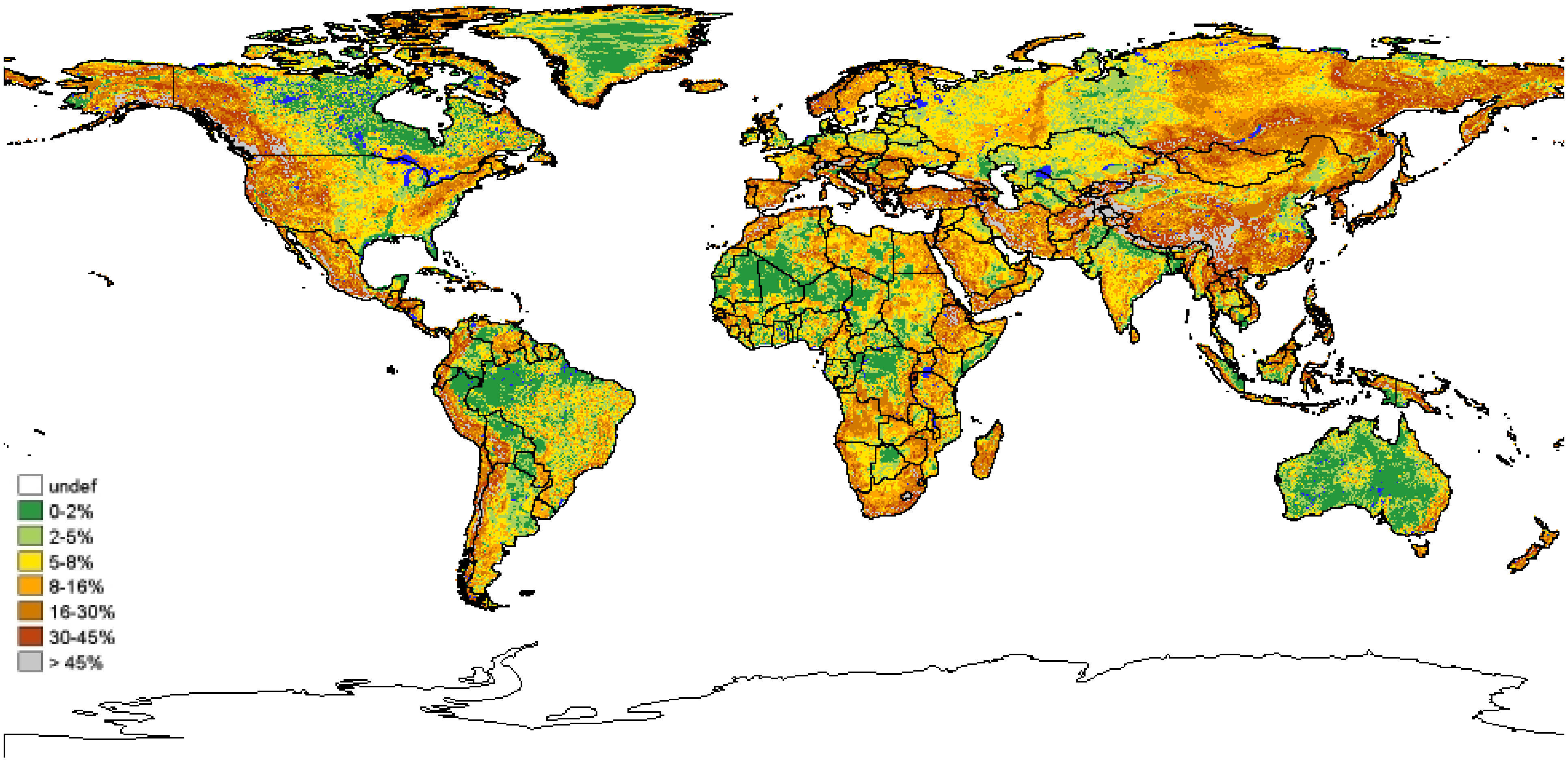
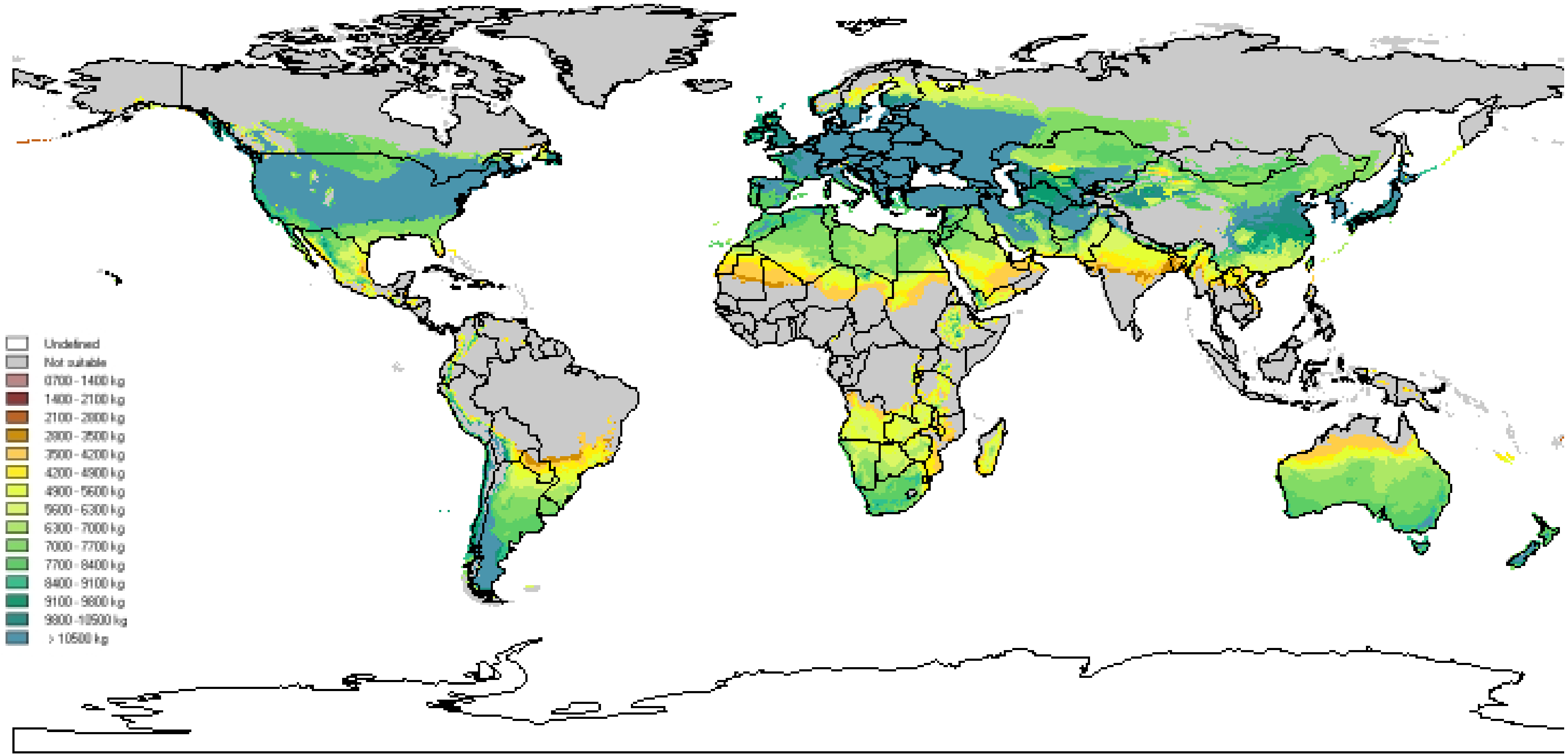


