Working Paper

Lifestyles and Global Land-use Change: Data and Theses

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WP-95-91
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Introduction[1]

One of the most influential publications on land-use change is a small booklet, published by the International Geosphere-Biosphere Programme (IGBP) and the Human Dimensions of Global Environmental Change Programme (HDP). It was written -- as its subtitle says -- as "a proposal for an IGBP-HDP Core Project" on "Relating Land Use and Global Land-Cover Change". The booklet can be seen as some kind of *programmatic statement* to guide international collaborative research on global land-use change. Unfortunately, the publication promotes a rather *biased* view of global land-use change. Using questionable statistics the authors conclude that the main focus of research should be the detailed investigation of changes in the *rural* land use. Urban areas and their infrastructures are considered irrelevant. As a consequence almost all attention is given to arable cultivation and livestock production -- with some interest left over to the forest sector. Population growth and the associated rising food demand are usually considered the main driving forces of global land-use change.

In this chapter I will argue that *rural* land use is only *one* of the processes which are shaping the globe's land cover. There are other and probably *more important* land-use changes which are caused by urbanization, infrastructure expansion, industrial production, or changes in consumption patterns and lifestyles. These changes in build-up land might affect only relatively *small* areas -- as compared to the huge areas of forests and agricultural land. But they are often much more

persistent and intrusive. Once a patch of land is sealed off by tons of concrete or highway pavement it is extremely difficult if not impossible to transform it back into a natural ecosystem. Once a valley was filled up with giga-tons of water for a reservoir or a gigantic hole was dug in an open pit mine, we have an almost irreversible land-cover modification.

Moreover, I will claim that agricultural land-use change is *not only* caused by increasing food demand due to population growth (as people usually assume), but also by changes in lifestyles and food preferences which are driven by economic modernization and urbanization. The paper presents FAO data which indicate that probably some 20 percent of the arable land world-wide is already cultivated for lifestyle-related products, such as drugs, tobacco, coffee, tea, sugar beet, sugar cane, cocoa, or cotton. There is a trend towards animal-based food in many parts of the world, notably in China where per capita meat consumption has significantly increased during the past 20 years. In Europe, Western Asia, and Northern America changing food preferences have caused growing demand for vegetable oils. These are just the most obvious examples of world-wide changes in food preferences which have triggered the expansion of certain (feed) crop areas, such as the expansion of Soybean production in Brazil or the increase of oil crops cultivation in Europe. Changes in *rural* land-use are often caused by driving forces which emanate from the urban centers of industrialized countries.

1. Are questionable statistics misleading research on global land-use change?

Reading papers and books on land-use change is a somewhat monotonous experience. The authors tend to address just two subjects: *deforestation* and land cover change due to *agricultural modernization and expansion* (which, in turn, is often considered as being caused by population growth). There are hundreds of publications adopting this approach.[2/3/4/5/6] A most typical example is the already mentioned report of the Human Dimensions of Global Environmental Change Programme (HDP) published by the International Geosphere-Biosphere Programme (IGBP)[7]. While the authors of this booklet stress the need for analyzing the *underlying* demographic, cultural, economic and social causes of land-use change, they mostly *describe* trends in deforestation and agriculture. One chapter is explicitly titled "underlying human driving forces" - but it also mainly deals with large-scale investments in *agriculture*. And the main illustrative case in the IGBP report is the deforestation of the Amazon.

Why do land-use researchers usually seem to perceive the world as a *rural* place? They often justify their view by citing certain aggregate statistics on land-cover or land-use, which supposedly indicate that areas for infrastructure and settlements are so small in size that they are *irrelevant* for global land-use analyses (see table 1).