**Plate 10. Temperature and radiation limited yield for rain-fed wheat (high inputs)**



## Plate 11. Agro-climatic suitability for rain-fed wheat (high inputs)

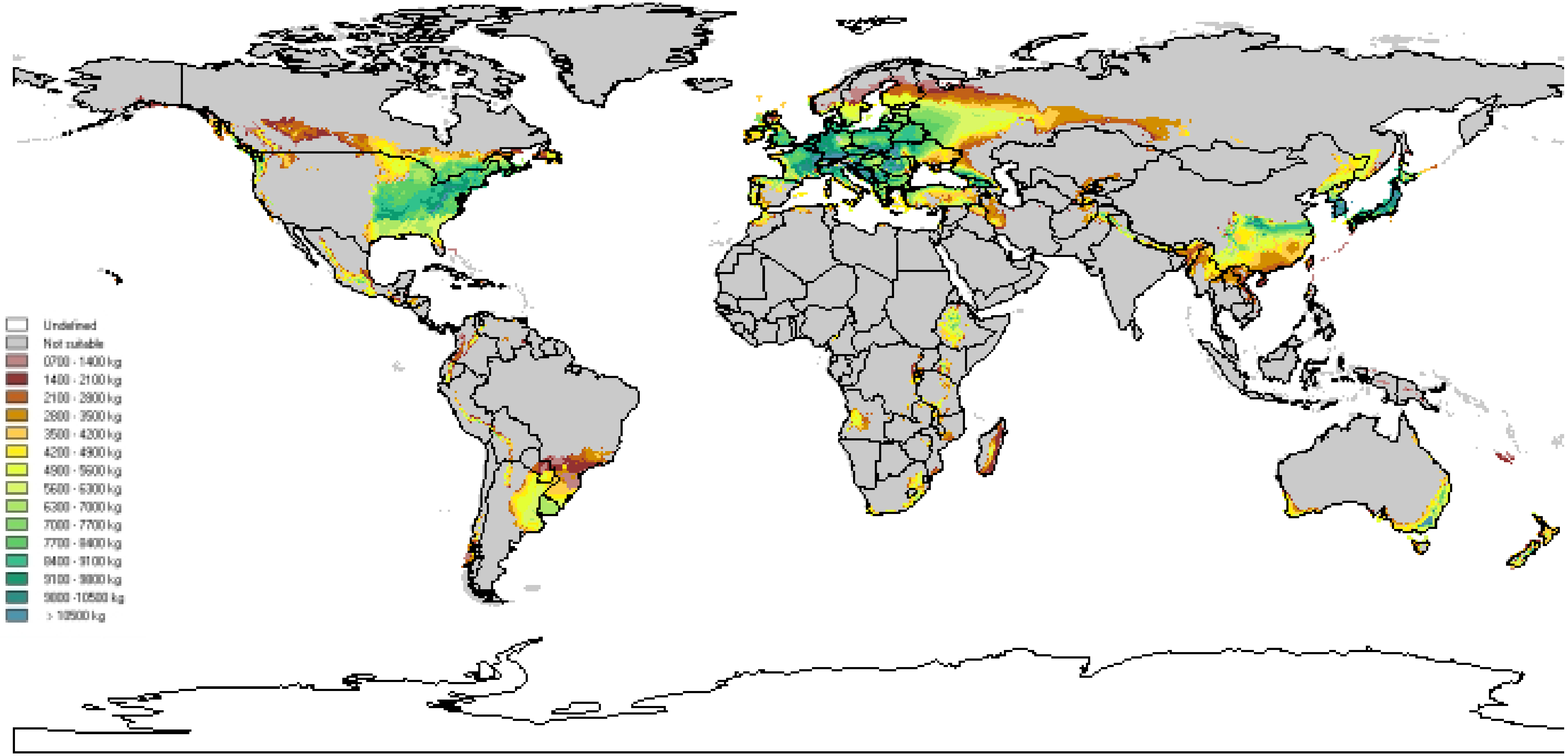


**Plate 12. Agro-climatic suitability for rain-fed and irrigated wheat (high inputs)**

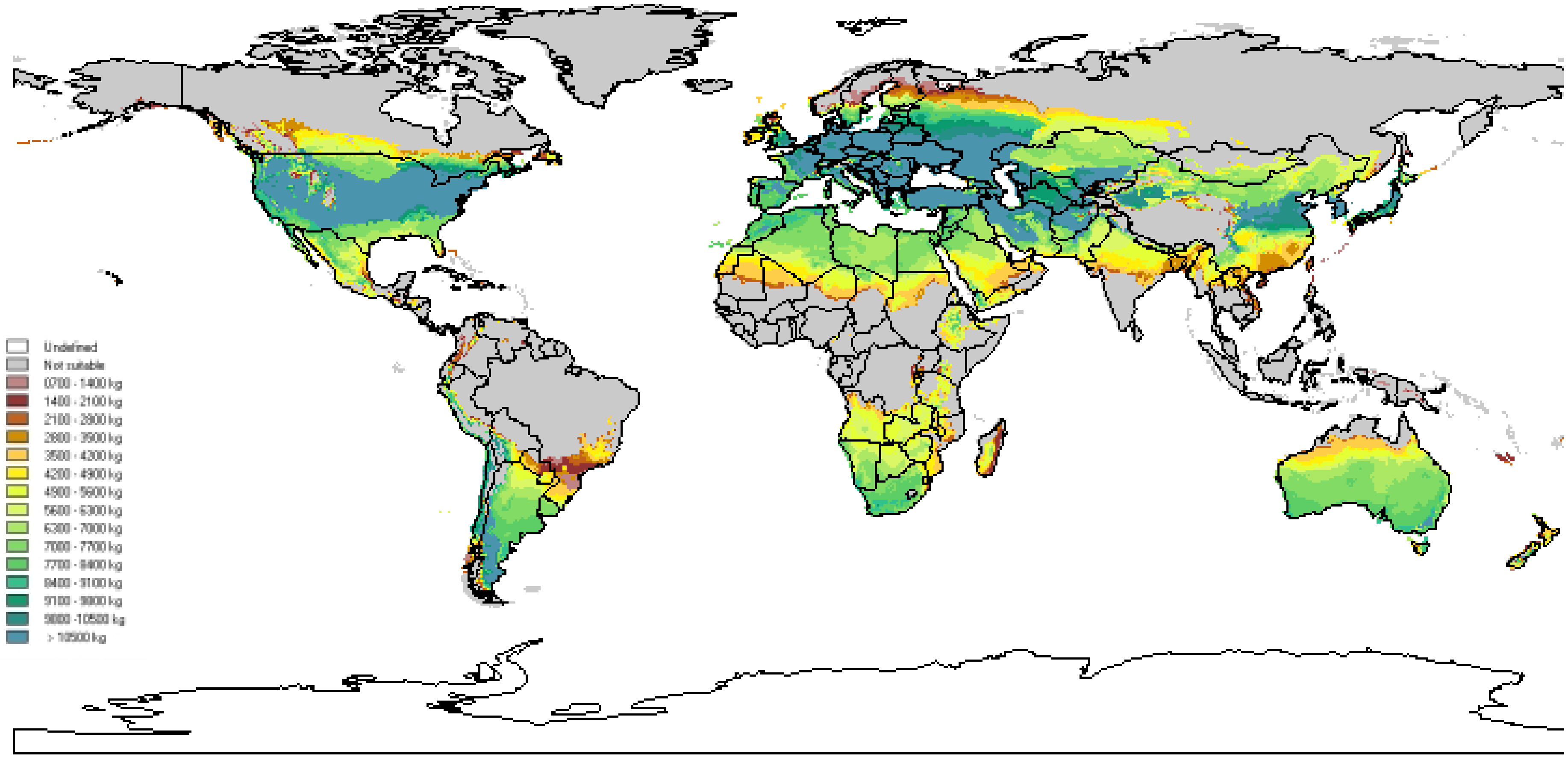


**Plate 13. Multiple cropping zones - rain-fed conditions**

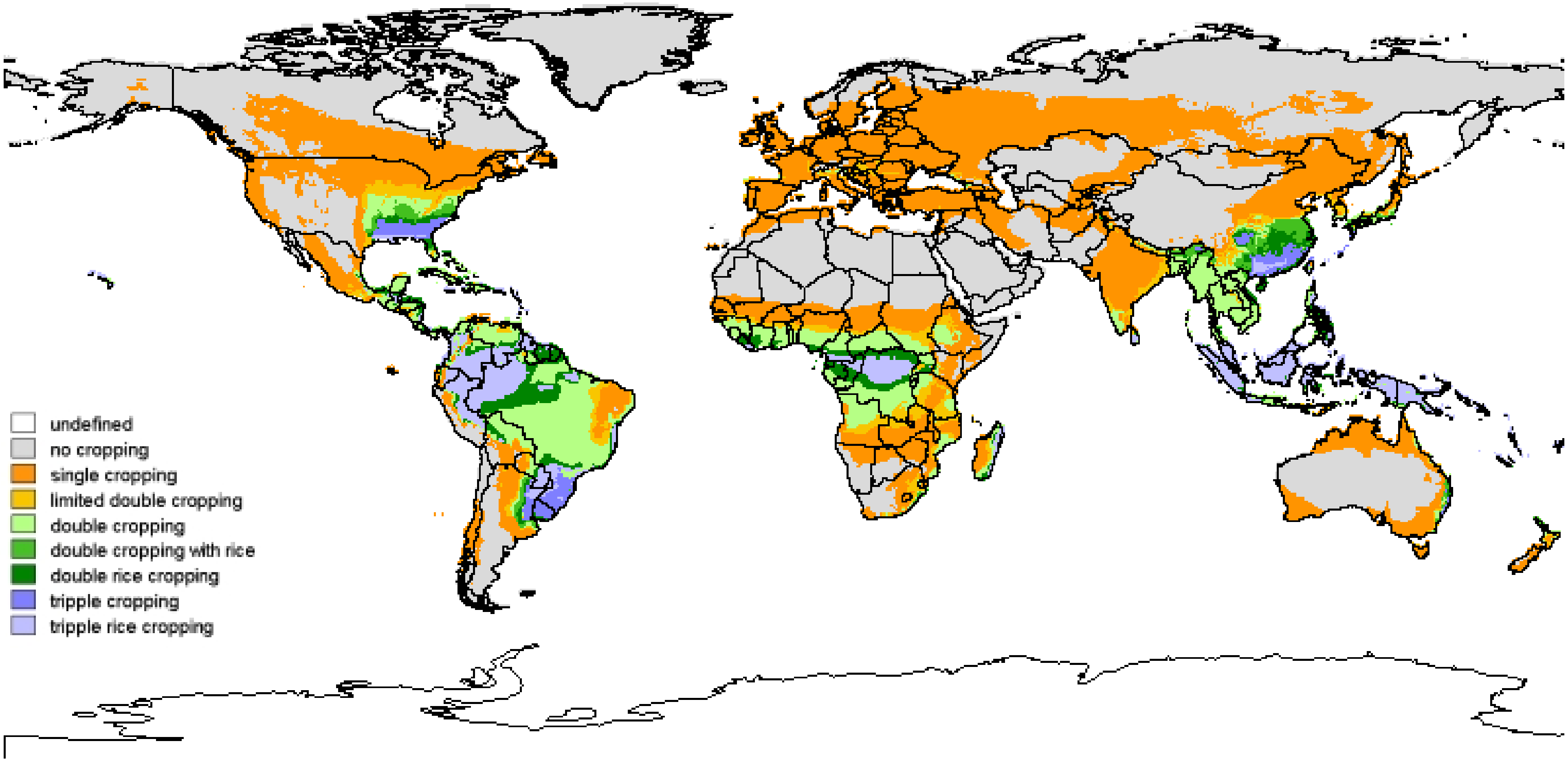


**Plate 14. Number of growing period days**

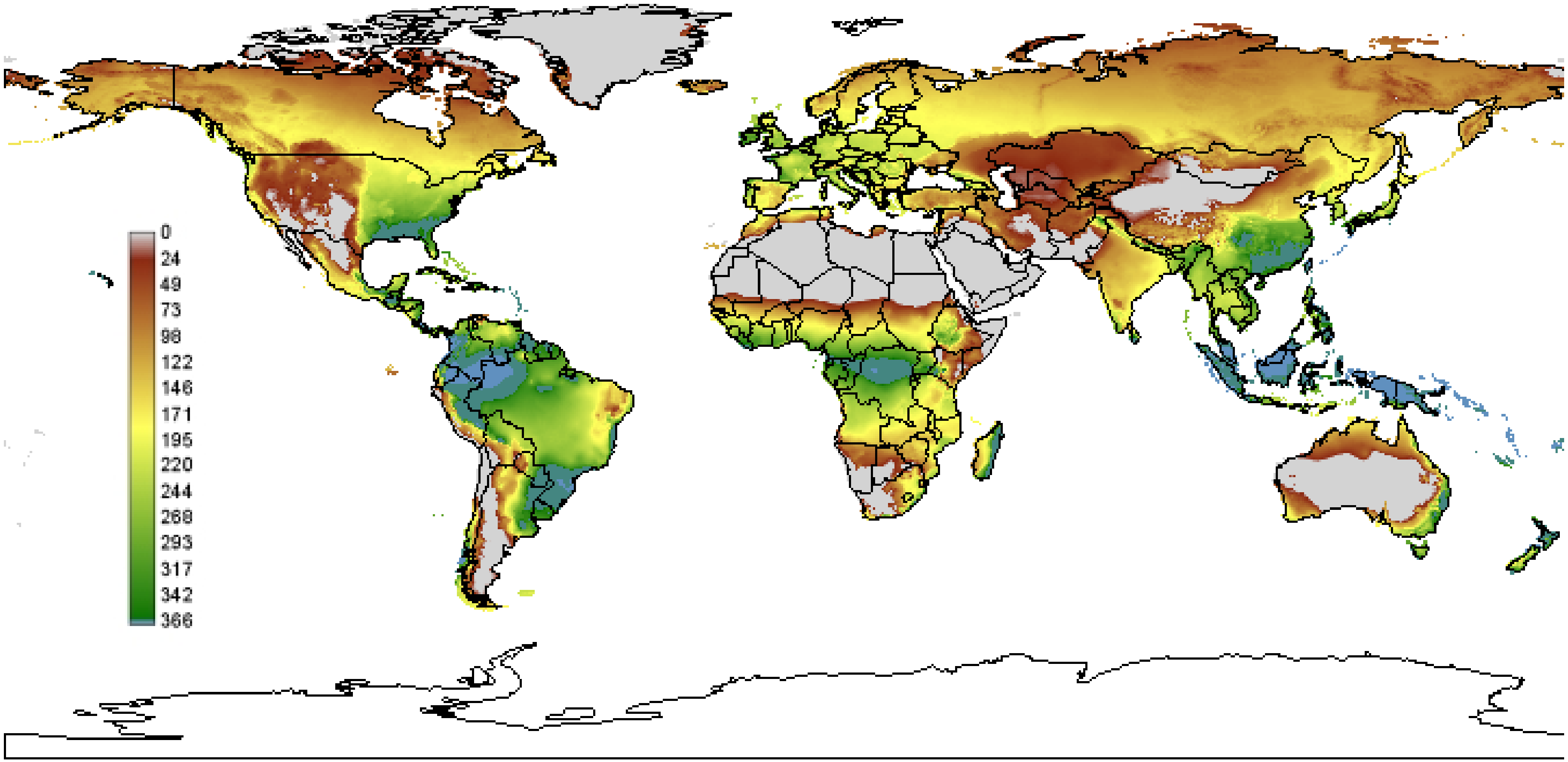


**Plate 15. Temperature and radiation limited yield for 120 day rain-fed grain maize (high inputs)**

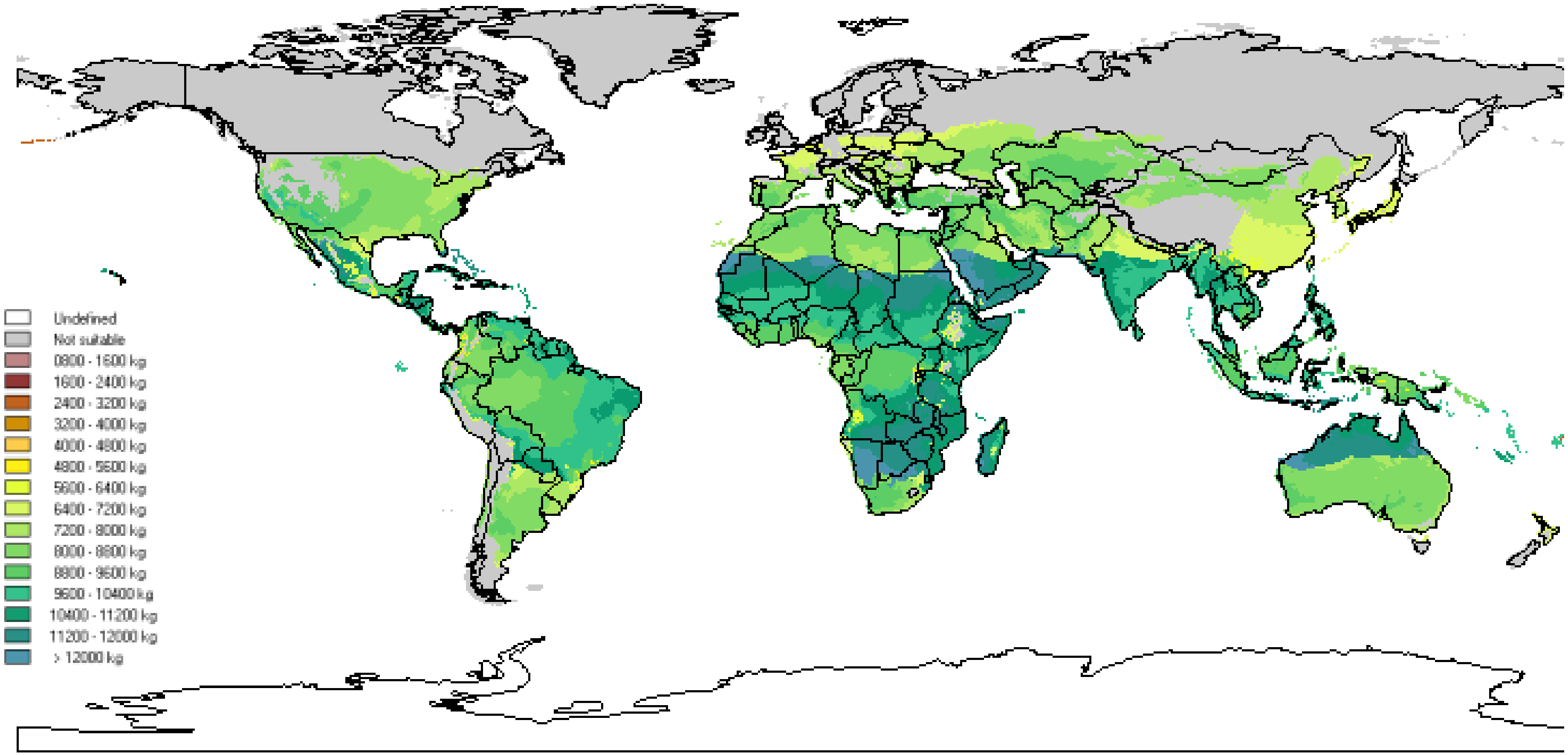


**Plate 16. Temperature, radiation and water limited yield for 120 day rain-fed grain maize (high inputs)**

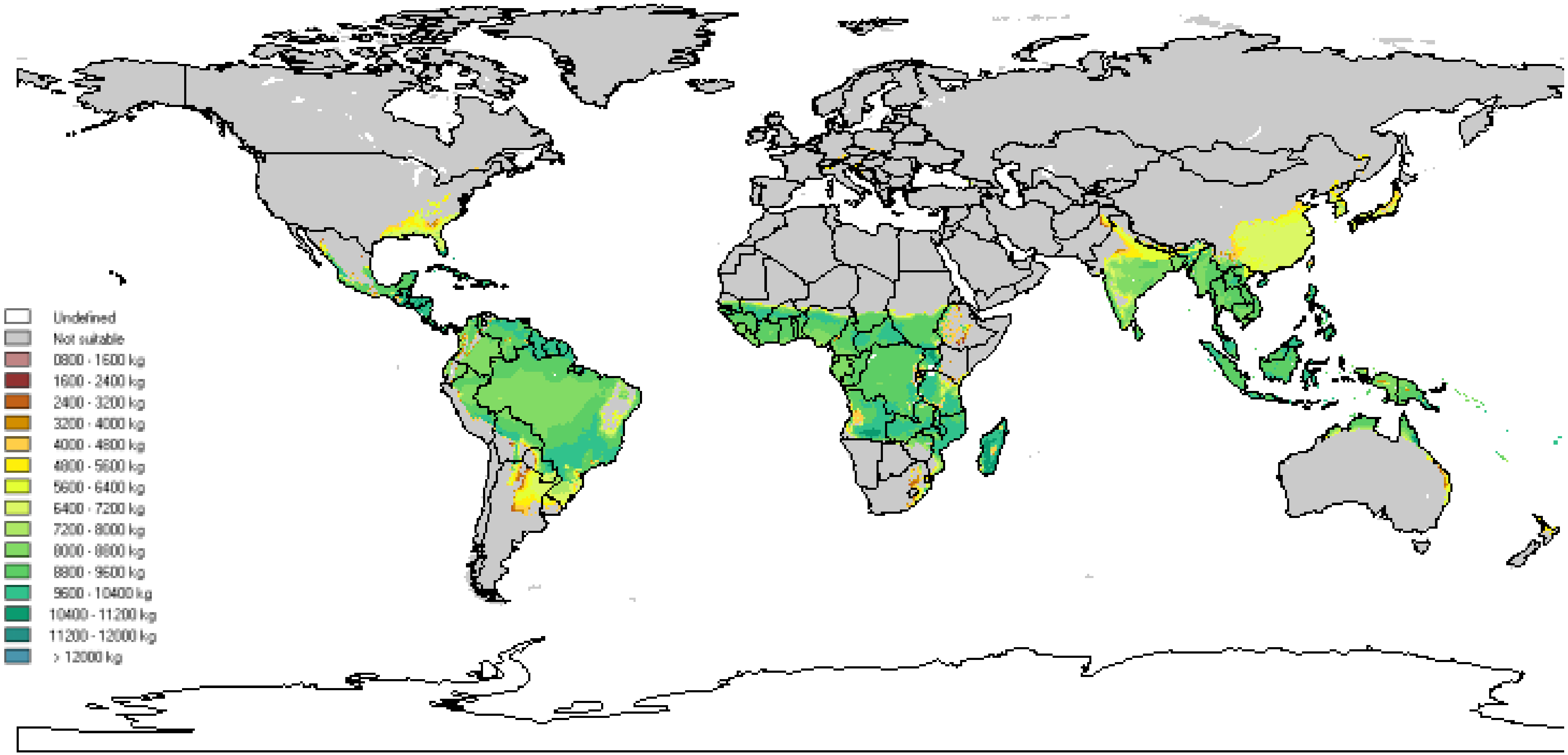


**Plate 17. Agro-climatically attainable yield for 120 day rain-fed grain maize (high inputs)**

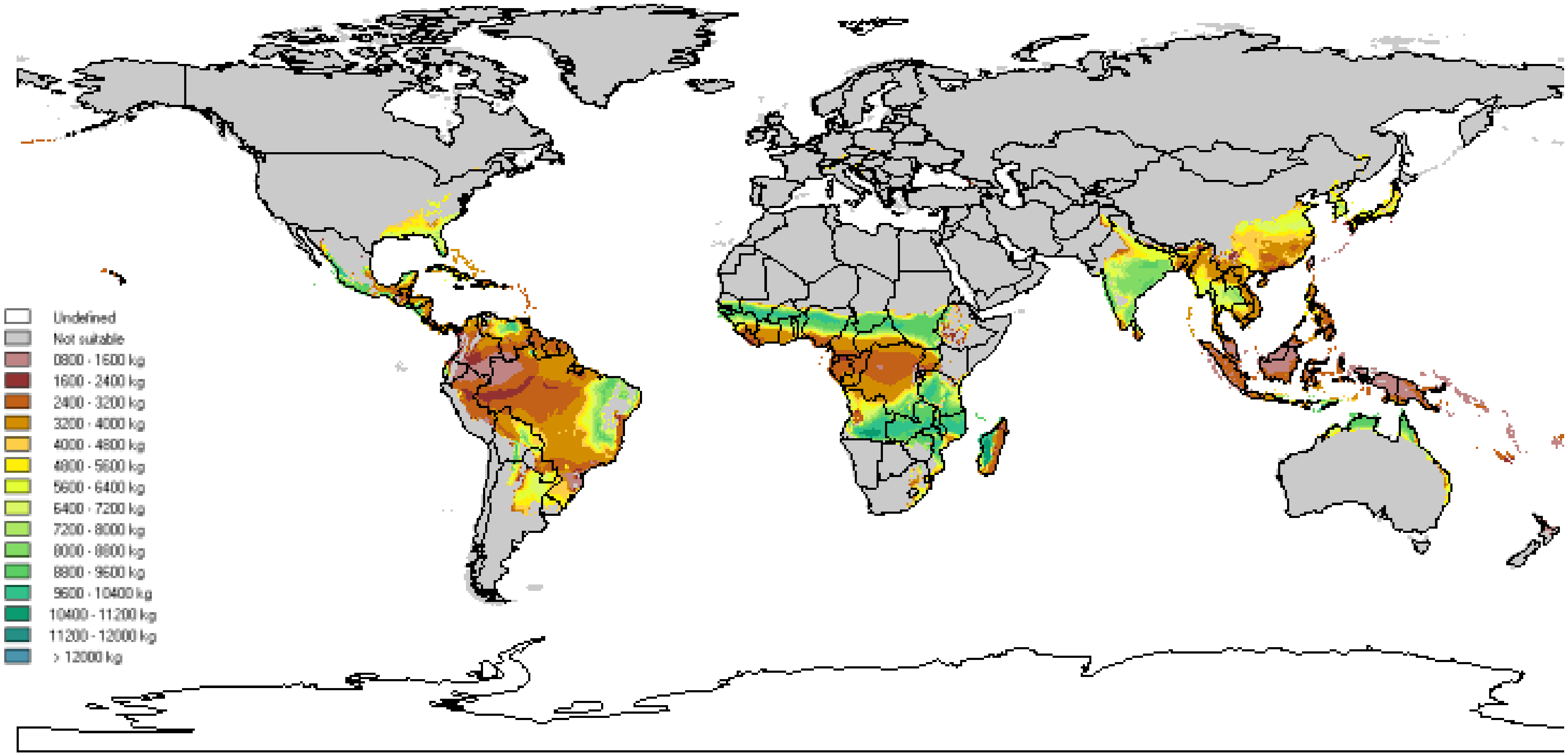


**Plate 18. Expected grid-cell output per hectare for 120 day rain-fed grain maize (high inputs)**

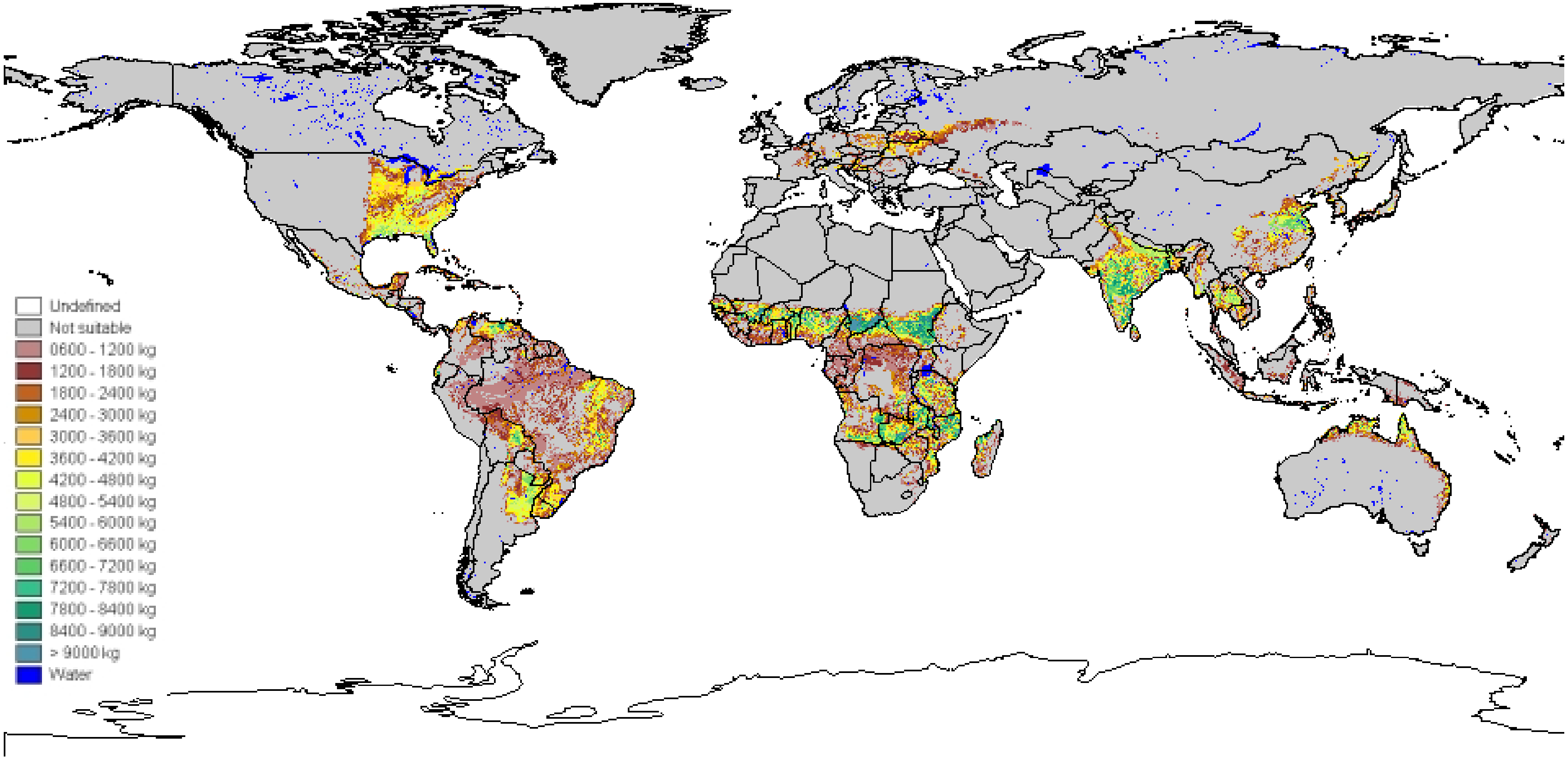


**Plate 19. Expected grid-cell output per hectare across all 13 rain-fed grain-maize types (high inputs)**

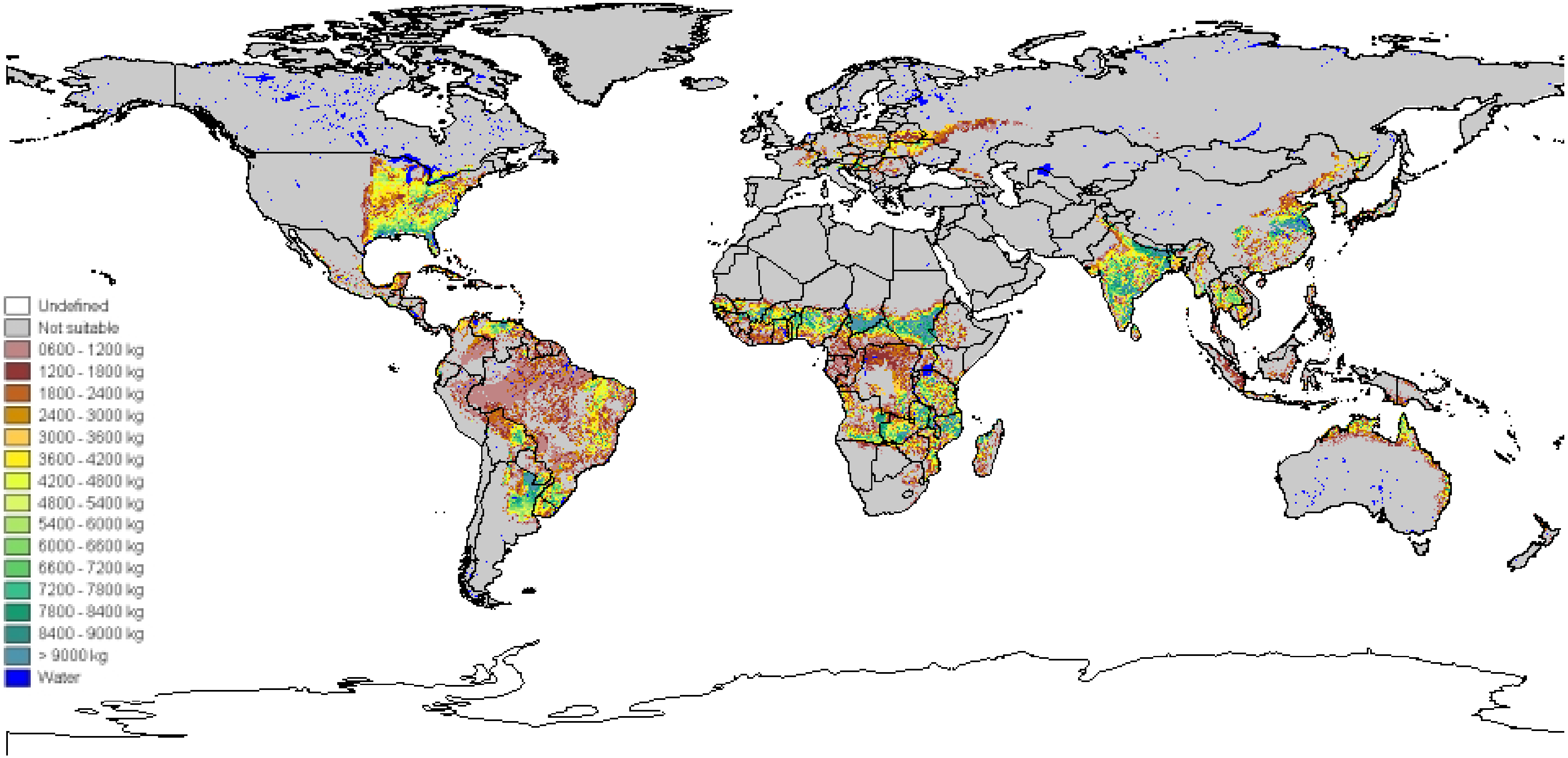


**Plate 20. Climate constraints**

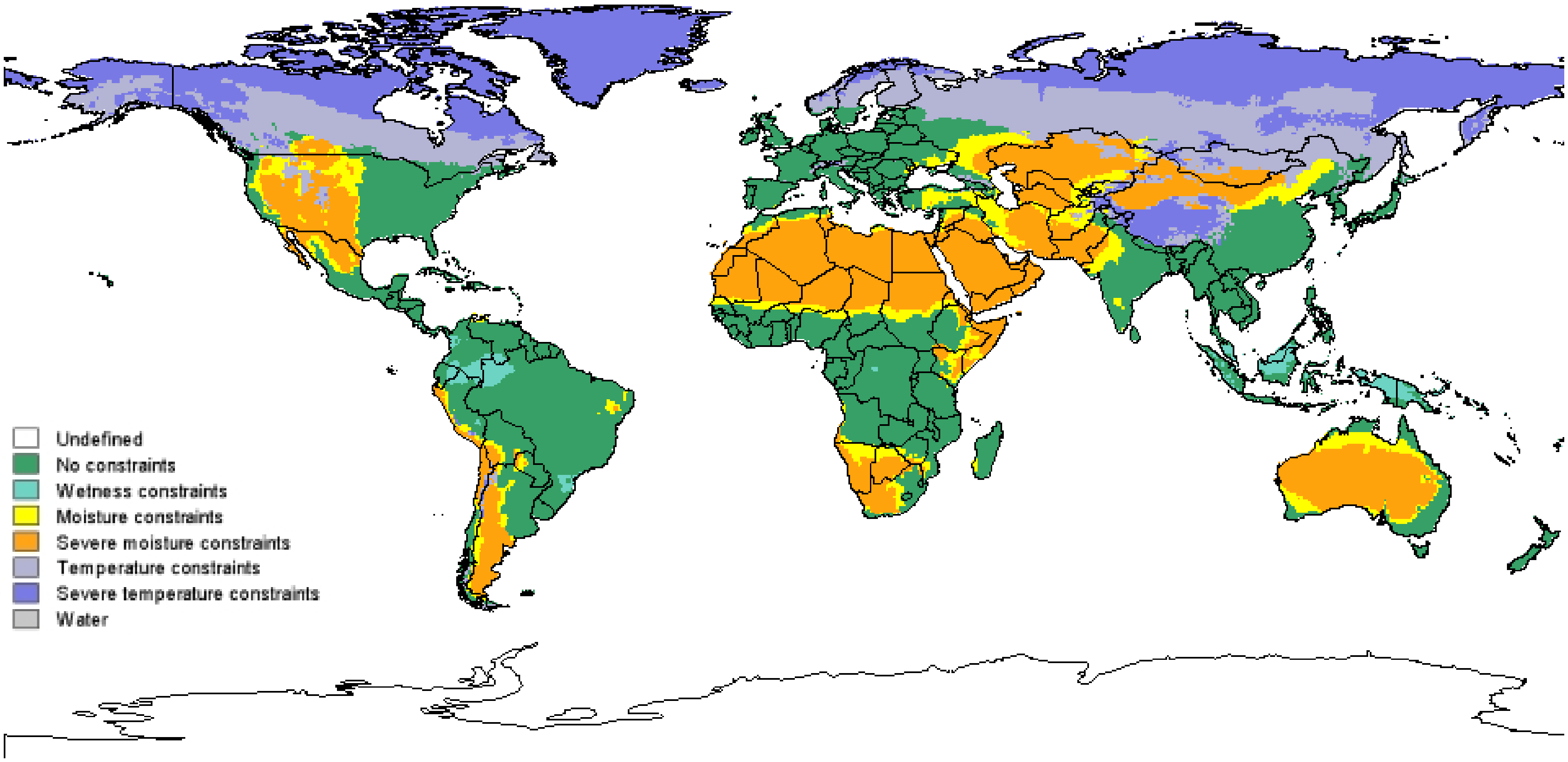
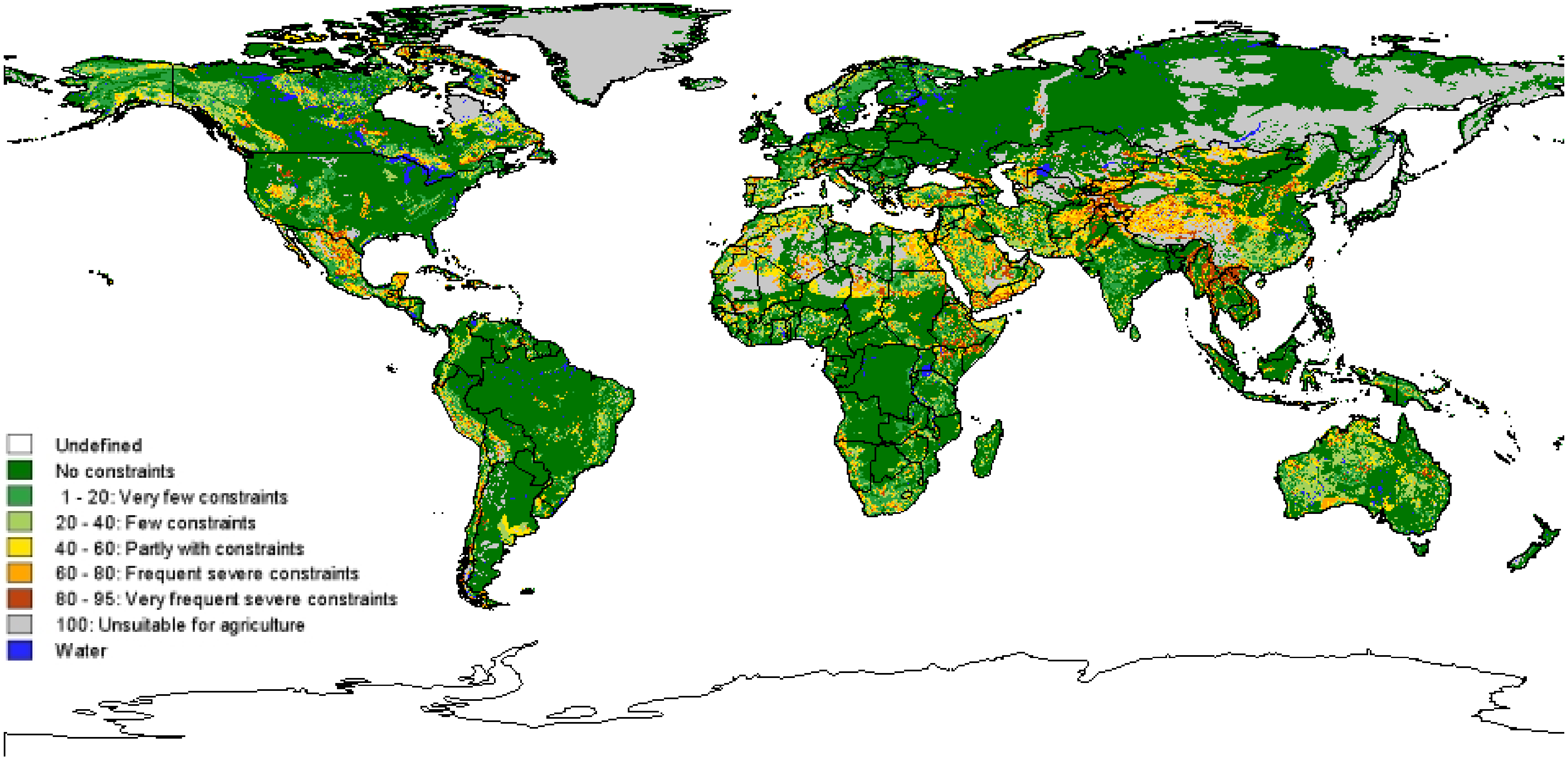