Table 1: Human-induced Conversions in Selected Land Covers

Covers	Date	Area ($x10^6 km^2$)	Date	Area ($x10^6 km^2$)	% Change
Cropland**	1700	2.8	1980	15.0	+435
	1700	3.0	1980	14.8	+393
Irrigated Cropland	1800	0.08	1989	2.0	+2400
Closed Forest pre-agricultural		46.3	1983	39.3	-15.1
Forest and Woodland pre-agricultural		61.5	1983	52.4	-14.8
Grassland/Pasture***	1700	68.6	1980	67.9	-1
Drained Land			1985	1.6	
Settlement					
Urban			1990	2.5****	
Rural			1990	2.1	

Notes: * The variation in dates and significant digits reflects the various sources from which they were taken; ** Estimates given from two different sources; *** Includes some areas often classed separately as shrub and arid land; **** Includes substantial areas not built up. Summary based on Meyer and Turner (1992)

Source: Turner, B.L. / Moss, R.H. / Skole, D.L. (1993): Relating Land Use and Global Land-Cover Change: A Proposal for an IGBP-HDP Core Project. A report from the IGBP/HDP working group on land-use/land-cover change. IGBP Report No. 24; HDP Report No. 5, p. 15

The statistics reported in table 1 are typical for this approach. The table is reproduced from the above mentioned IGBP-Report and supposedly shows (as the authors say) that ...

> *"the two largest land uses, in terms of their spatial domain, are arable cultivation and livestock production. Around 14-15 million km2, an area about the size of South America, is in some form of cultivation. An additional 70 million km2 is used for some form of livestock production, as either rangeland or pasture. In contrast, settlements of all kinds and their infrastructure (e.g., roads) cover only a few per cent of the world's land area.* ***Understanding global-scale patterns in land-cover change therefore requires detailed investigation of the changes in the rural land use*** *" (bold by Heilig).*[8]

Other authors, for example Meyer and Turner, have come to similar conclusions.[9] Grübler asserts that

> *"the area covered by artifacts of our technological civilization most likely covers less than one percent of the Earth's land area. In contrast, the areas used for agriculture and pasture cover close to 40 percent of the global land area."*[10]

However, both these statistics and the conclusions are highly debatable.

First, there is obviously something wrong with table 1: the different land categories simply don't add up. The table says that there are about 15 million km^2

of cropland (I assume that the 2 million km^2 of *irrigated* cropland are included in this figure). Then we have 52.4 km^2 of forest and woodland (probably including the reported areas of Closed Forest). And then the table reports about 69 million km^2 of grassland or pasture and 4.6 km^2 of settlements. This amounts to some 140 million km^2. Unfortunately the total *land* area of the world -- according to FAO and some other reference books -- is about 130 million km^2. So -- where are the more than 9 million square km^2? Of course I am aware that these statistics are very crude. But 9 million km^2 is *twice* the size of the reported worldwide settlement area!

Table 2: Clean Up of Table 1

	sqkm	% based on (a)	% based on (b)
1 Cropland (incl. Irrigated Cropland)	14.8	10.6%	11.3%
2 Forest and Woodland (incl. Closed Forests)	52.4	37.5%	40.2%
3 Grassland / Pasture	67.9	48.6%	52.1%
4 Settlements (rural + urban)	4.6	3.3%	3.5%
(a) Total from 1 - 4	**139.7**		
(b) Total Land Area (FAO)	**130.4**		

Secondly, the interpretation of the table by the authors is not convincing: the IGBP-HDP report says that only a few percent of the worldwide land area is covered by settlements which is why they are *irrelevant* for the investigation of land-use change. Grübler even believes that it is less than 1 percent. But according to table 1 the size of land covered by *urban and rural* settlements is 4.6 million km^2. This is certainly *more* than *three percent* of the Total Land Area (no matter whether we calculate the percentage with the 140 million km^2 reported in the table or with the 130 million km^2 reported by FAO). One might say that 3% is, in fact, not much, but it has to be set in relation to *other human land uses*. If we compare the reported urban and rural settlement area (in Table 1) with the worldwide crop area (from FAO statistics) we find that it amounts to about *one third* of the cropland. Can we really say that this is negligible?

However, the most important flaw in table 1 is the fact that land which is *inadequate* for almost *any* kind of human land-use, such as areas covered by ice, sand deserts, steep mountains or bare rock is not excluded. If we would subtract these areas from the Total Land Area and only deal with land that *can* be actually *used*, we would come up with a percentage of *urban* land use in the range of 4 to 5 percent.