**Plate 21. Soil depth constraints**



## Plate 22. Soil fertility constraints

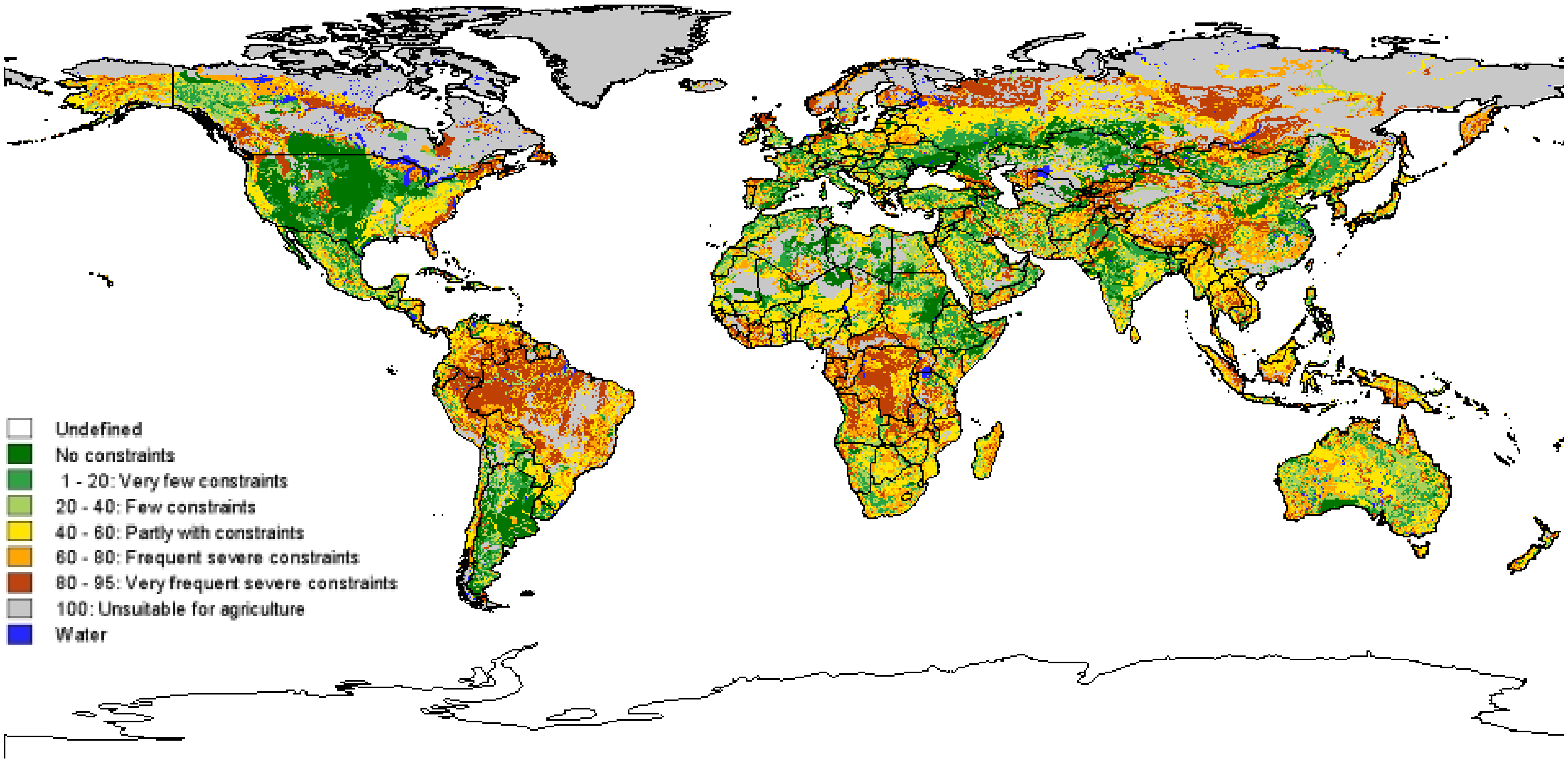
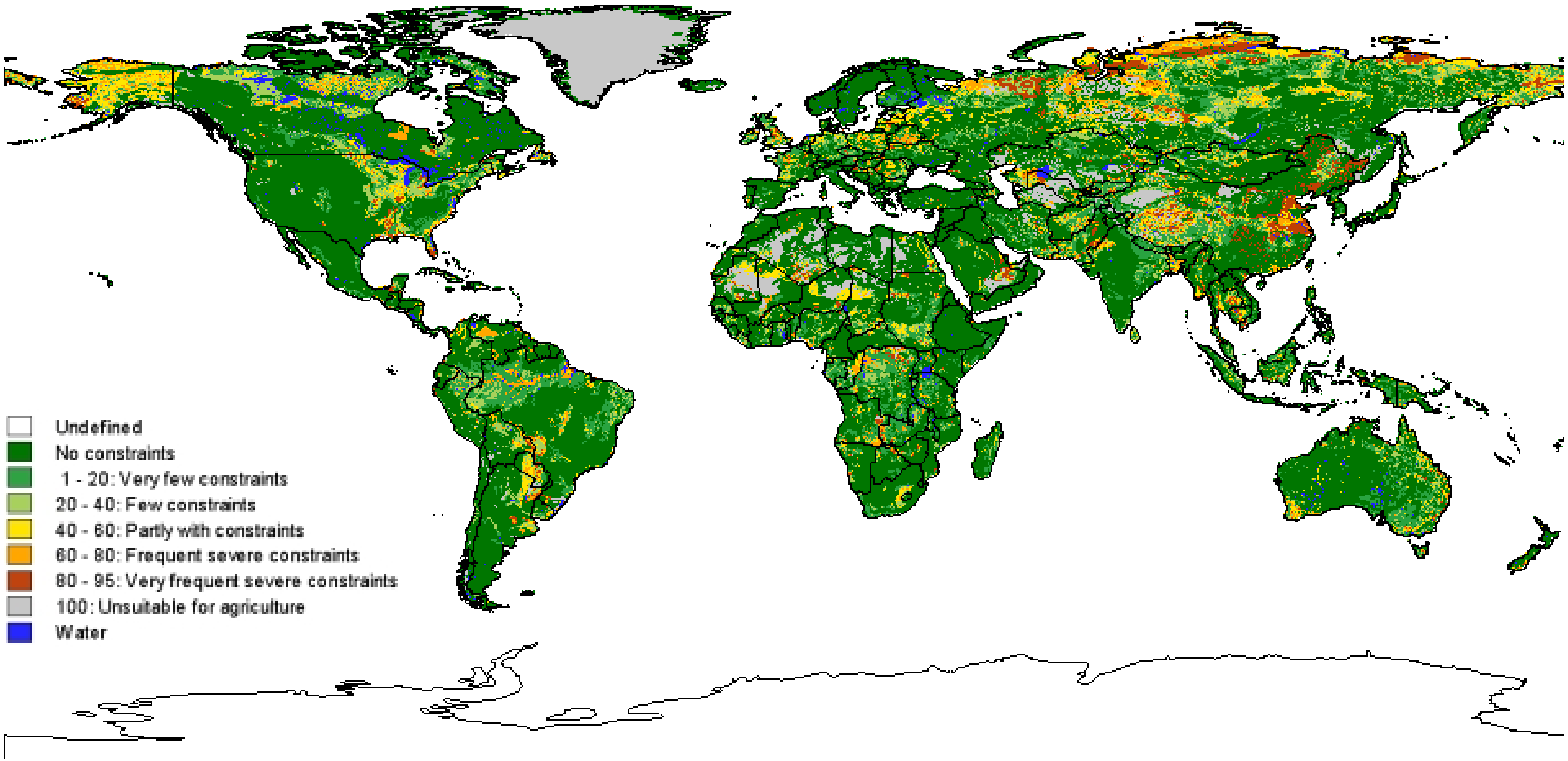


**Plate 23. Soil drainage constraints**



## Plate 24. Soil texture constraints

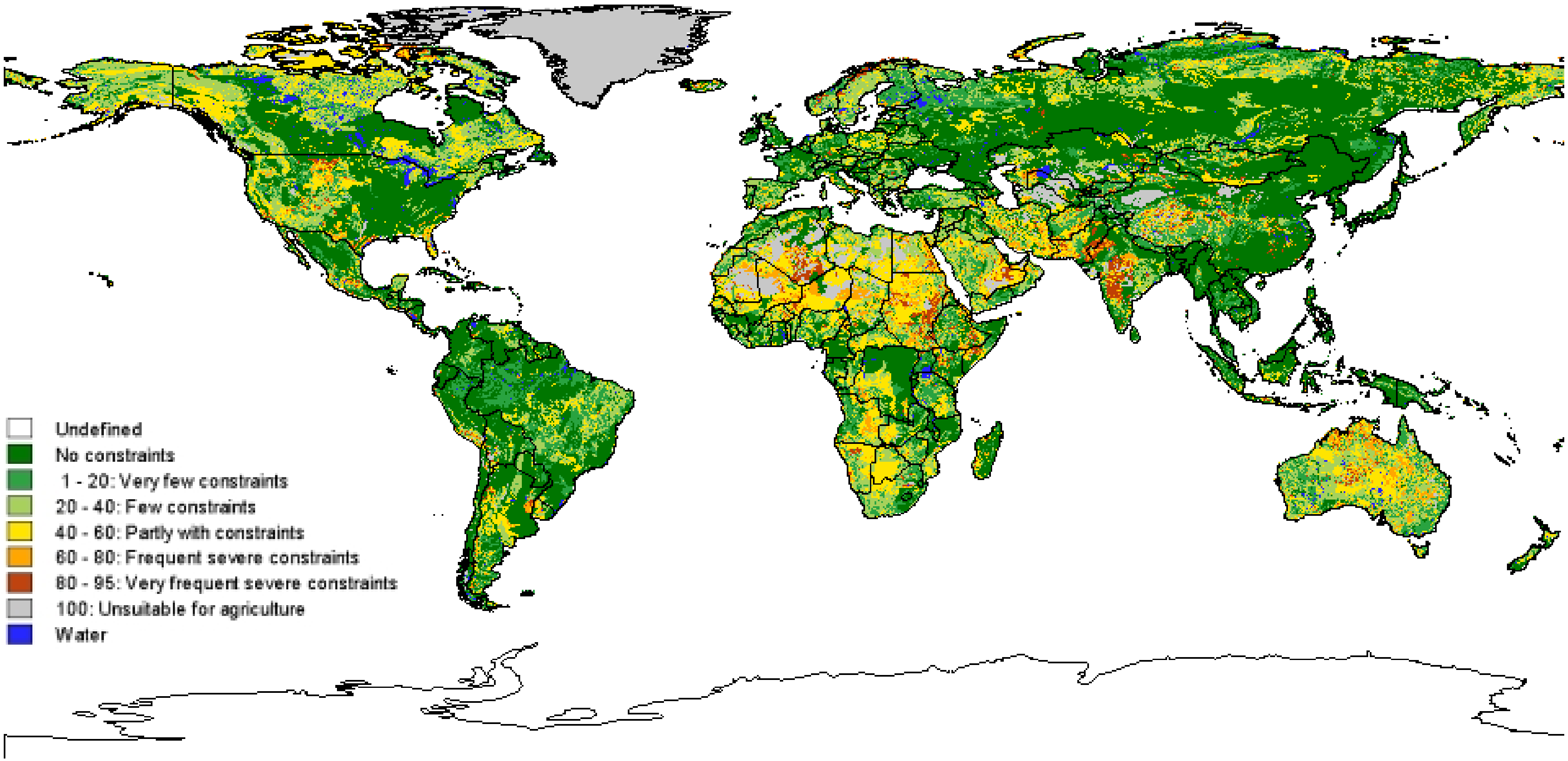


**Plate 25. Soil chemical constraints**

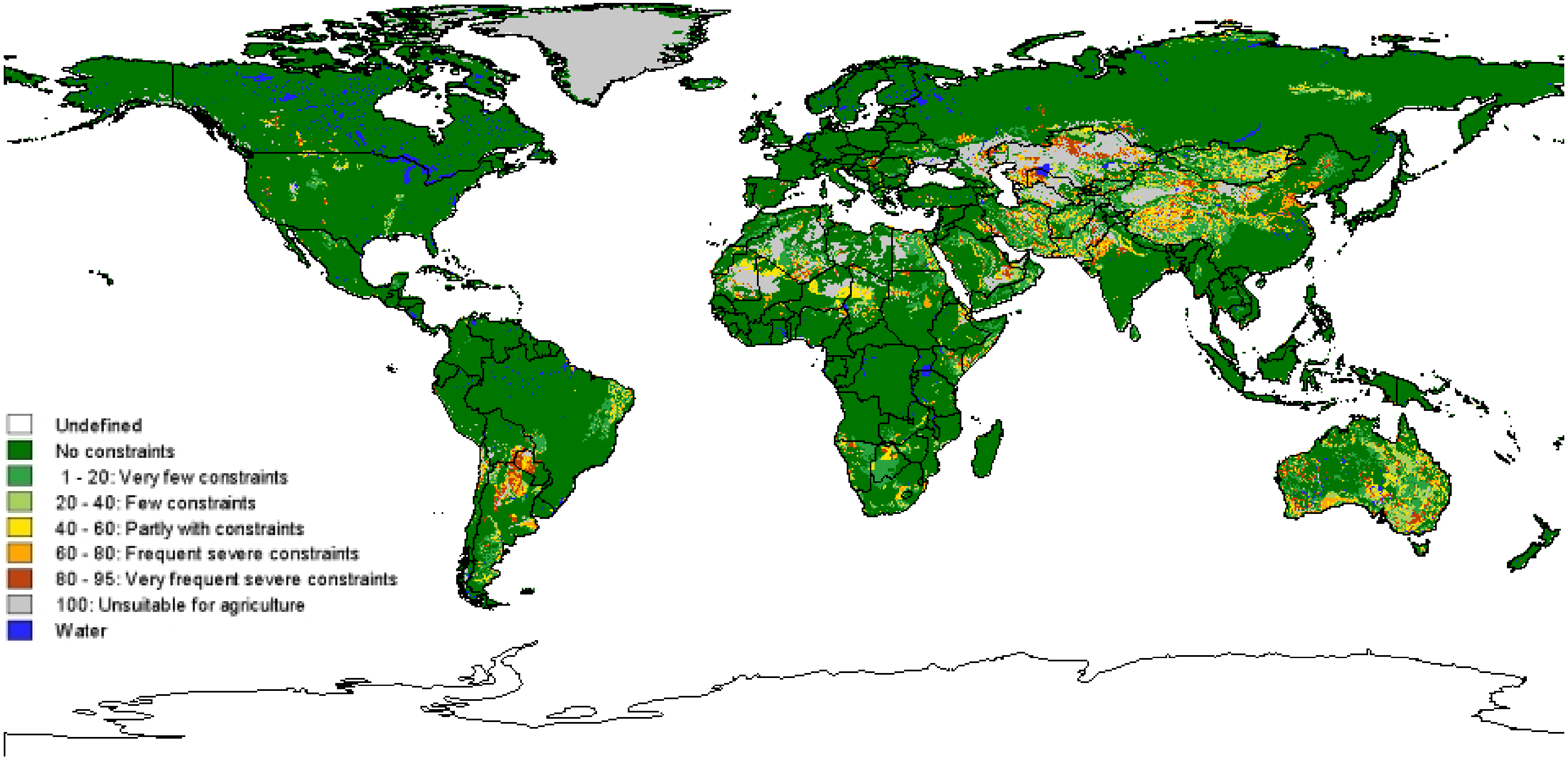


**Plate 26. Terrain slope constraints**

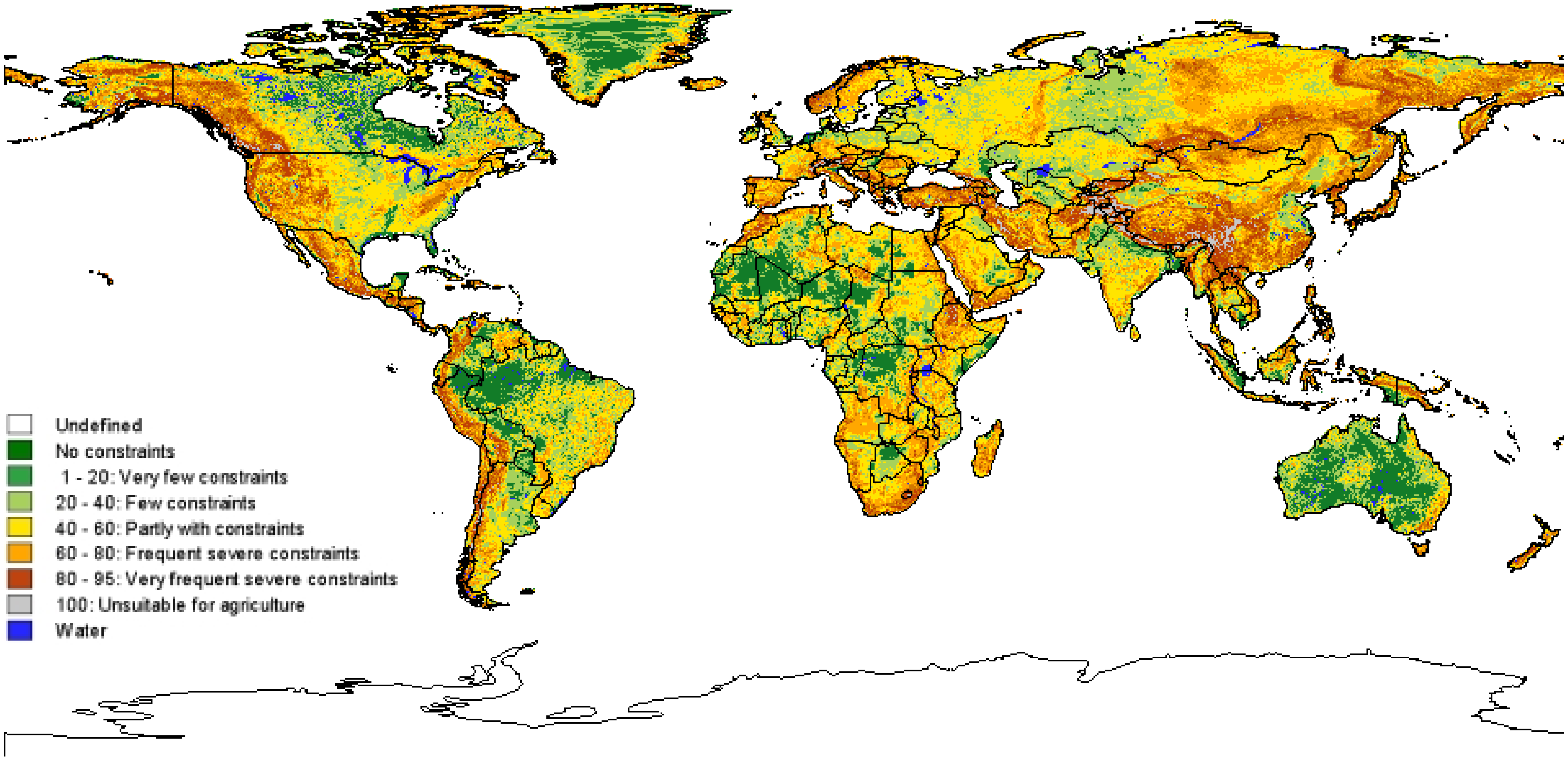


**Plate 27. Soil constraints combined**

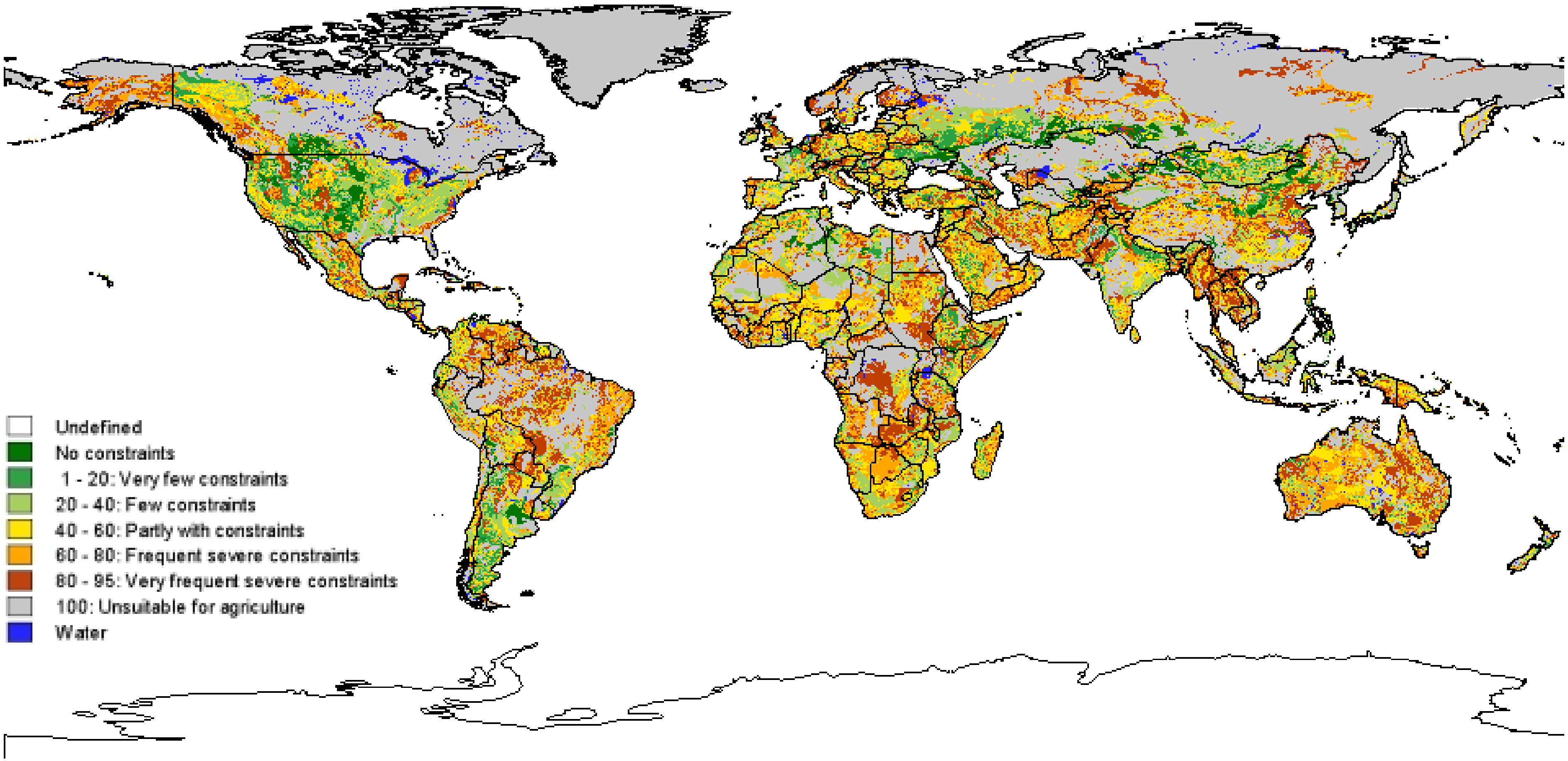


**Plate 28. Climate, soil and terrain slope constraints combined**

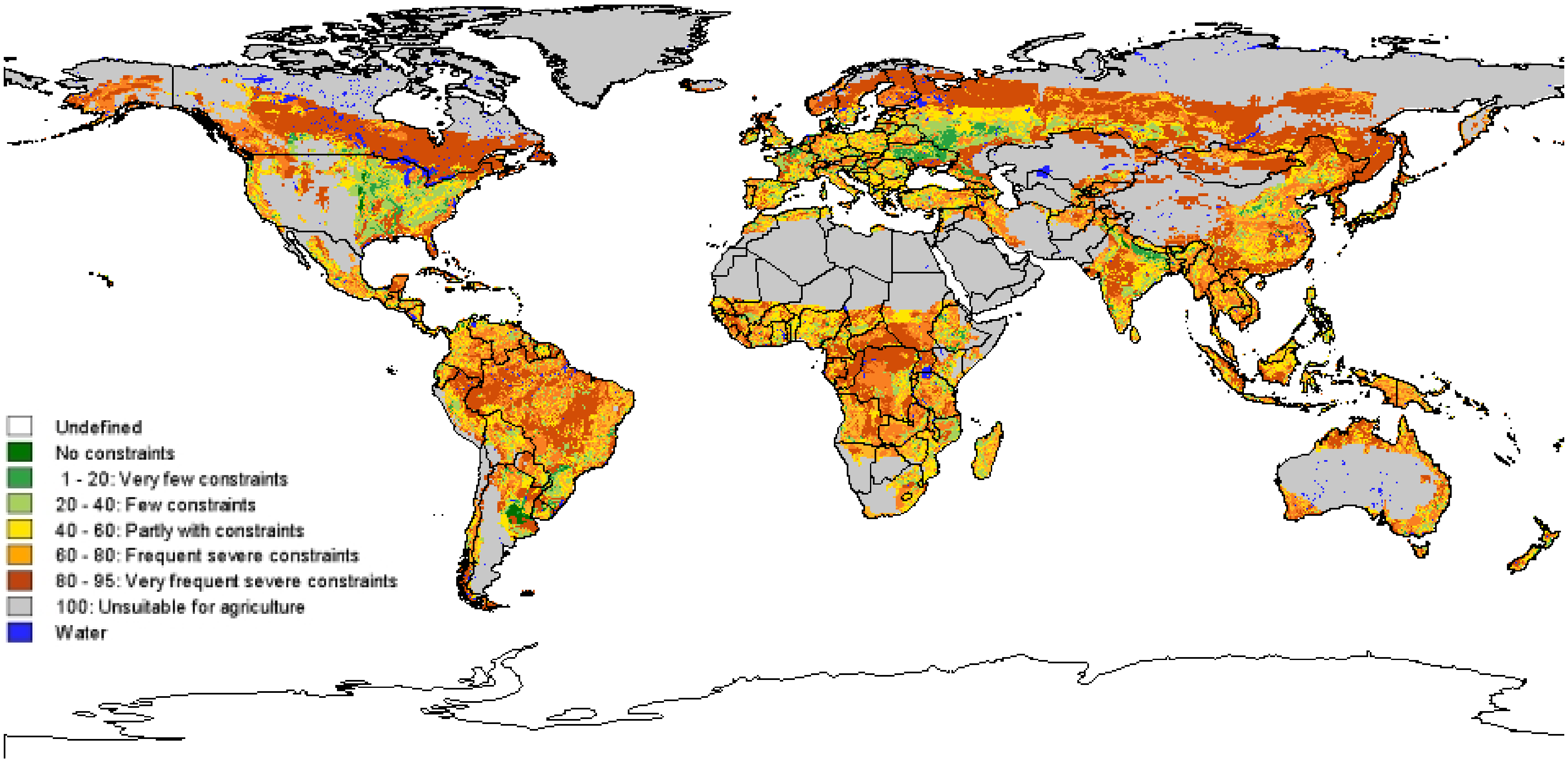


**Plate 29. Suitability for rain-fed wheat (intermediate inputs)**

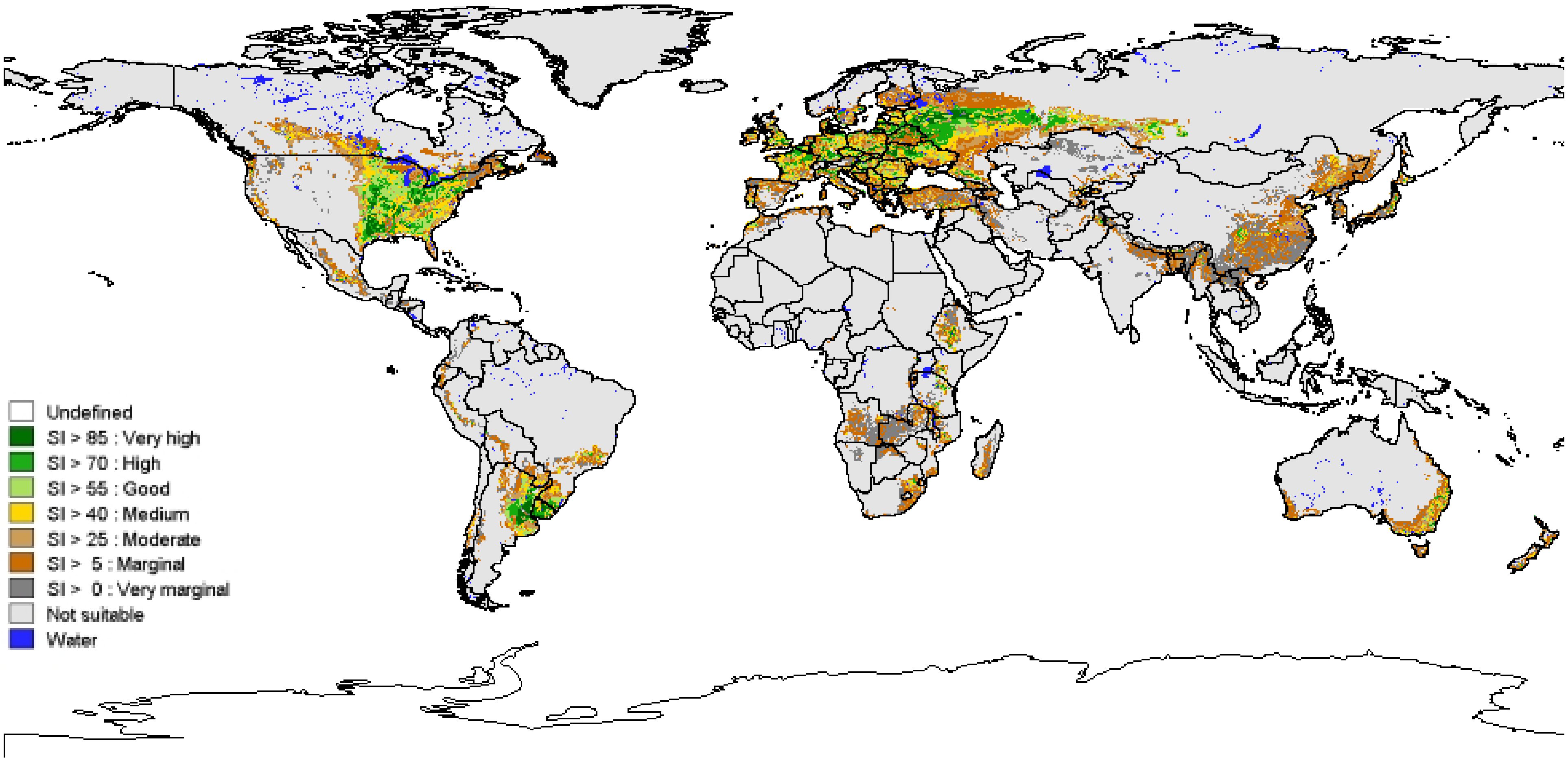


**Plate 30. Suitability for rain-fed grain maize (intermediate inputs)**

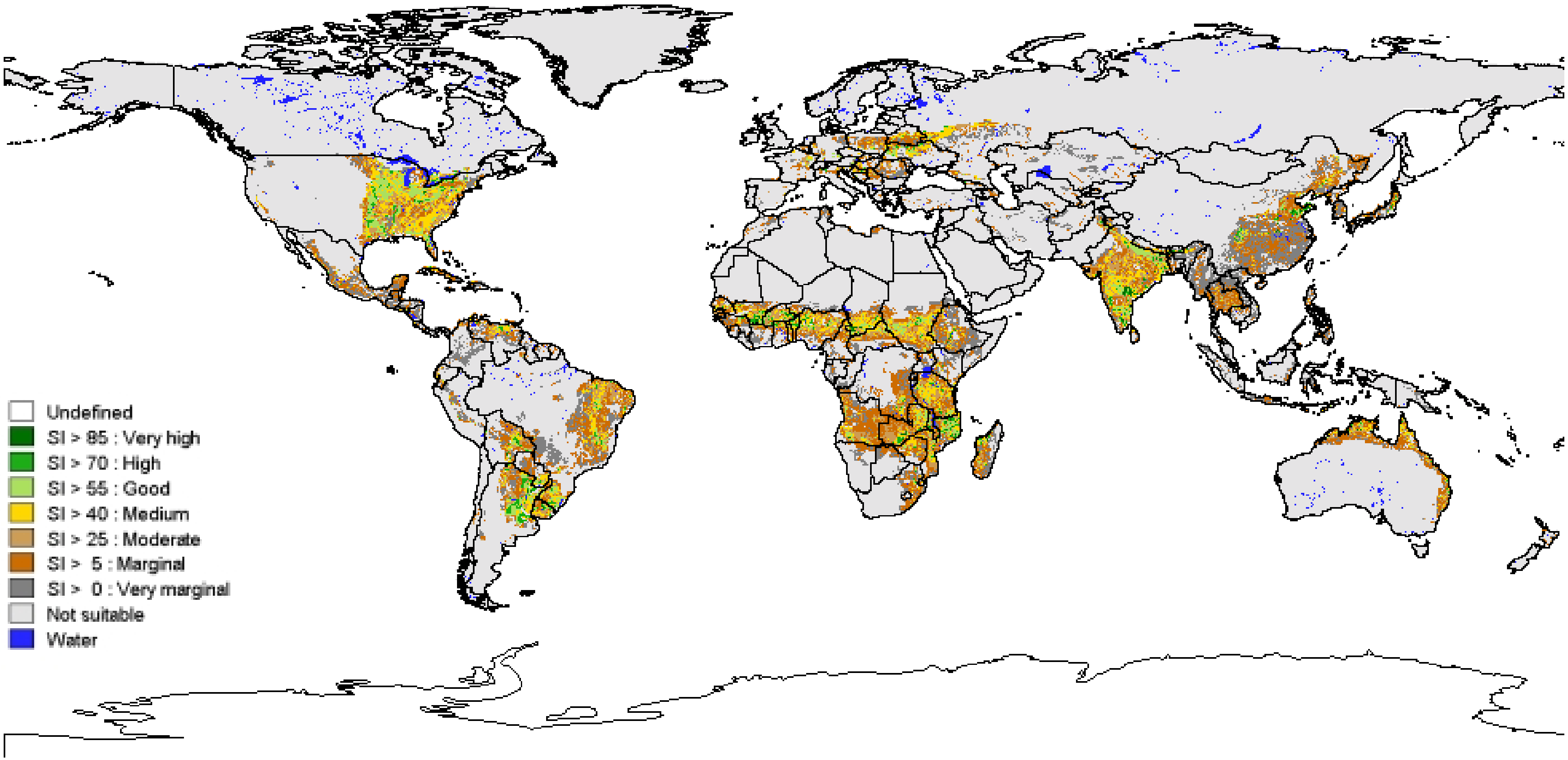


**Plate 31. Suitability for rain-fed cereals (intermediate inputs)**

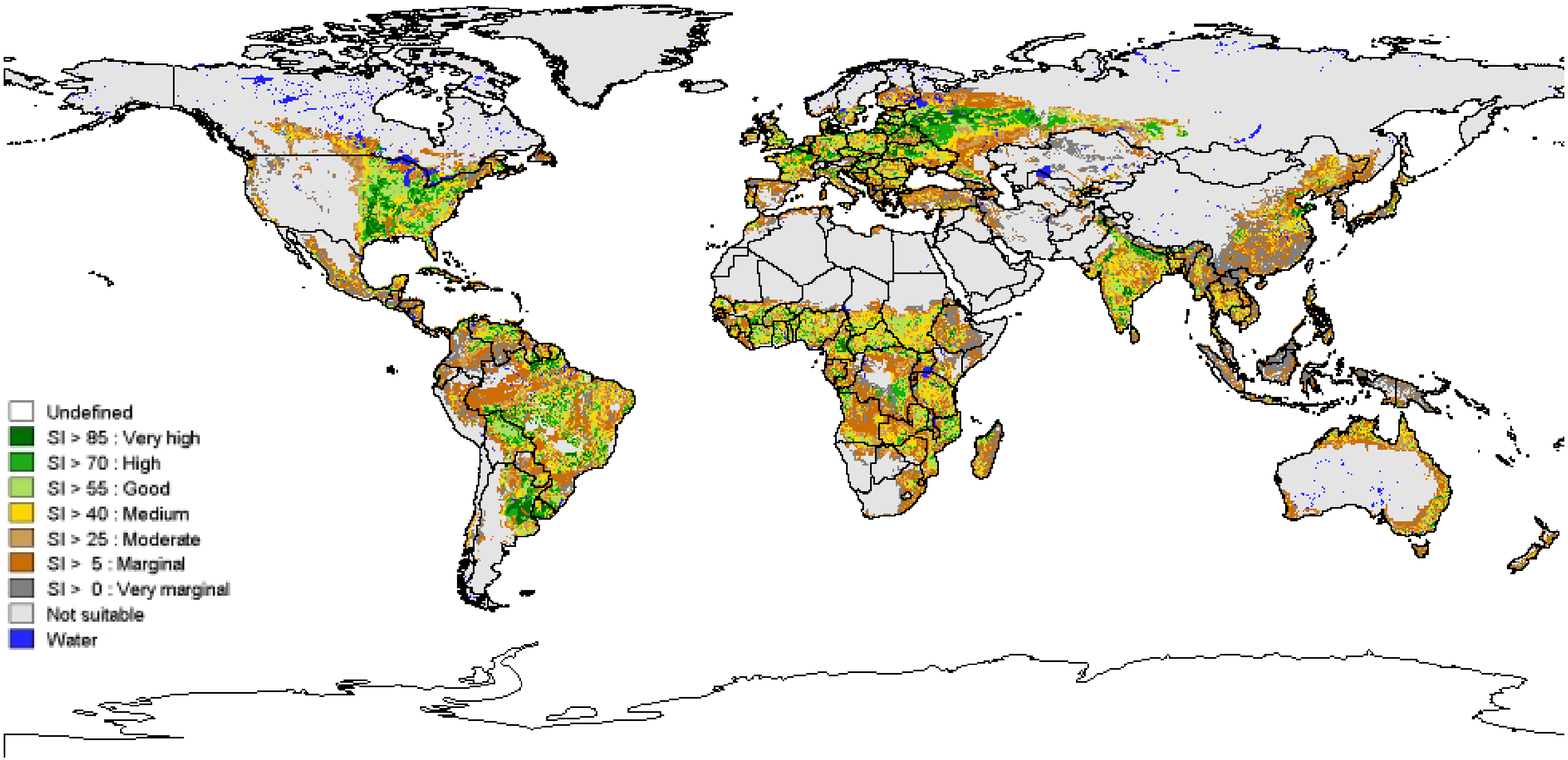