In China, for instance, 22.4% of all land is covered by glaciers, sandy desert, the bare rocks and stones of the Gobi desert and other marginal land -- mostly steep mountains. Cultivated land makes up only 14.2% of the total land area. Urban

areas, rural settlements and infrastructures cover 3.4% of the *total* land area, but 4.3% of the "usable" land (see table 3). These urban and rural settlements, industries and infrastructures cover an area which is comparable in size to almost *one quarter* of the country's cultivated land. This clearly indicates that even in China, which is still a predominantly rural society, the urban and industrial sector is an important user of land.

Table 3: Land Cover / Land Use in China

No:		Area (in million km2)	Area (in % of Total Land Area)	Area (in % of "Usable" Land)	Area (in % of Cultivated Land)
1	**Total Land Area**	**9.600**	**100.0%**		
2	Cultivated Land	1.364	14.2%		100.0%
3	Horticulture	0.074	0.8%		
4	Forests / Woodland	1.954	20.4%		
5	Grassland	3.386	35.3%		
6	***"Agricultural" Land (Total: 2 - 5)***	***6.778***	***70.6%***		
7	Cities / Towns / Industry	0.019	0.2%	0.2%	1.4%
8	Rural Settlements	0.235	2.4%	3.2%	17.2%
9	Infrastructure	0.071	0.7%	0.9%	5.2%
10	***Non-Agricult. Land (Total: 7- 9)***	***0.324***	***3.4%***	***4.3%***	***23.8%***
11	Inland Water Bodies / Fish Ponds	0.325	3.4%		
12	Beaches	0.022	0.2%		
13	***(Total: 11 - 12)***	***0.347***	***3.6%***		
14	Glacier / Snow	0.069	0.7%		
15	Sandy Desert	0.467	4.9%		
16	Stone / Rock Desert (Gobi)	0.304	3.2%		
17	Other (marginal) Land / Mountains	1.312	13.7%		
18	***(Total: 14 - 17)***	***2.151***	***22.4%***		
19	**"Usable" Land (1 minus 18)**	**7.449**		**100.0%**	

Source: Adapted from: Wu Chuangjun / Guo Huangcheng (1994): Land Use of China. Beijing, Science Press (in Chinese), p. 91

Regional land cover statistics for Europe, Northern America and parts of Asia report much higher percentages for settlements and infrastructure. In Europe most countries have settlements and infrastructures which cover more than 10% of the land. In the Netherlands 6.3% of the land is used for "parks and recreational areas", 10.5% for "infrastructures, residential buildings, industry and commerce" and 10.8% for "other uses". In other words, almost 28% of the country's land area is under some kind of human use *other* than agriculture or livestock production. Forests, on the other hand, cover just 9.7% of the land, and the famous agriculture needs only 22.6%.[11]

In its evolution the human species has undoubtedly converted huge areas of *natural* land into *agricultural* areas. Large sections of the forest cover were cut down for cultivation and cattle ranging. And much of the remaining forests and woodlands were used to "harvest" wood and were thus transformed into *managed* land. But this process was basically driven by the *first* -- the agricultural -- revolution and the population growth associated with it. With the *second* -- the industrial -- revolution land-use change became a quite different process. At the industrial level of technology a *competition* between agricultural and *non*-agricultural land-use emerged. Land gradually became less important as a resource for food production and forestry, and is increasingly used for *other*

purposes -- such as industrial production, housing, infrastructure, or recreation. The worldwide crop area, for instance, remained almost *unchanged* in size since the early 1950s -- despite a *doubling* of the world population (and a more than doubling of food production). Due to the "Green Revolution" we can often feed twice or three times as many people from a given area of land. Today, rapidly growing urban agglomerates, expanding infrastructures, industrial areas and sites of industrial resource exploitation are increasing the pressure on land (very often at the cost of arable areas or commercial forests).