**Plate 32. Suitability for rain-fed roots and tubers (intermediate inputs)**

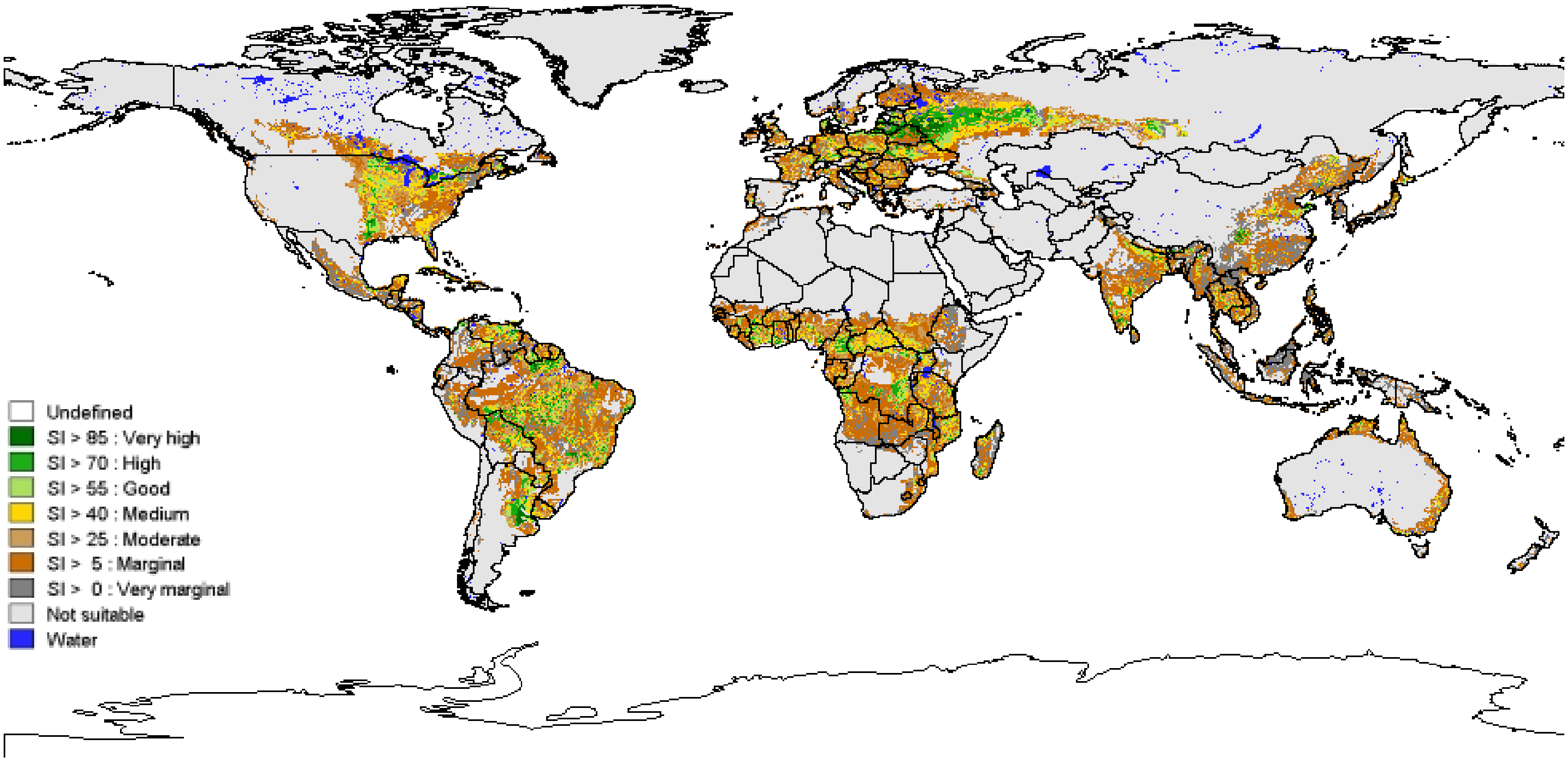


**Plate 33. Suitability for rain-fed pulses (intermediate inputs)**

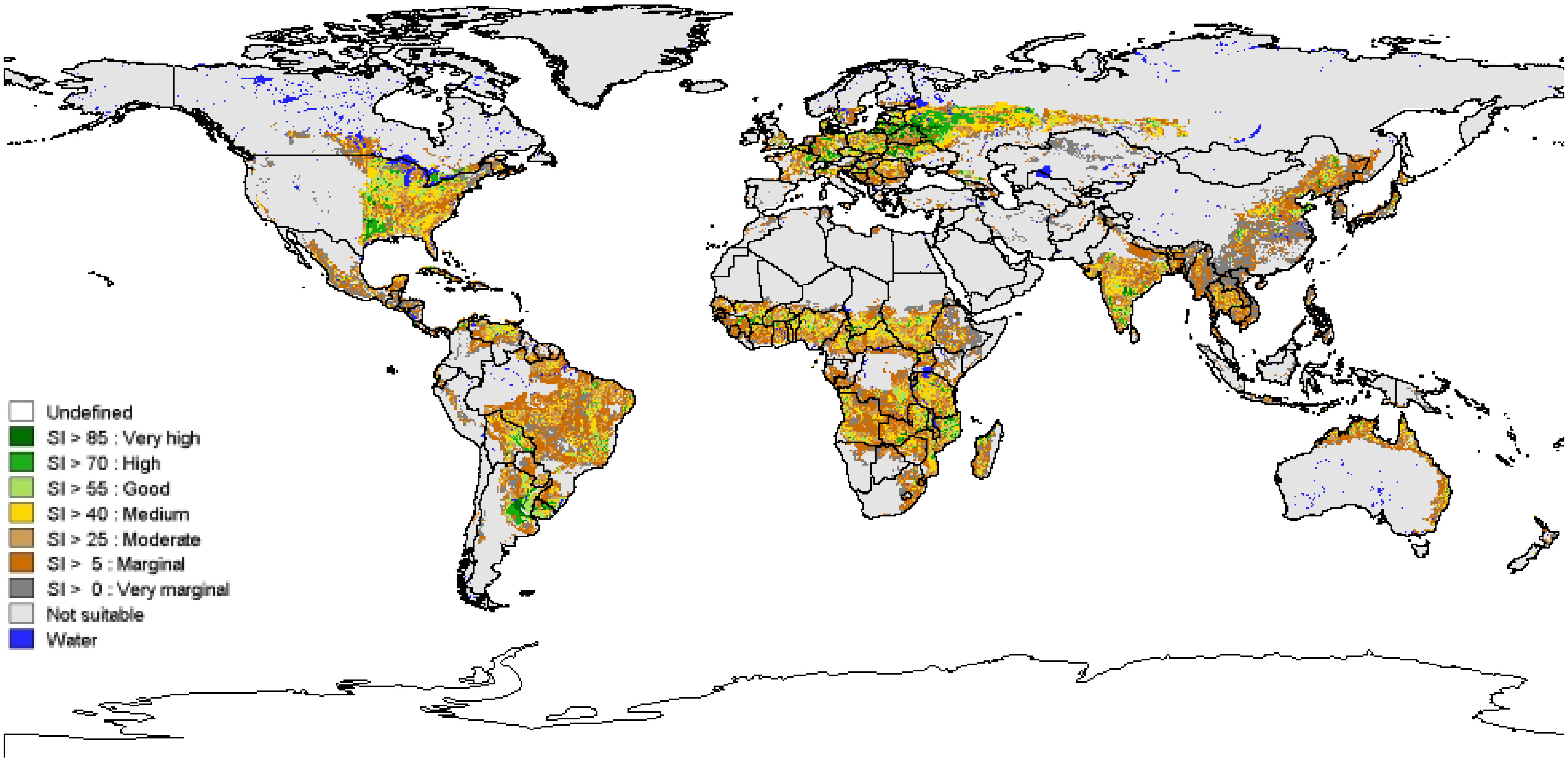


**Plate 34. Suitability for rain-fed oil crops (intermediate inputs)**

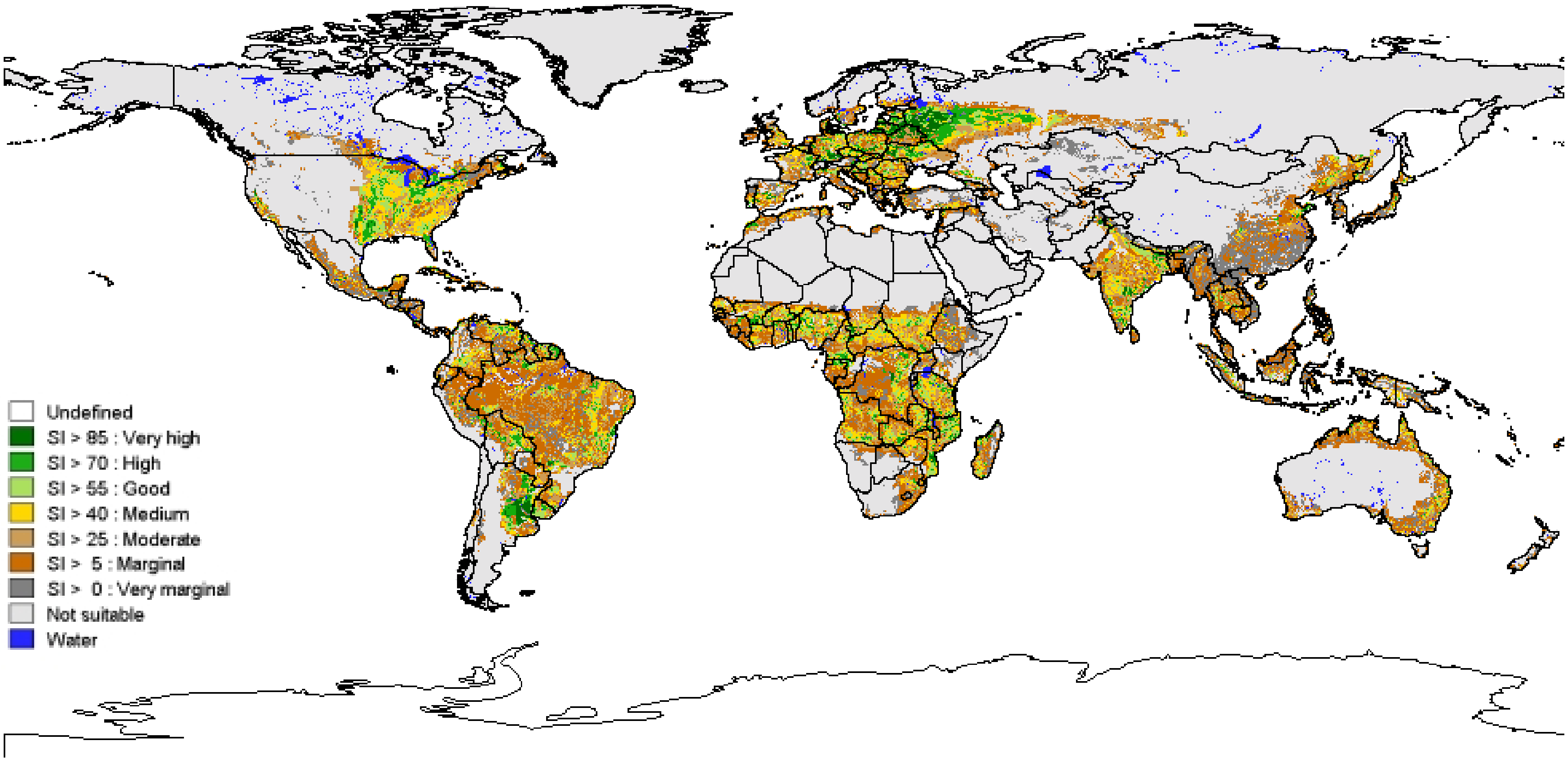


**Plate 35. Suitability for rain-fed sugar crops (intermediate inputs)**

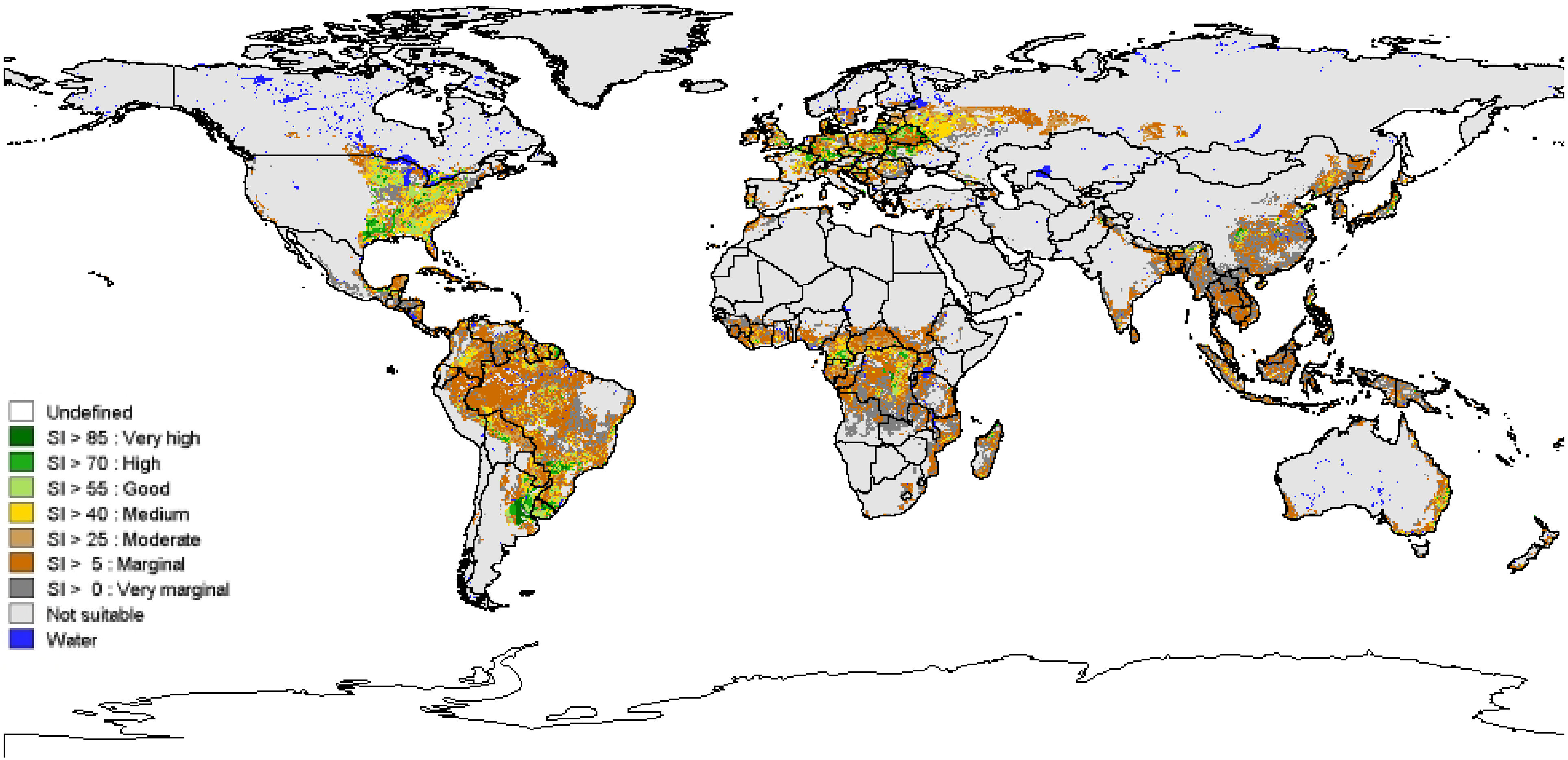


**Plate 36. Suitability for rain-fed cotton (intermediate inputs)**

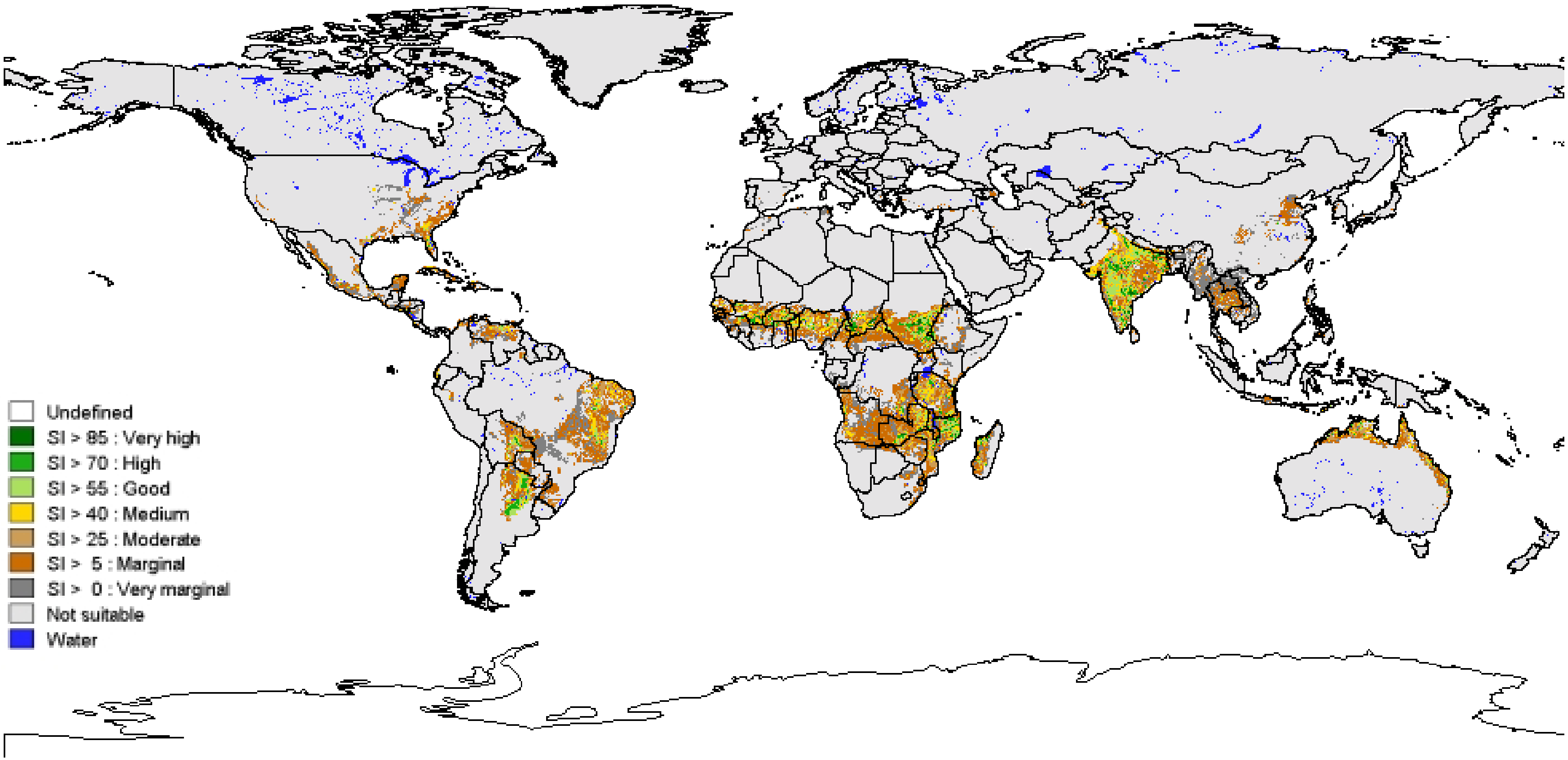


**Plate 37. Suitability for rain-fed and irrigated wheat (high inputs)**

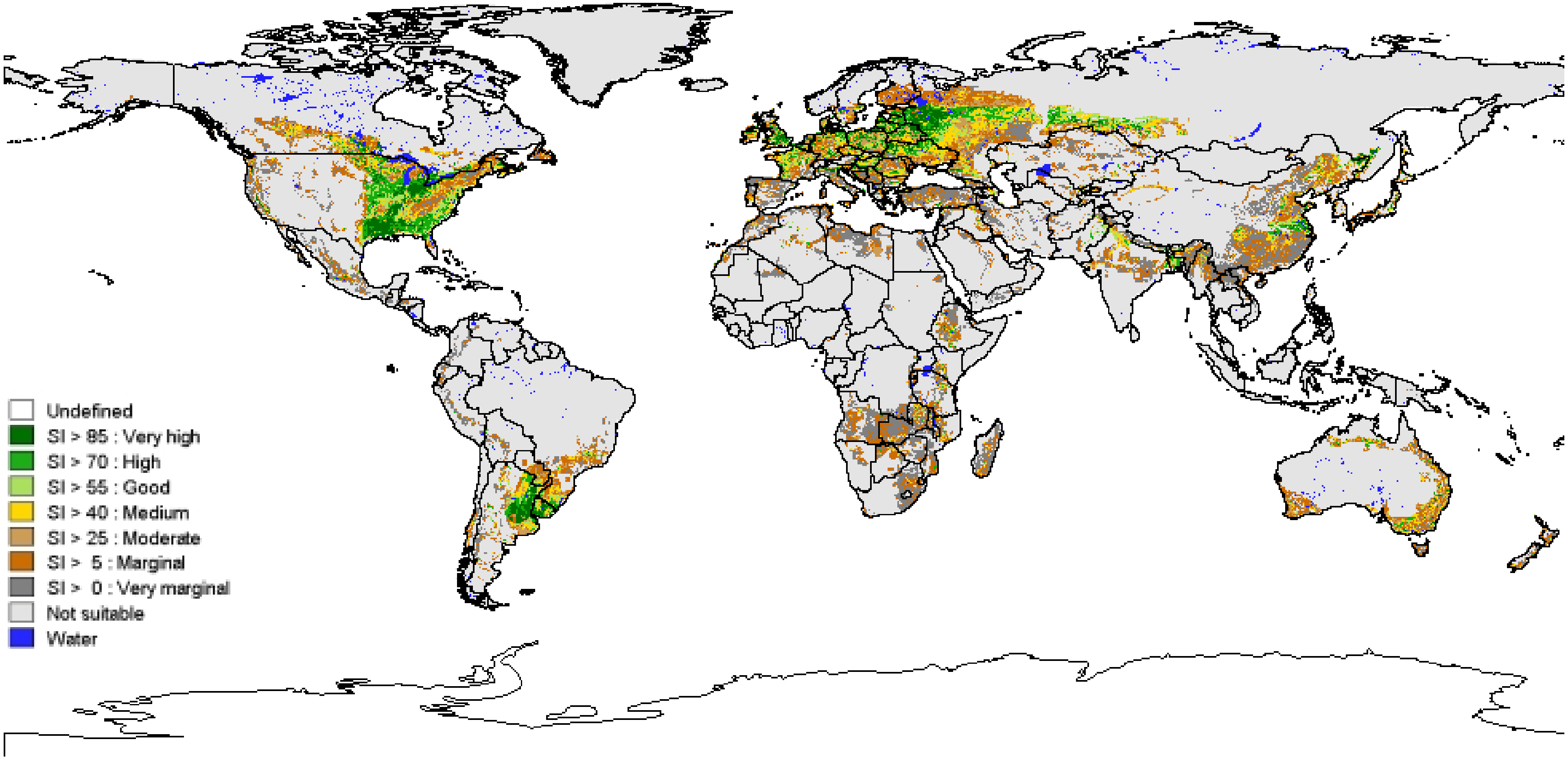


**Plate 38. Suitability for rain-fed and irrigated rice (high inputs)**

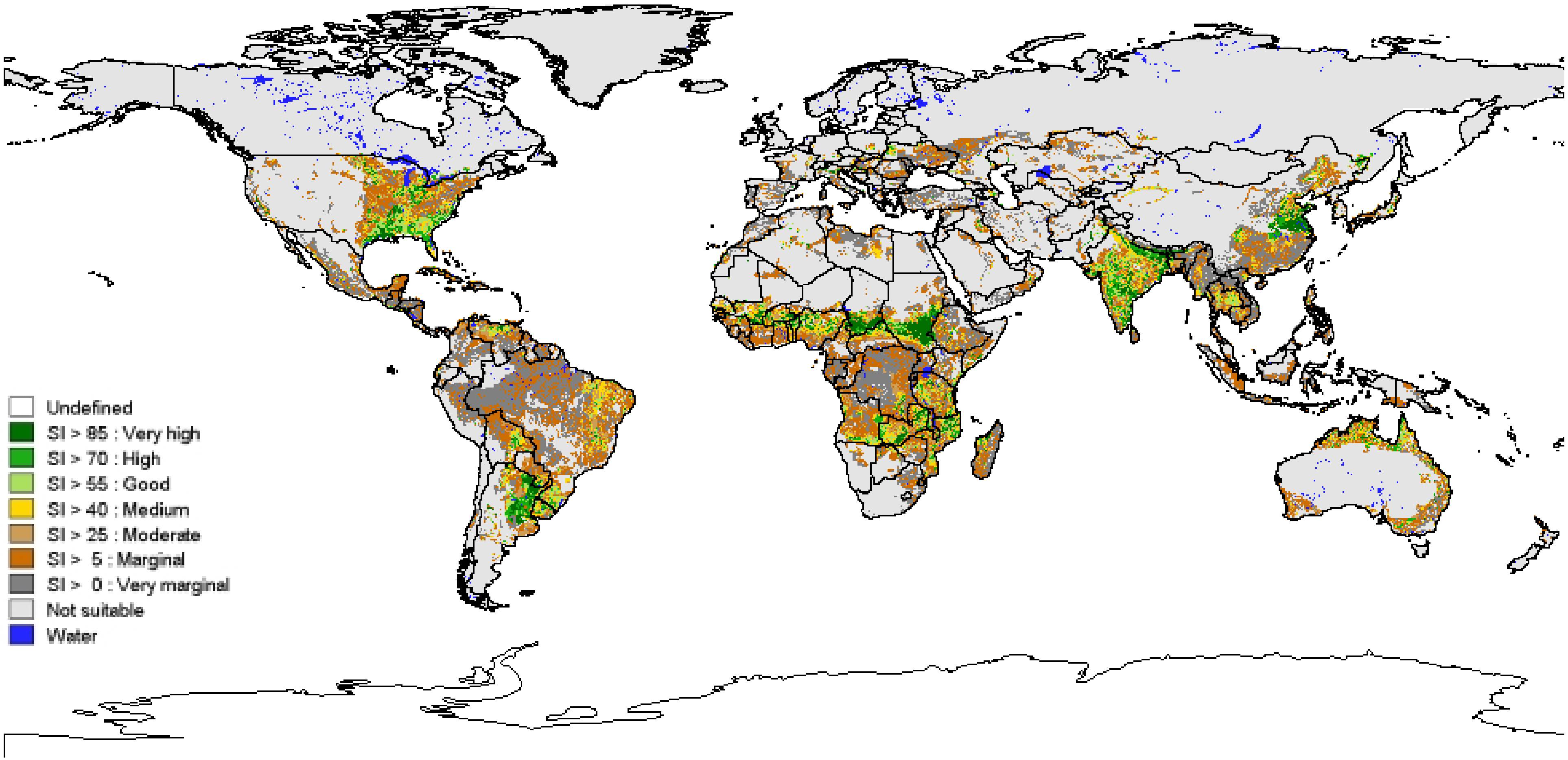


**Plate 39. Suitability for rain-fed and irrigated grain maize (high inputs)**

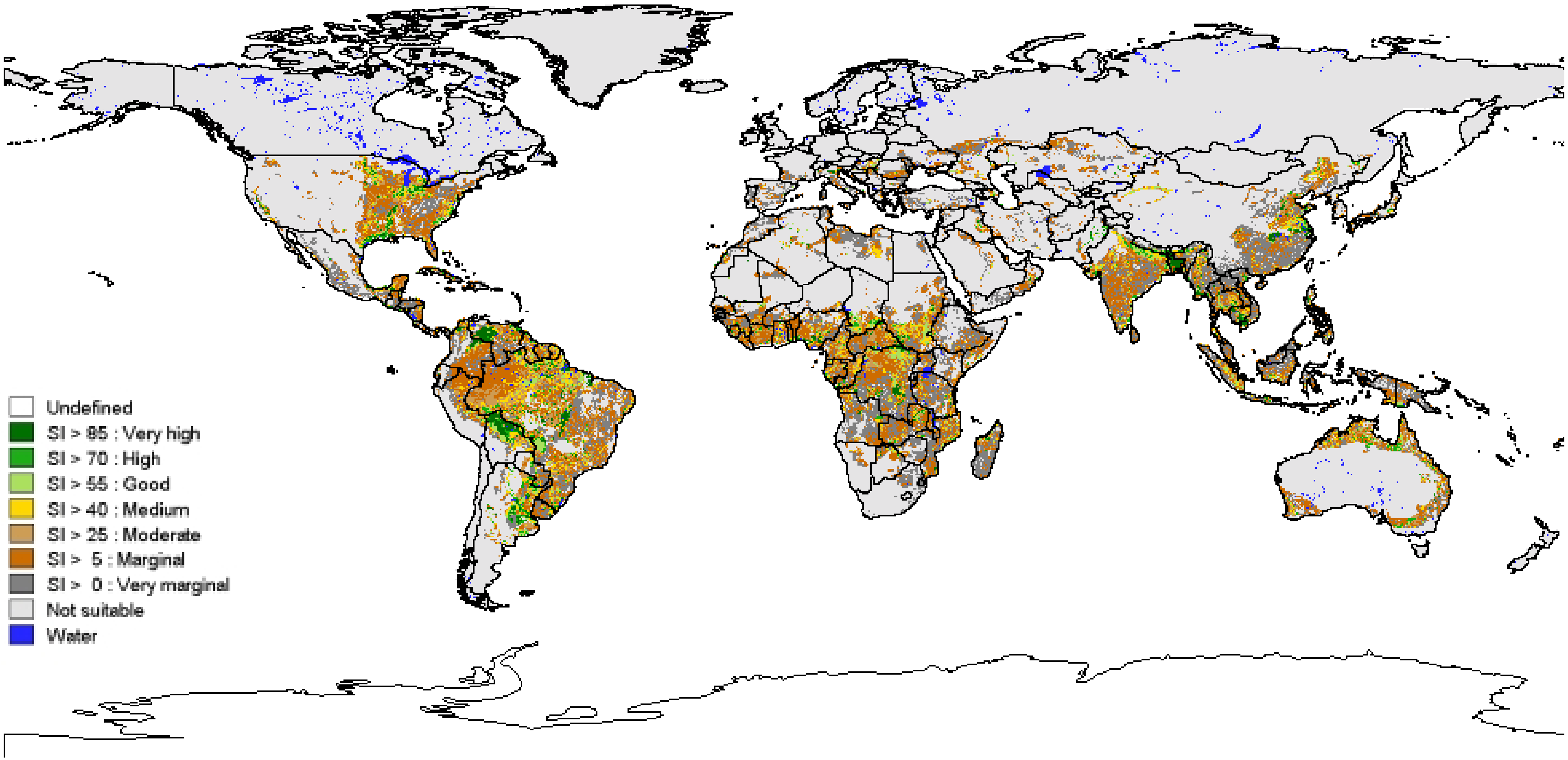


**Plate 40. Suitability for rain-fed and irrigated cereals (high inputs)**

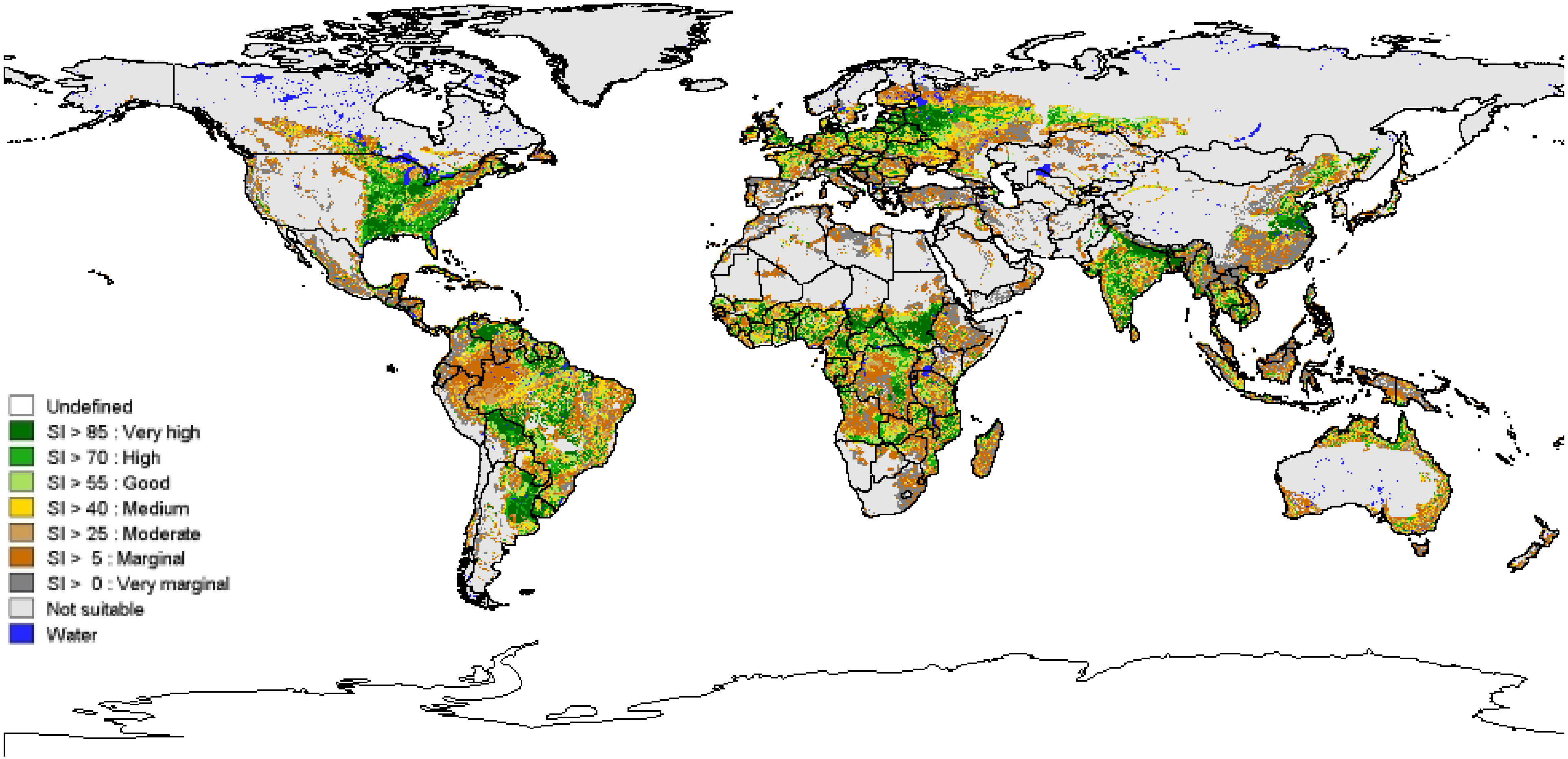


**Plate 41. Suitability for rain-fed and irrigated roots and tubers (high inputs)**

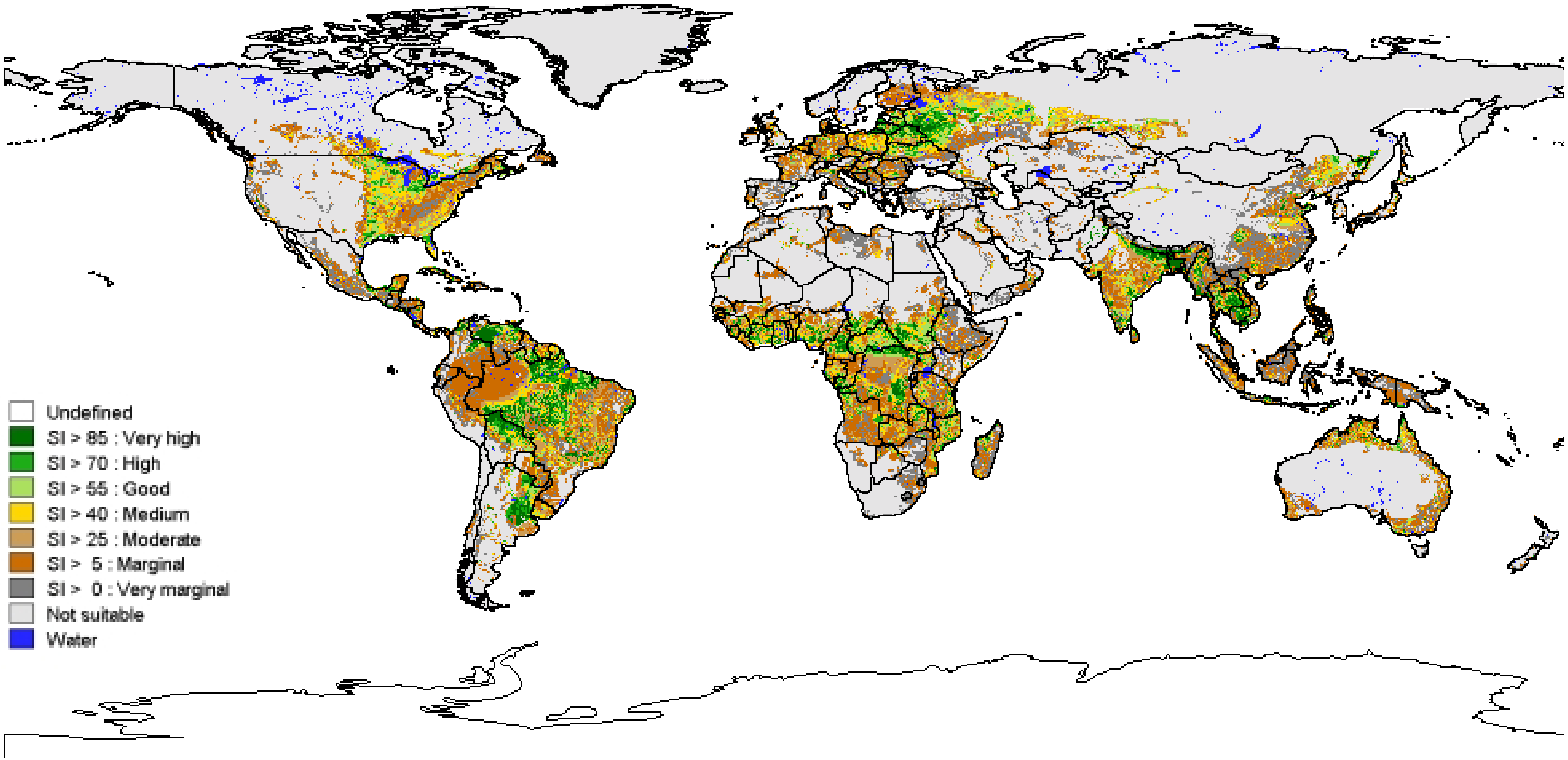


**Plate 42. Suitability for rain-fed and irrigated pulses (high inputs)**

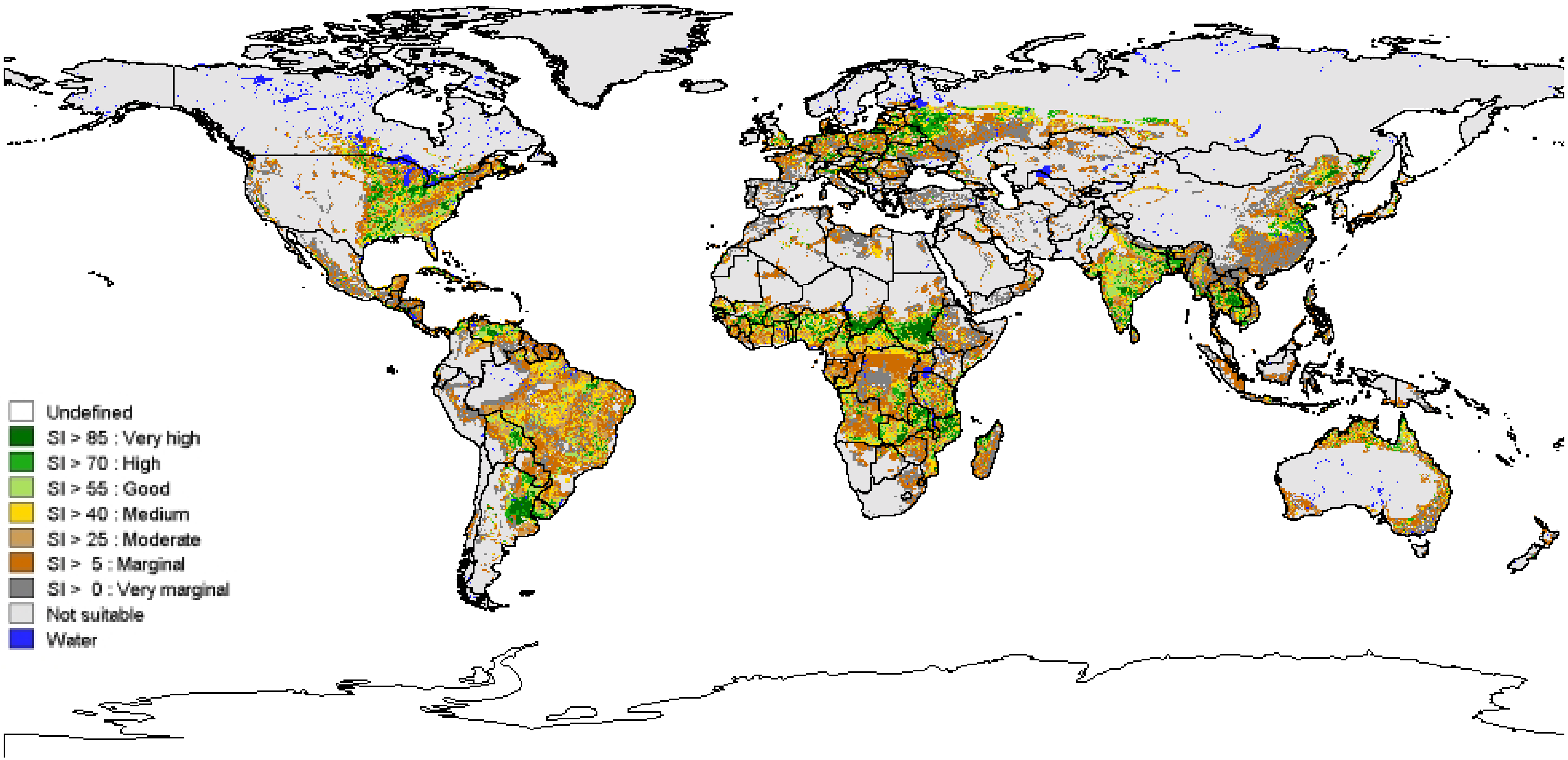


**Plate 43. Suitability for rain-fed and irrigated oil crops (high inputs)**

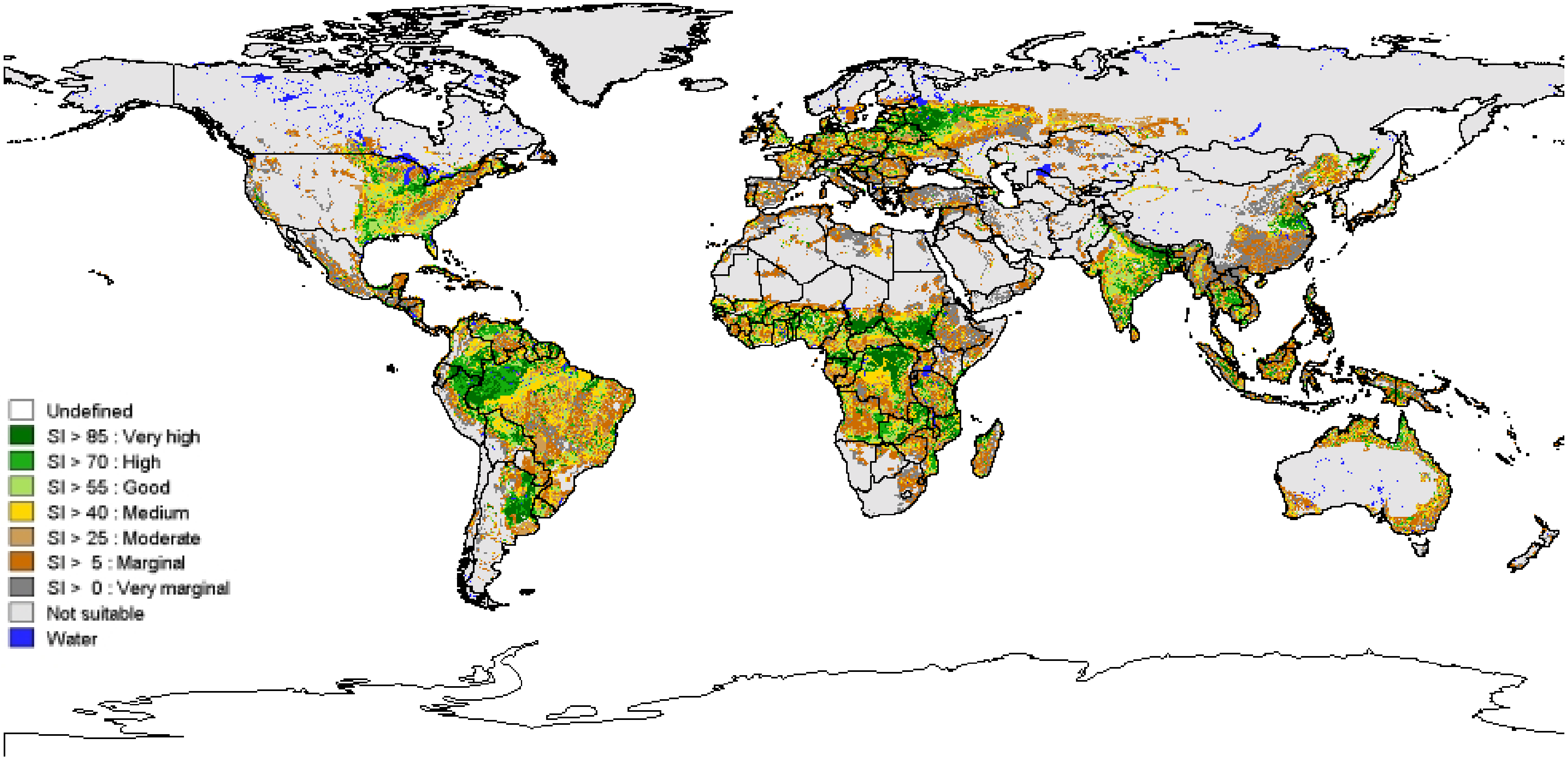


**Plate 44. Suitability for rain-fed and irrigated sugar crops (high inputs)**

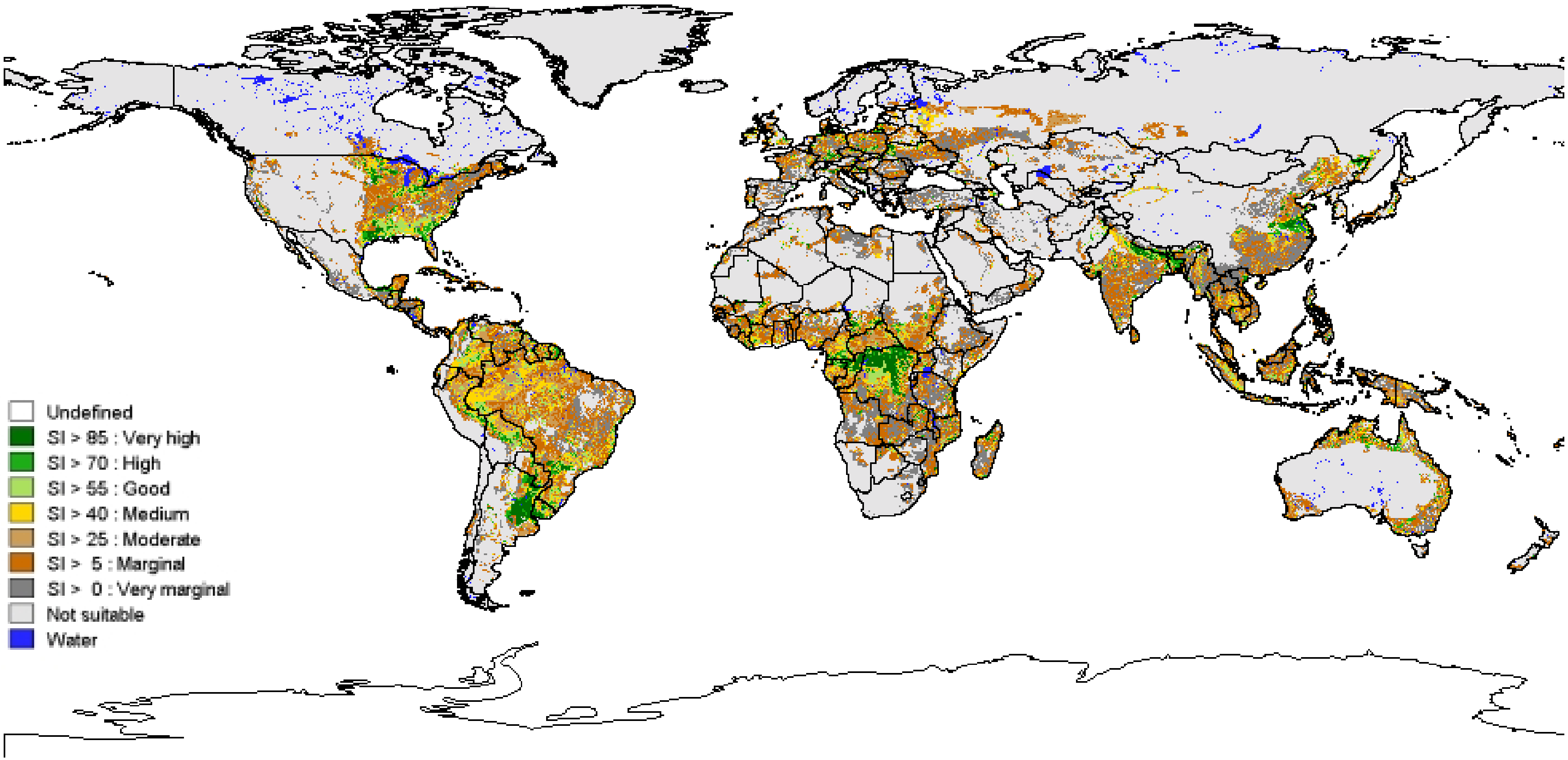


**Plate 45. Suitability for rain-fed and irrigated cotton (high inputs)**

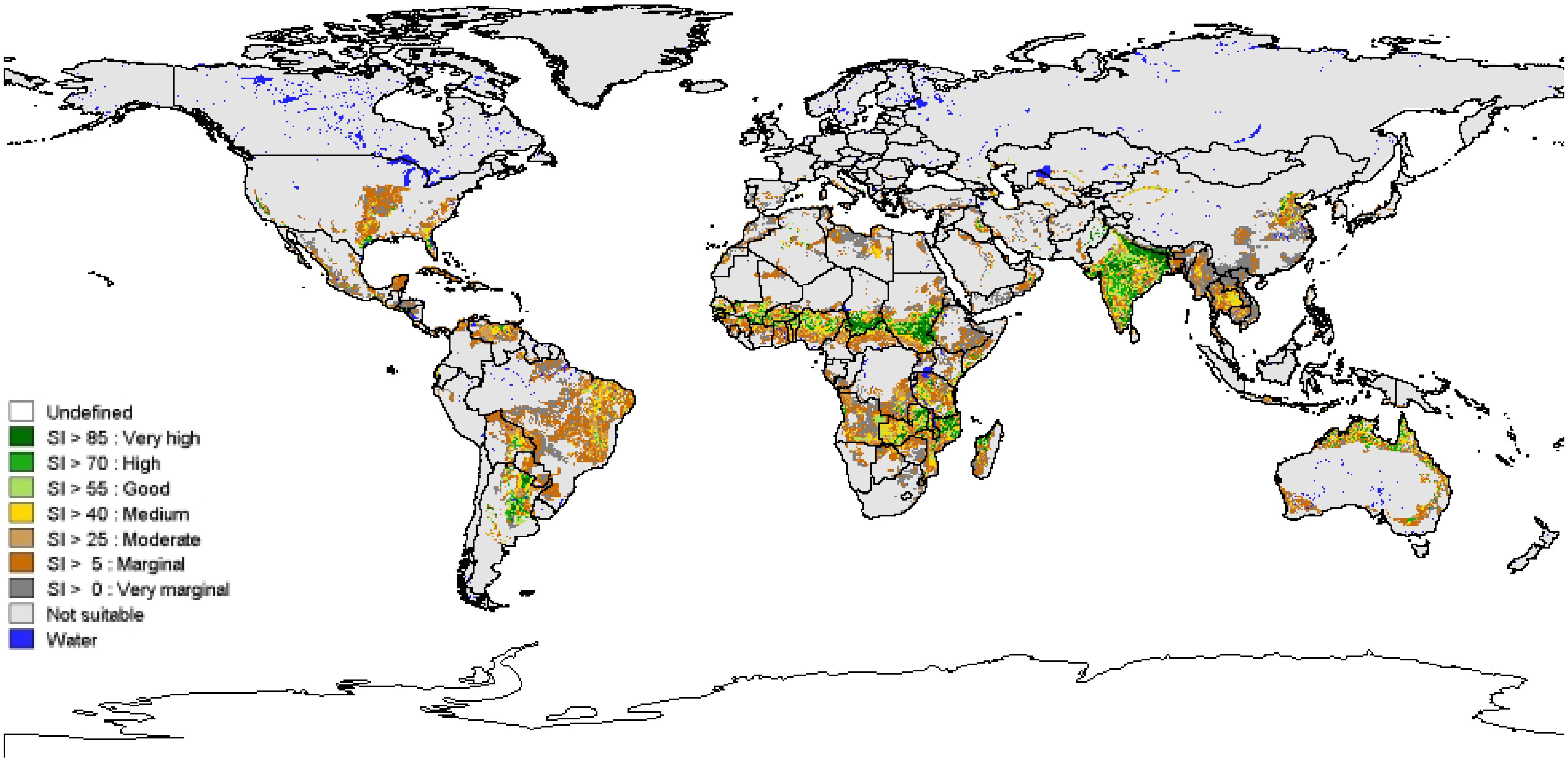
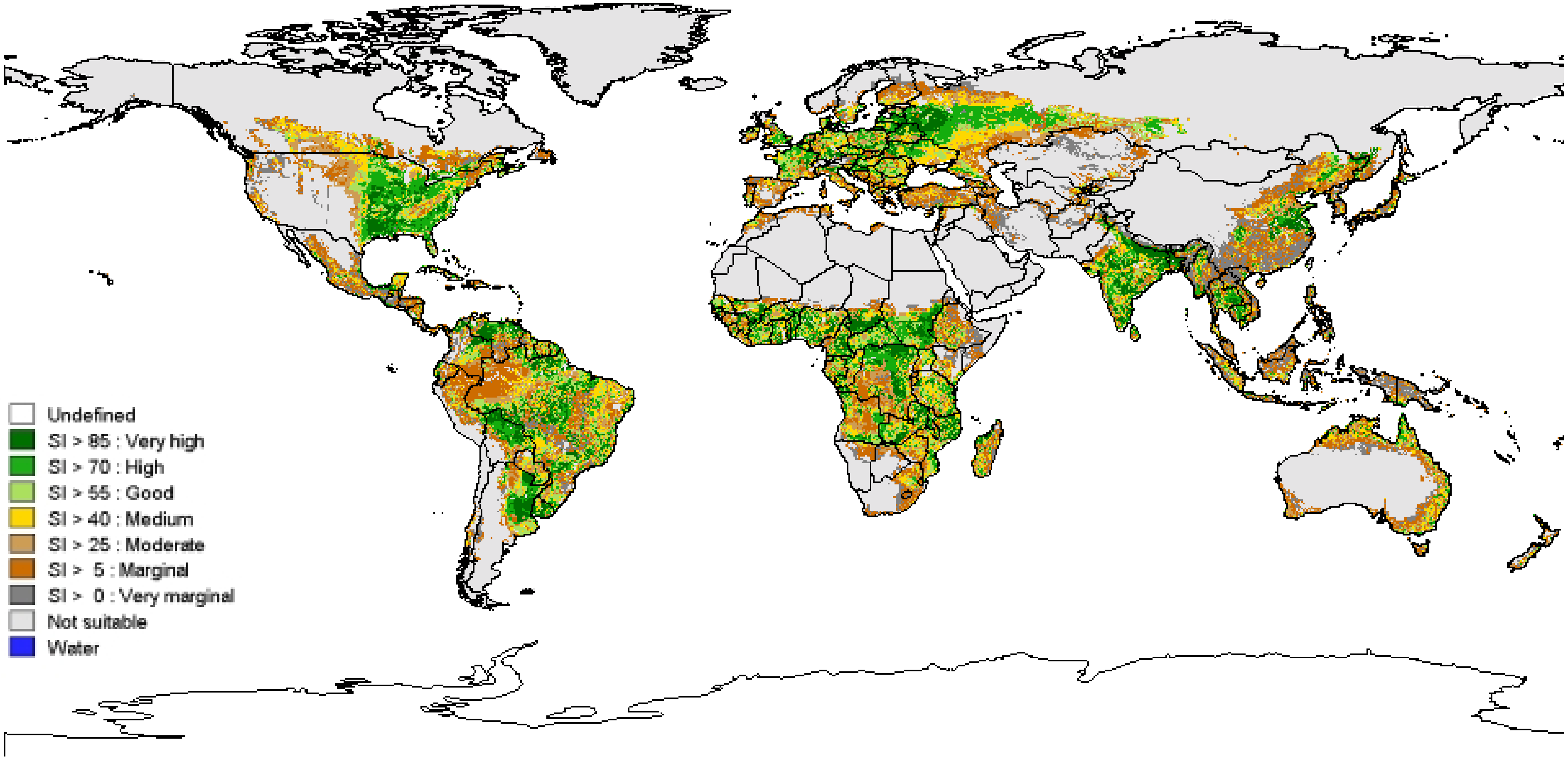


**Plate 46. Suitability for rain-fed crops - maximizing technology mix**



## Plate 47. Irrigation impact classes

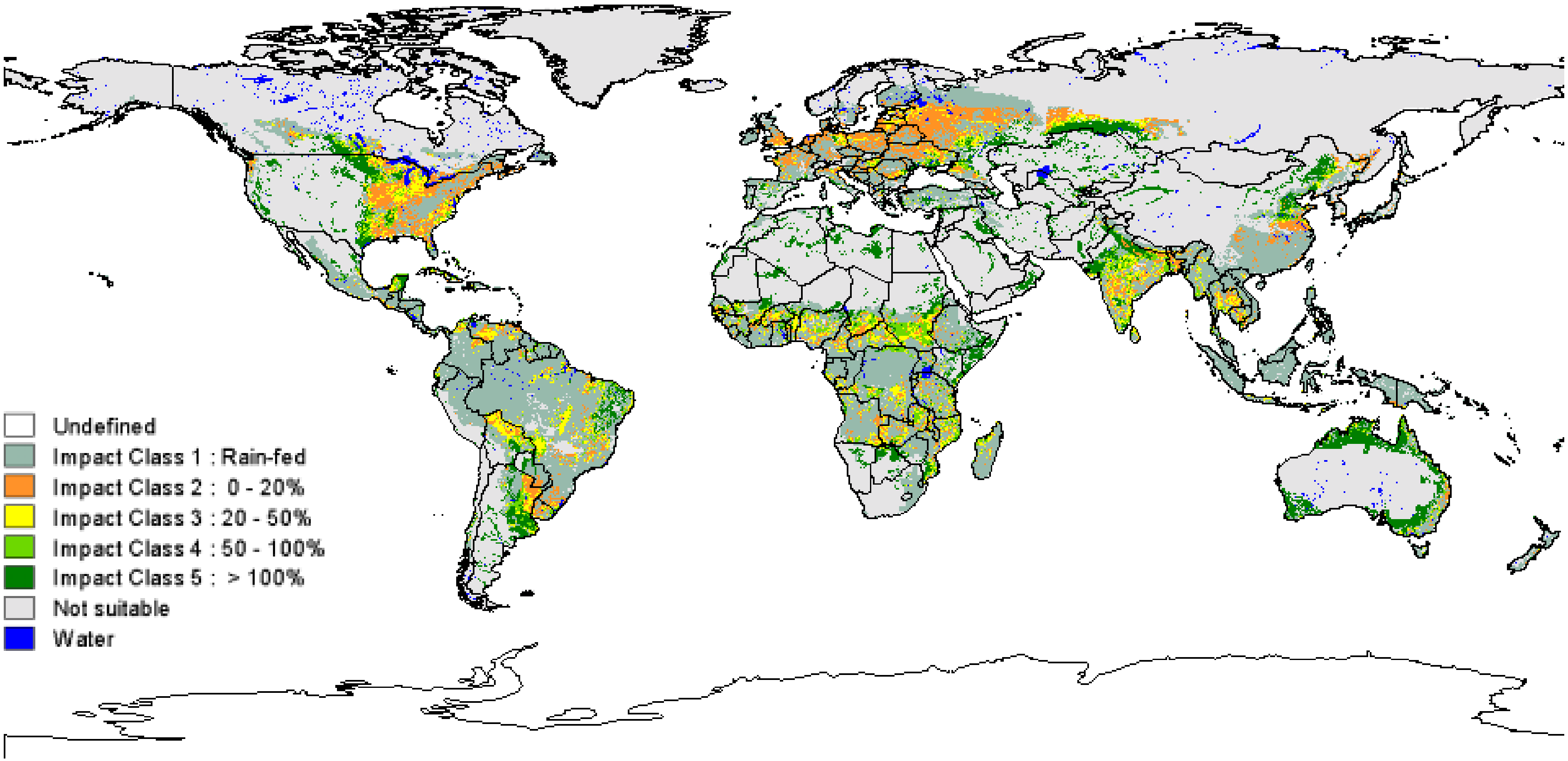


**Plate 48. Most suitable cereal (agronomic suitability)**

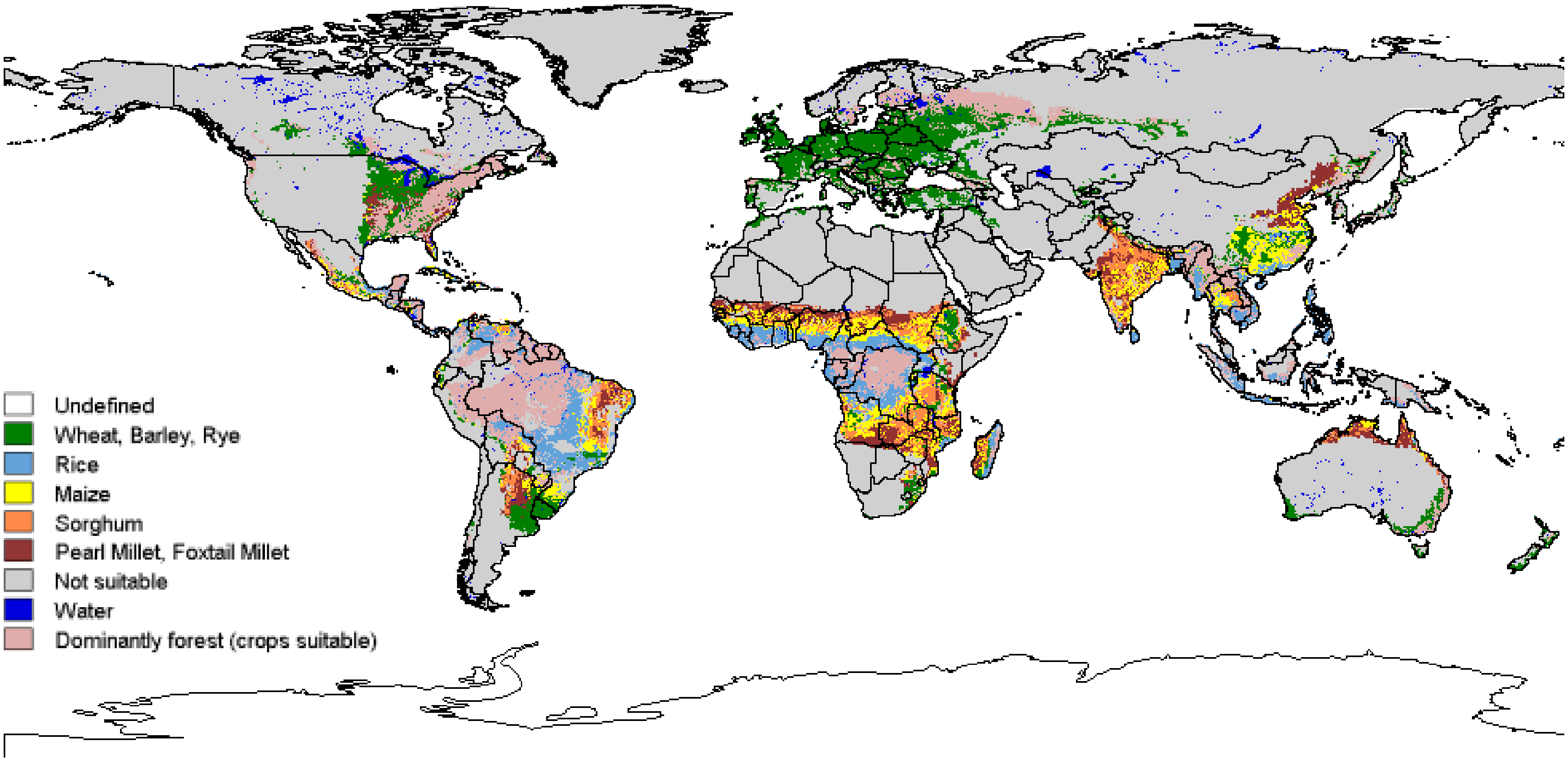


**Plate 49. Most suitable cereal (food energy)**

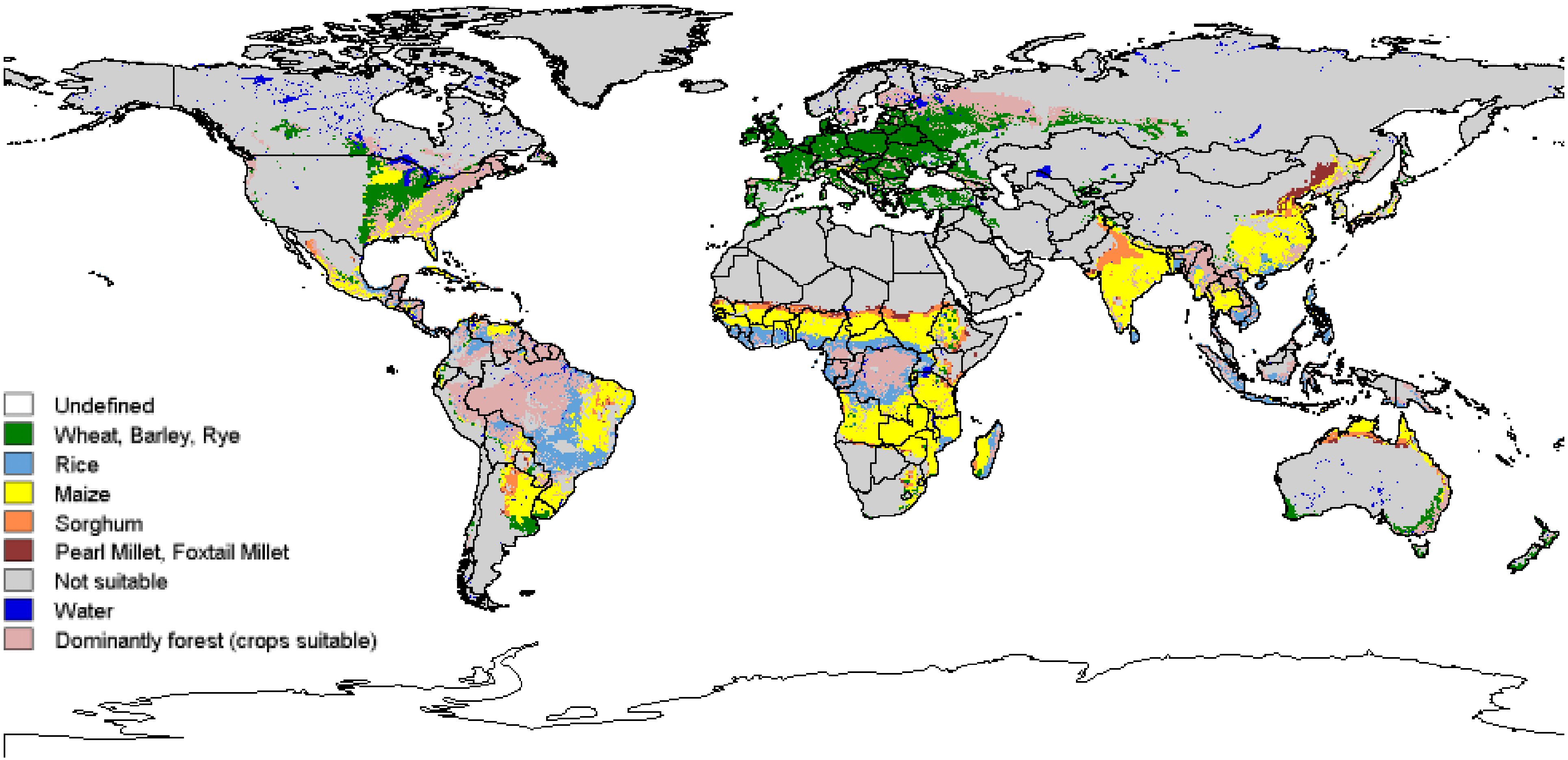


**Plate 50. Most suitable cereal (output value)**

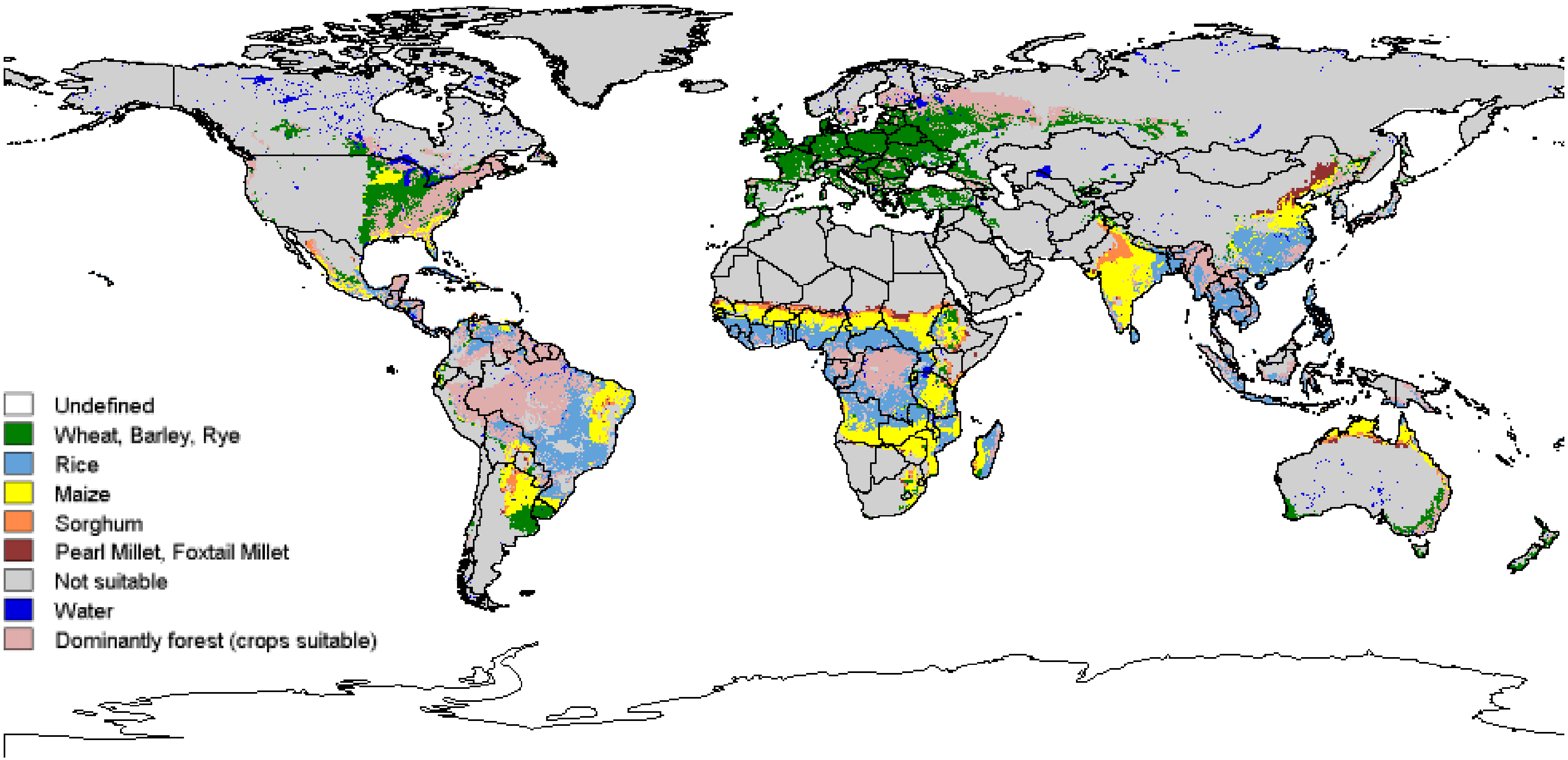


**Plate 51. Expected grid-cell output per hectare for single cropping of rain-fed cereals (high inputs)**

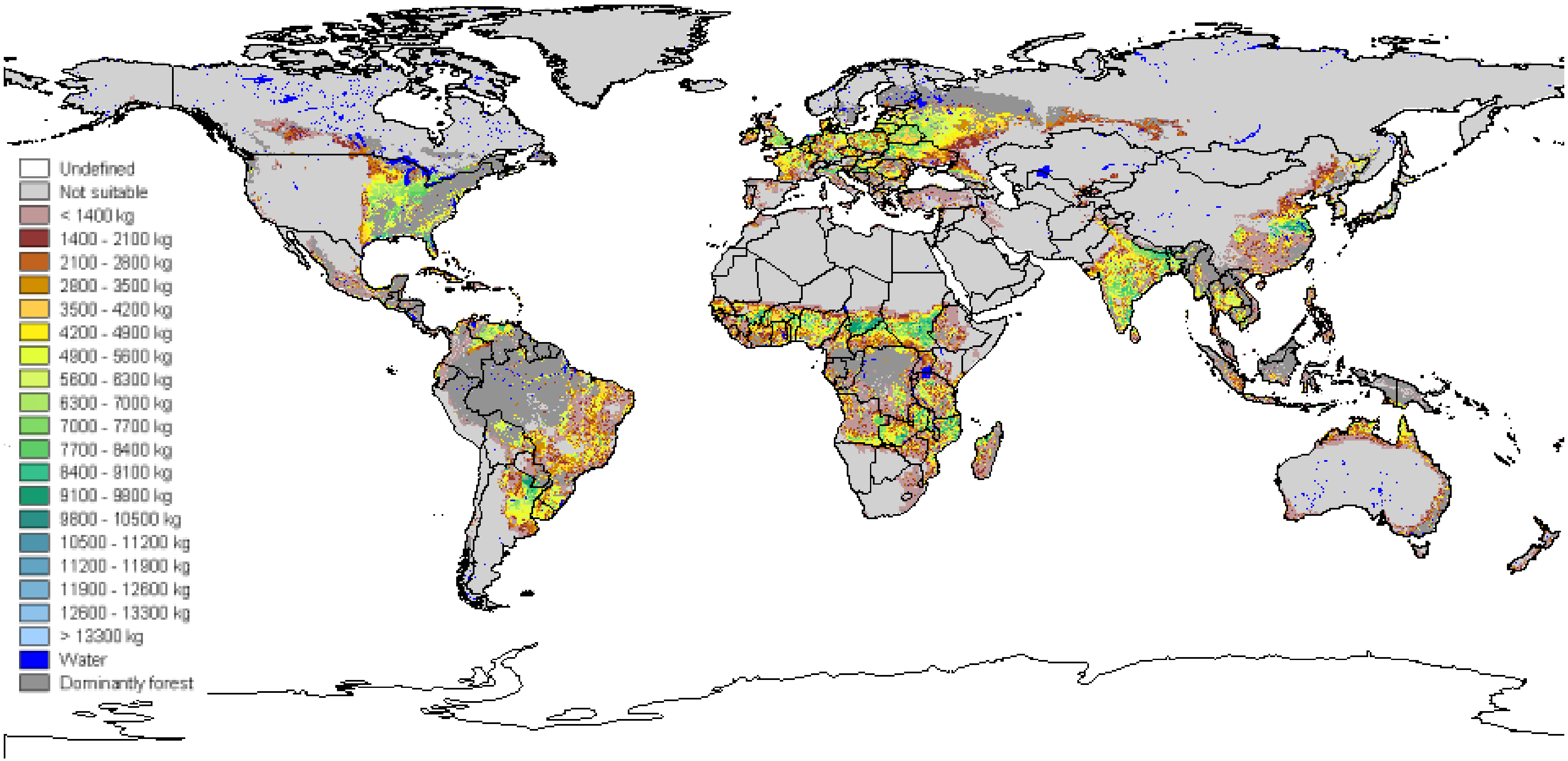


**Plate 52. Expected grid-cell output per hectare for single cropping of rain-fed and irrigated cereals (high inputs)**

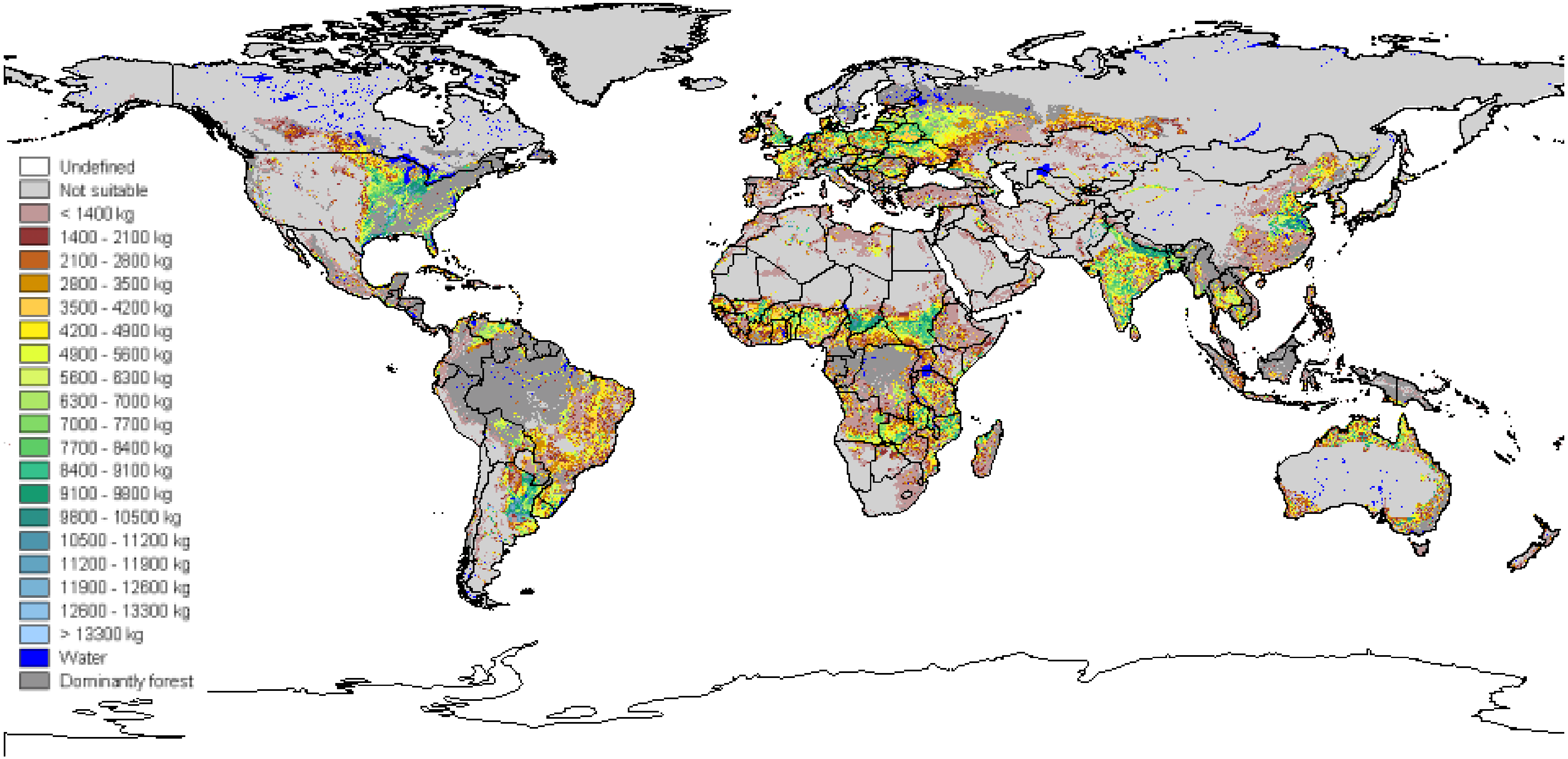


**Plate 53. Expected grid-cell output per hectare for multiple cropping of rain-fed cereals (high inputs)**

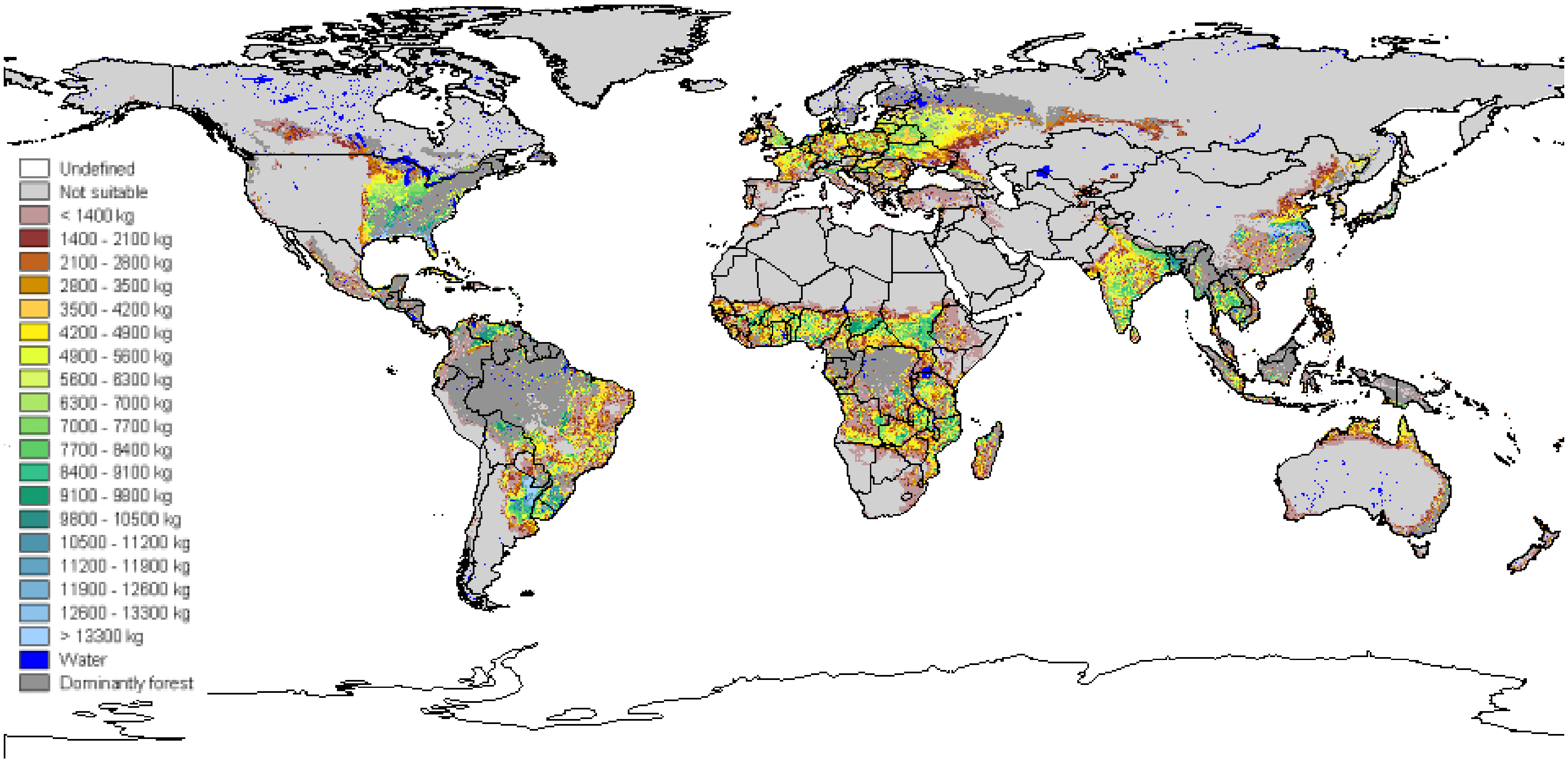


**Plate 54. Expected grid-cell output per hectare for multiple cropping of rain-fed and irrigated cereals (high inputs)**

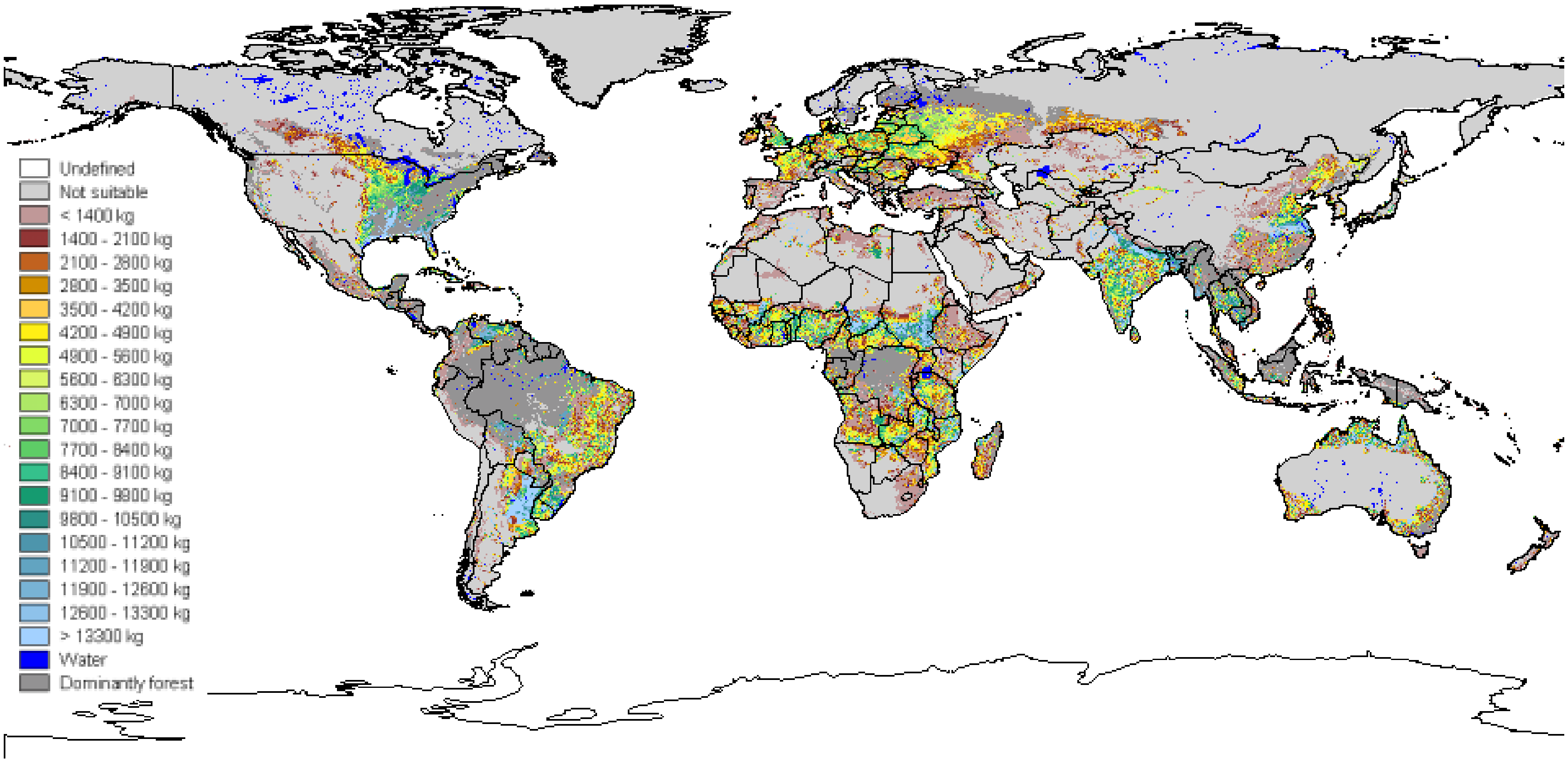


**Plate 55. Dominant ecosystem classes**

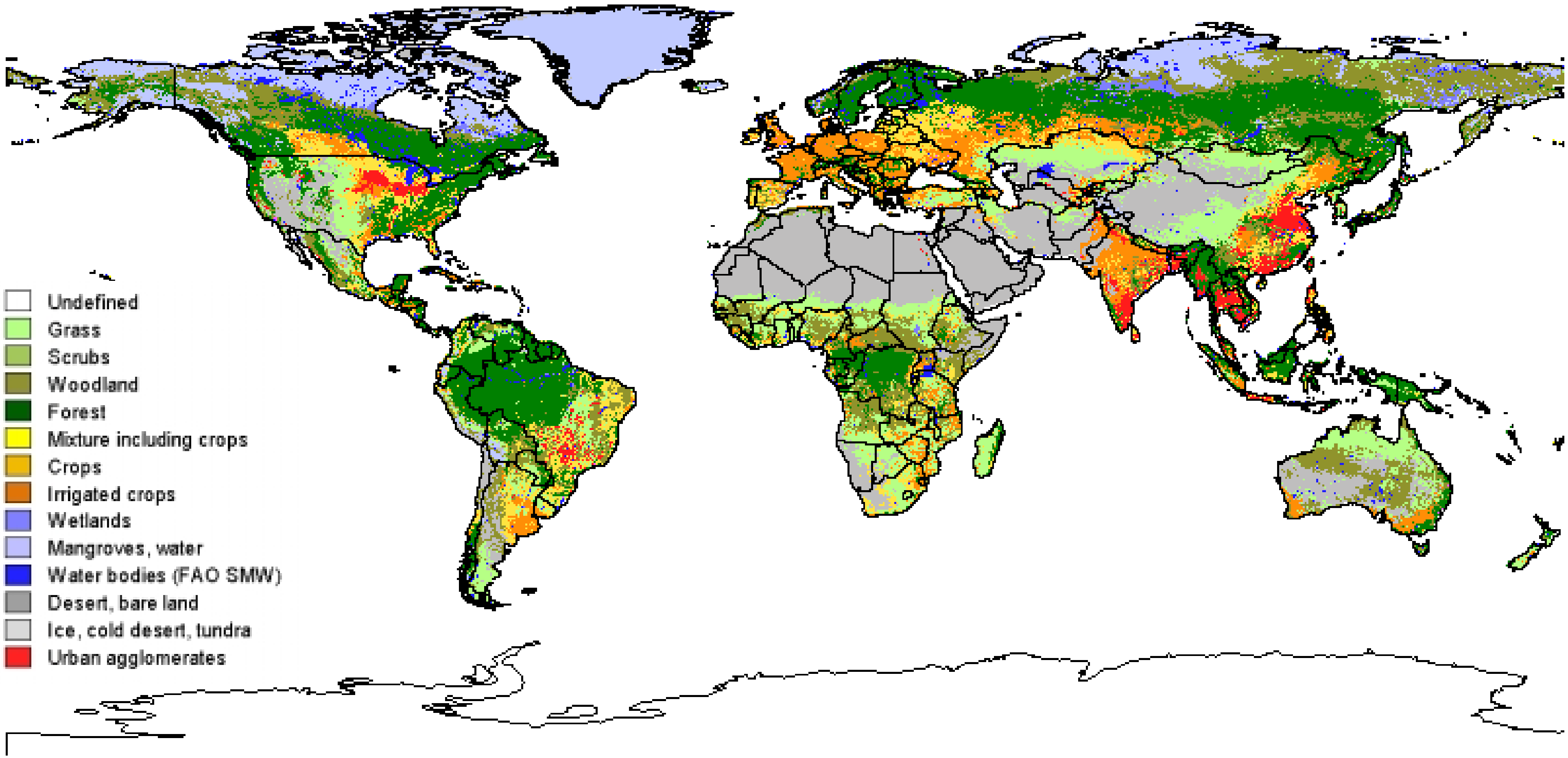


**Plate 56. Suitability for rain-fed crops excluding forest ecosystems**

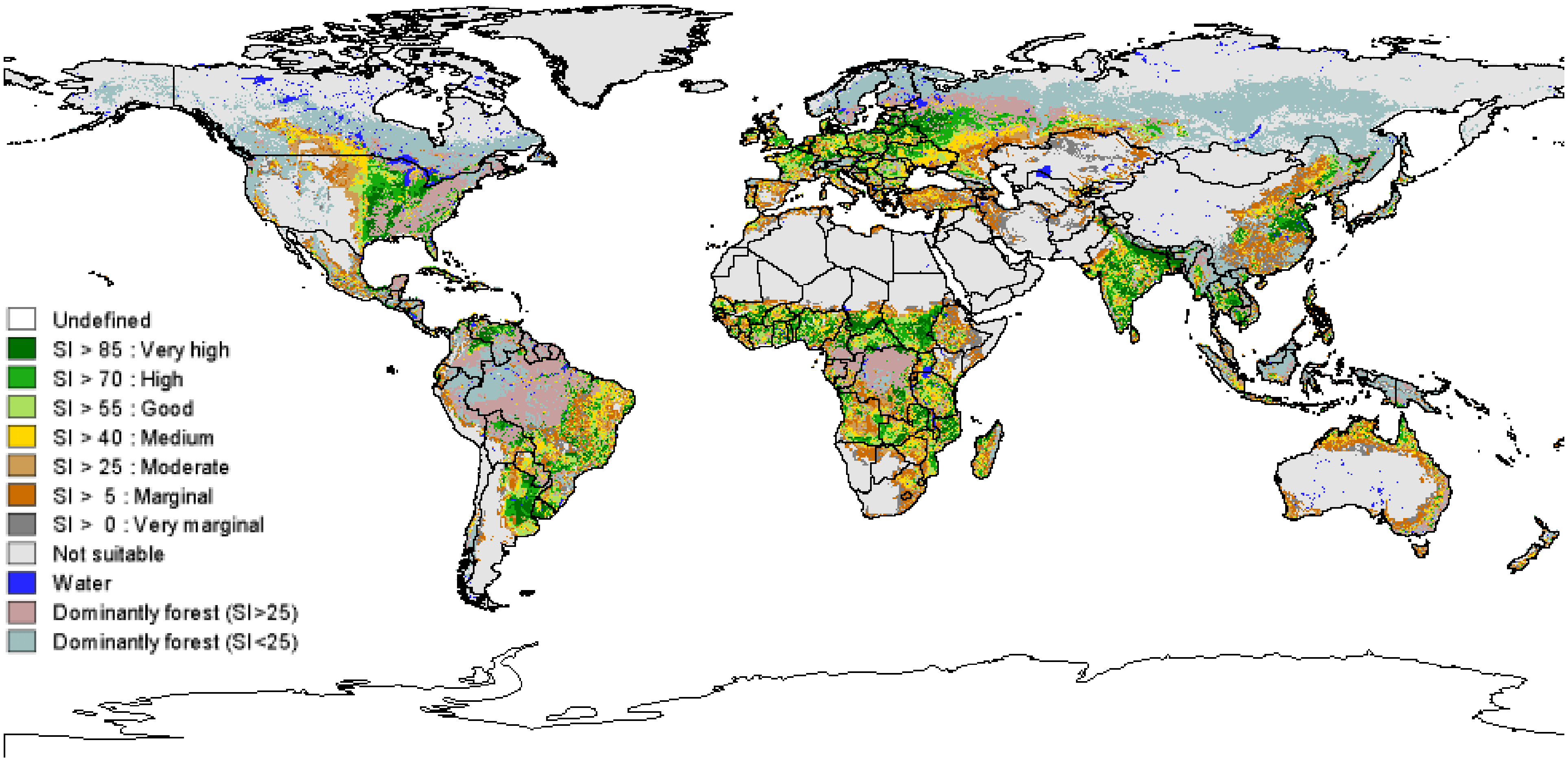


**Plate 57. Suitability for rain-fed crops under forest ecosystems**

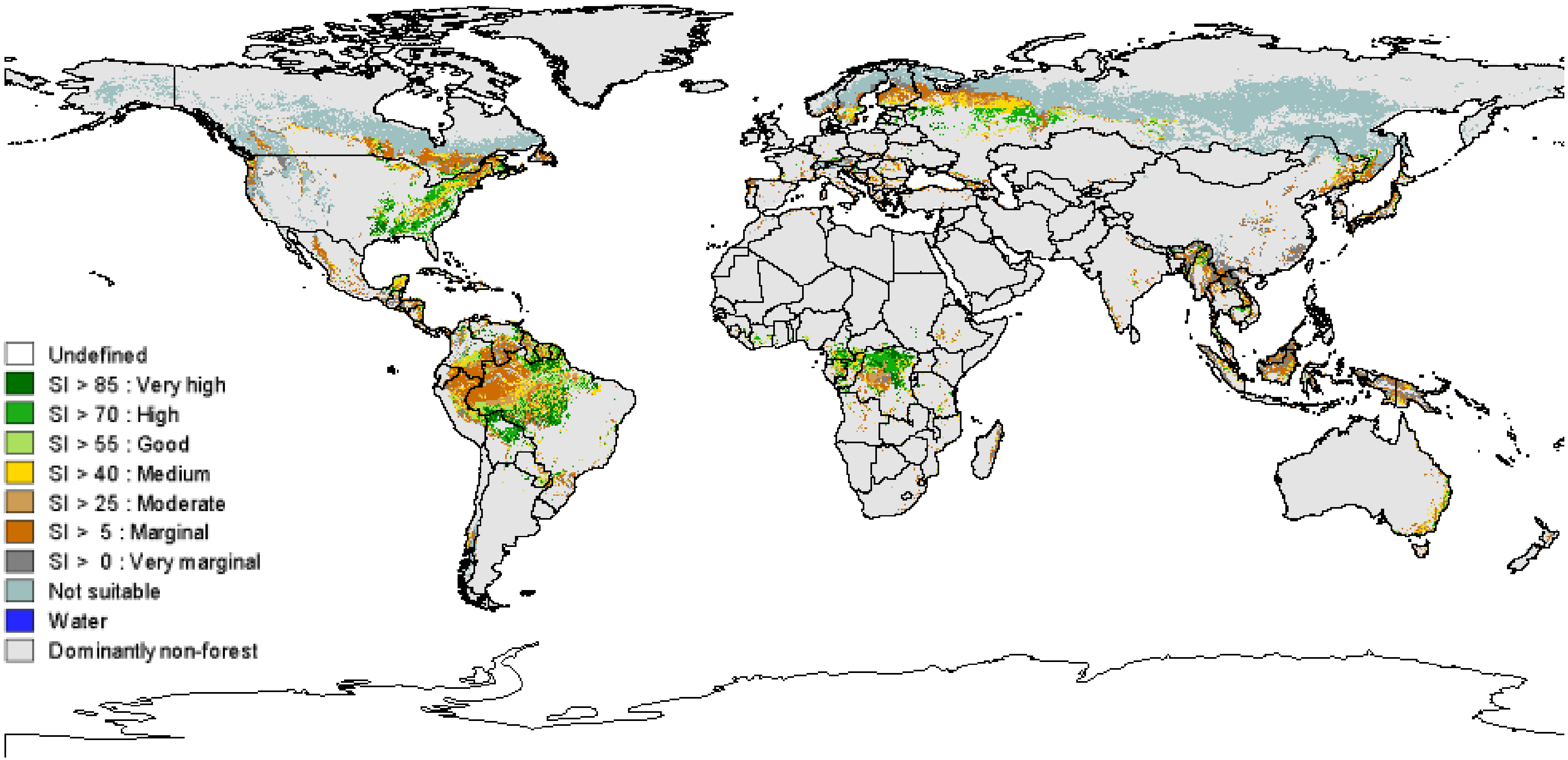
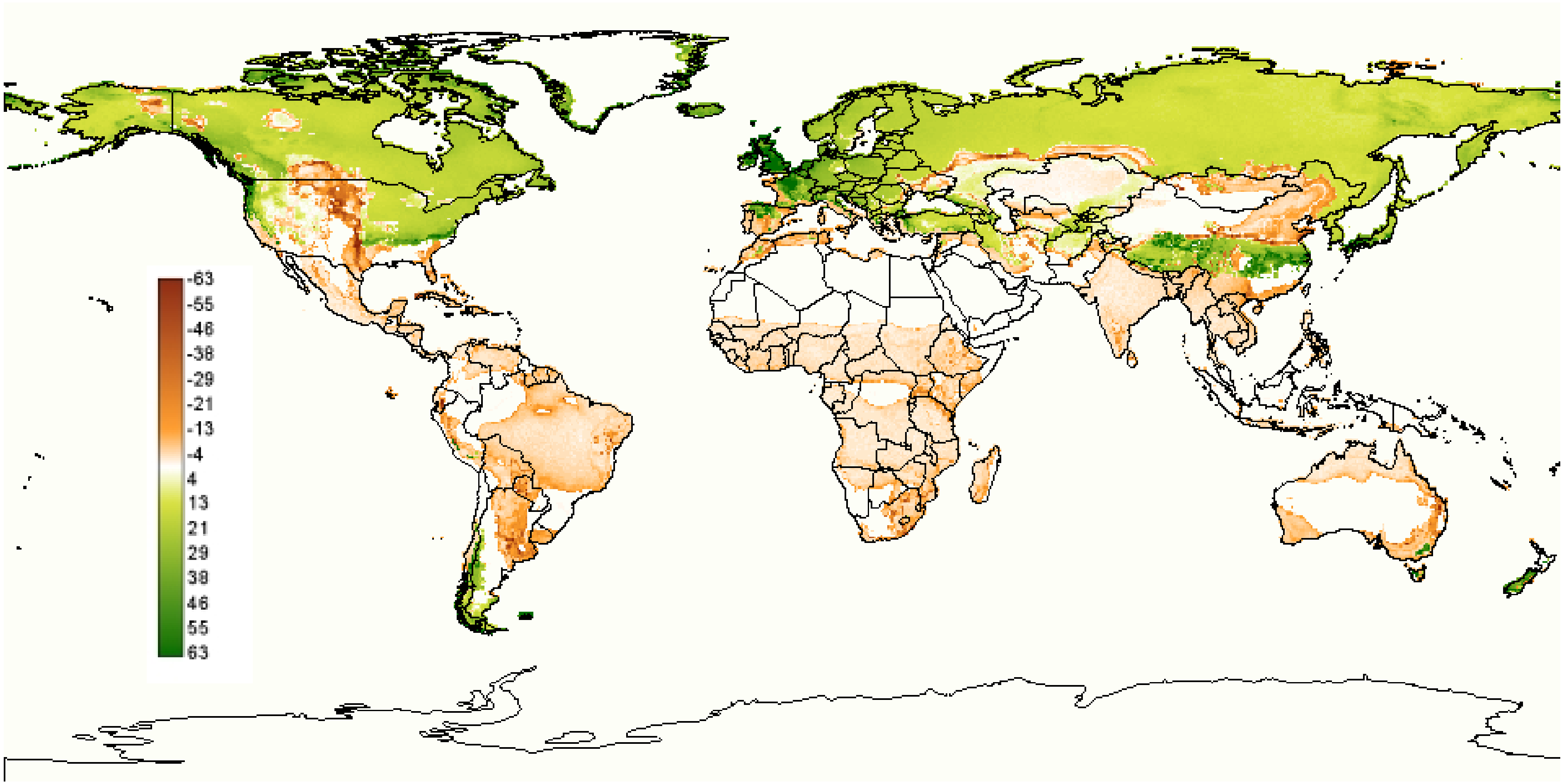
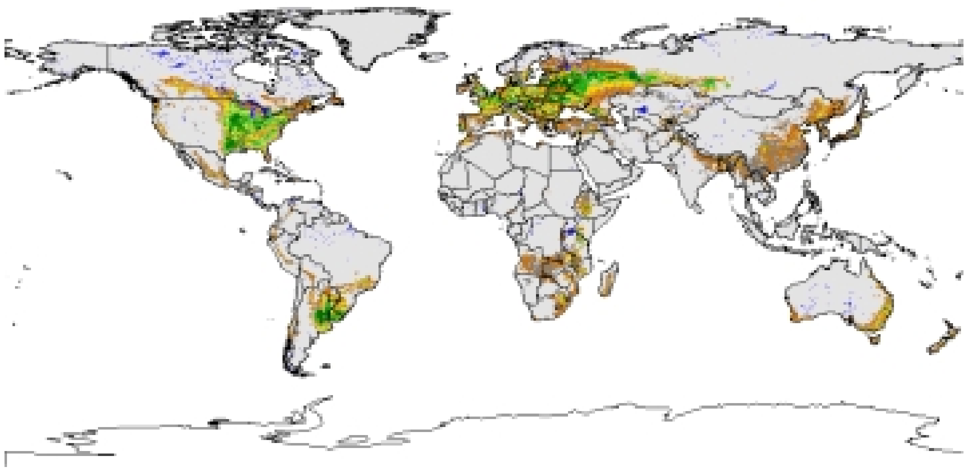


**Plate 58. Change in number of growing period days at +2° C**

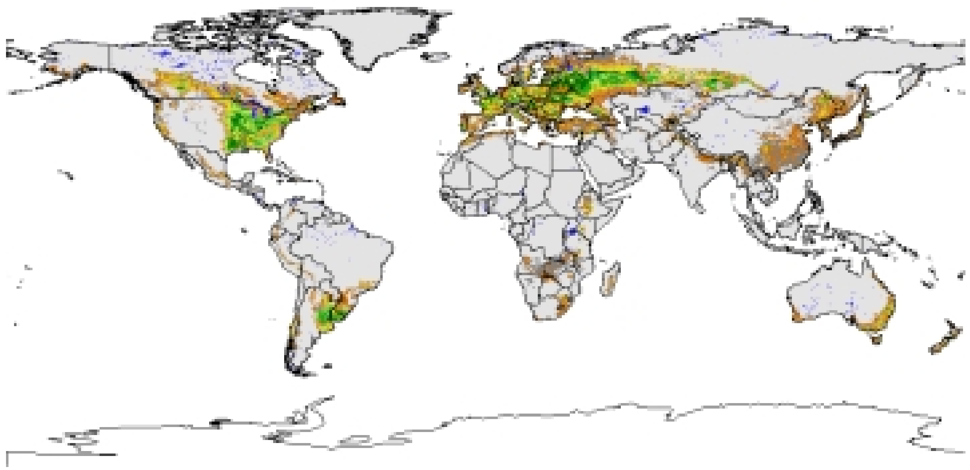


## Plate 59. Climate Sensitivity: Suitability for rain-fed wheat (intermediate inputs)

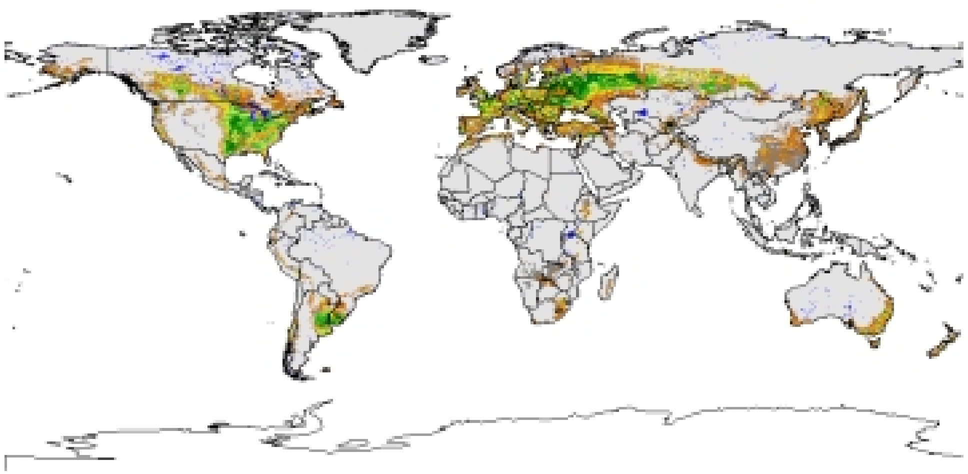
**Reference Climate**



**Climate sensitivity: +2°C**



**Climate sensitivity: +3°C, +10% precipitation**



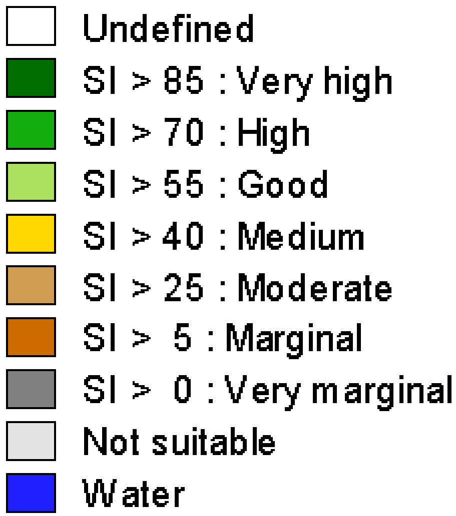
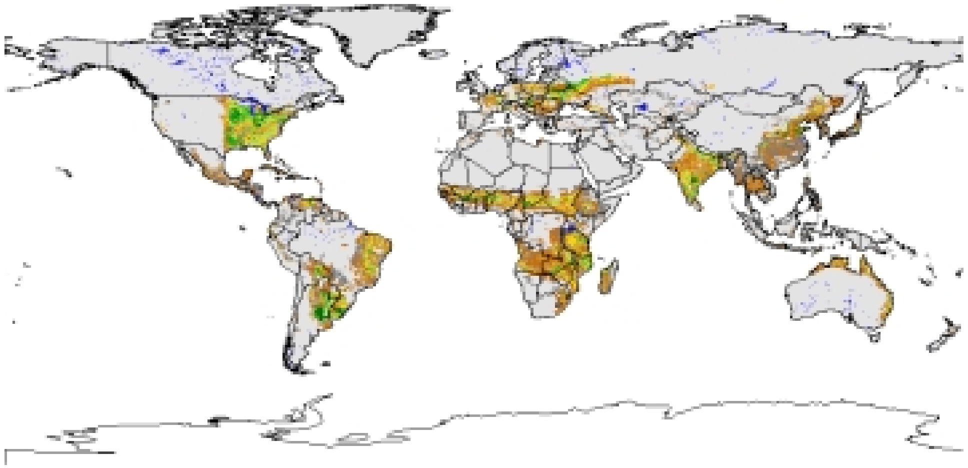
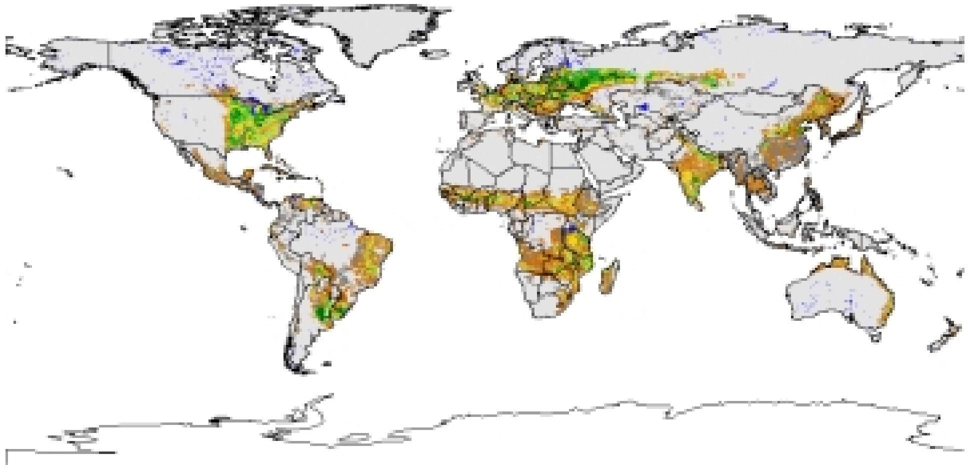


**Plate 60. Climate Sensitivity: Suitability for rain-fed grain-maize (intermediate inputs)**

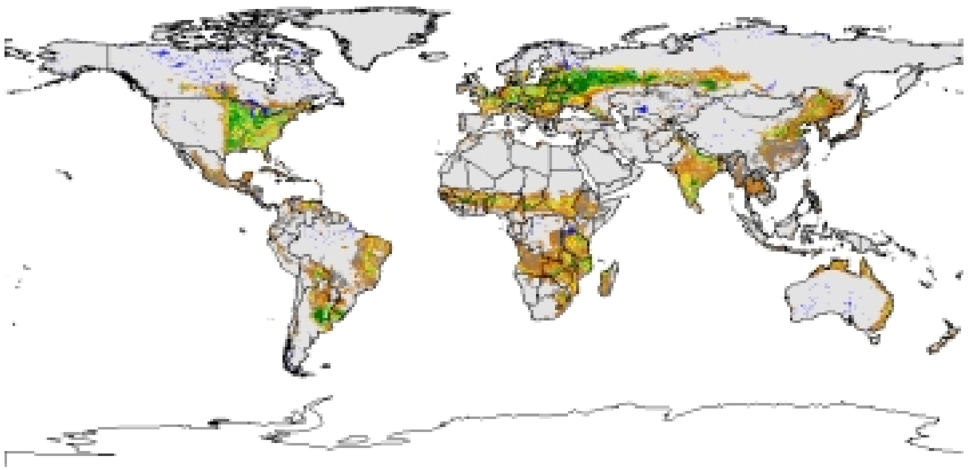
**Reference Climate**



**Climate sensitivity: +2°C**



**Climate sensitivity: +3°C, +10% precipitation**



Undefined
SI > 85 : Very high
SI > 70 : High
SI > 55 : Good
SI > 40 : Medium
SI > 25 : Moderate
SI > 5 : Marginal
SI > 0 : Very marginal
Not suitable
Water

## Plate 61. Regions used in global AEZ

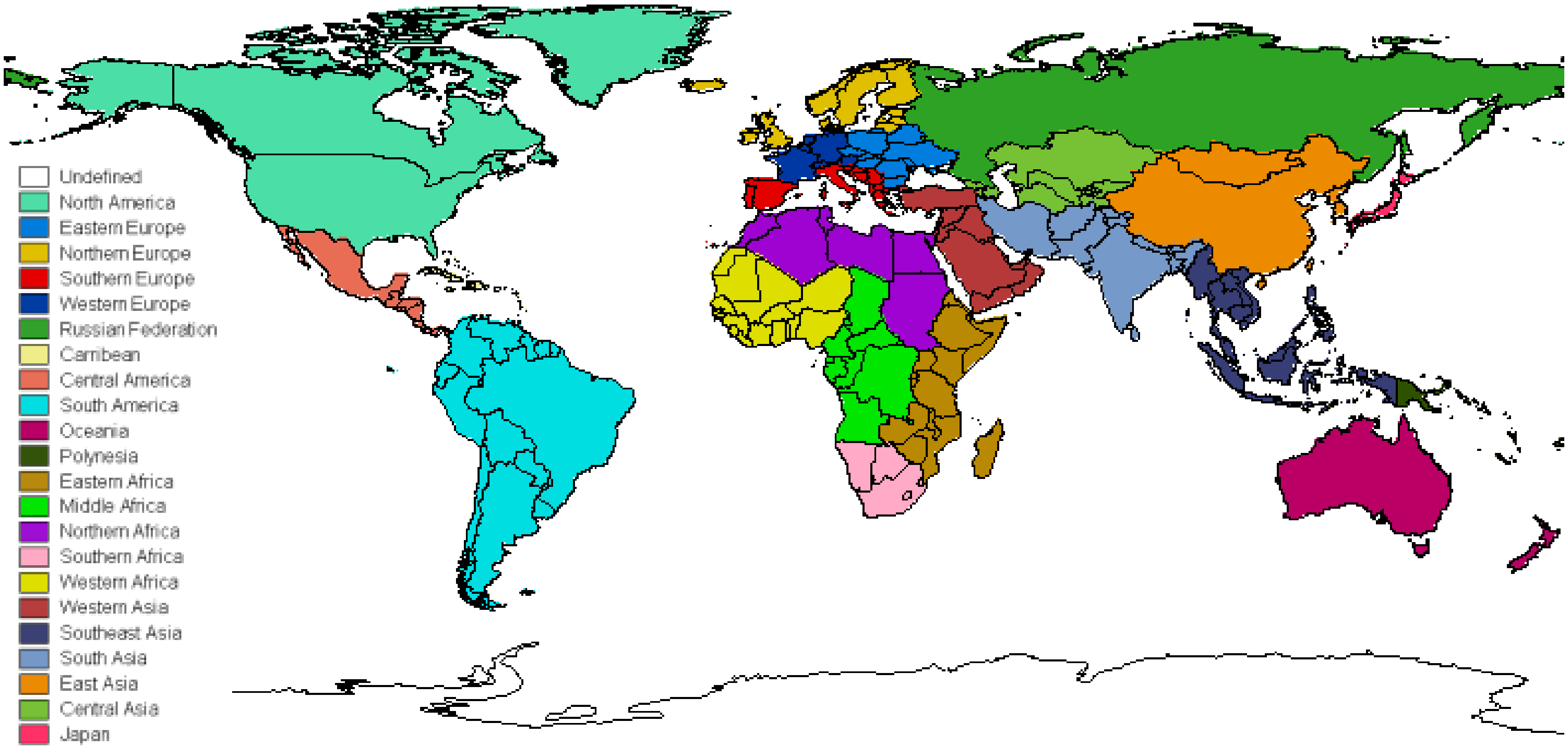


**Plate 62. Population density in 1995**