From a demographic and economic point of view it is absurd to focus land-use change research on studying *rural* and *forest* areas or our globe. Industrialization and urbanization have become basic driving forces of global change. A significant amount of land is already used for urban and industrial purposes. About 45 percent of all people already live in urban areas and more than 90% of the world's GDP is generated in sectors *other* than agriculture or forestry. In the highly industrialized countries agriculture typically generates only between 1 and 5% of the gross domestic product. Even in developing countries agriculture on average contributes *less* than 20% to the GDP.[12]

Agricultural and forest sectors are no longer driven exclusively by the food and resource demand of the *local* or national population (not even in developing countries), but respond to *international* markets. They have to provide numerous functions to urban and industrial centers. Lifestyles and consumption patterns in these far-away centers can trigger fundamental land-use change in remote rural areas. We can only study the driving forces of global land-use change, if we investigate the urban and industrial sectors. The *rural* world may be still large in size, but it is gradually becoming the "hinterland" of urban and industrial agglomerates, which more and more determine how the land is used.

2. Land-use change is a multi-sectoral process

To understand the rapid change of earth's surface at the turn to the 21st century we must take into account (at least) four **basic trends**:

- the rapid **spread of modern technology**, which affects *all* sectors of life, including the modes of *agricultural* land use;
- the historically unprecedented **increase of population** and its **shift into urban agglomerates**, which not only drives the demand for food, but also generates additional urban land use;
- the **growth and globalization of our economies**, especially the rapid industrialization in Asia and the emergence of worldwide trade relations;
- changes in **consumption patterns and lifestyles** in affluent societies.

These fundamental trends drive other mechanisms which could be called the **proximate determinants** of land use change. They include worldwide driving

forces, such as (1) the increase of *commercial* (road, sea, and air) *transport* for the supply of growing industries and urban areas; (2) increases in *leisure activities* (especially tourism) and *individual mobility*; (3) the growing *demand for food* and other agricultural products, which drives the intensification of agriculture and livestock production; and (4) *the increasing demand for (commercial) energy, minerals and natural resources* such as oil, coal, or wood.

These forces are finally linked to certain **alterations of the land surface and its biotic cover**, such as (a) deforestation,[13] (b) draining of natural wetlands, (c) regulation of river systems and artificial lakes, (d) man-induced desertification, (e) sealing of land through artefacts (air fields, streets, buildings). In the end the land cover modifications can change the (regional) hydrology,[14] reduce biodiversity, influence the biogeochemical cycles (including the emission of radiative trace gases such as CO_2 and CH_4), or even affect the climate. They can trigger soil erosion and increase sediment transport.

Land-use changes vary in **size**, **intensity**, **duration** and **impact**. Changes in agriculture or forestry often affect *large* areas while their duration, intensity or impact may by less severe. When a boreal forest is "harvested" with strictly controlled small-scale logging it is quite possible that not much is changed in its ecosystem. The *duration* of the land-cover modification can be short: the forest may "recover" in a few decades. The *intensity* of the land use is certainly minor and its *impact* may be restricted to the vegetation cover. Compare this to the land-use change caused by the expansion of infrastructure, such as the construction of an airport! The *size* of the land-use modification is relatively small; but its *intensity* is extremely high (for instance, a forest area had to be *clear-cut* and covered with concrete for a new runway of Frankfurt's airport; not a single bush remained in the spot!). Man-made construction may not be designed for eternity, but once we have built a city or water reservoir or an airport it stands for a while. And finally, the *impact* of land-use change caused by infrastructure may reach much further than to the directly affected ecosystem: the dam of a water reservoir, for instance, not only affects the flooded valley, but might trigger multiple ecological damage and land-use change in far-away areas *down-stream*.

As this brief outline suggests, global land-use change has to be studied as a *multidimensional* process which links activities in *various sectors* of society to changes in land cover. Developing a detailed model of these interactions is a task too ambitious for this discussion. All we can do is to give a check list for research and a few examples. In Boxes 1 and 2 of the Appendix one can find a listing of major sectors and behavioral trends that affect land-use. In the text below we will discuss some *non-rural* driving forces of land-use change.

2.1 Urbanisation

Urbanization is a *major* factor of global land-use change. In 1950 the world had an *urban* population of 738 *million*; today (1995) it is 2.6 *billion* and by 2015

about 4.1 billion will live in urban areas -- according to the most recent UN projections.[15] The rural population, on the other hand, increased from 1.8 to 3.1 billion between 1950 and 1995 and is projected to grow only slightly to 3.3 billion in 2015. While the *urban* population of the world will probably more than *quintuple* between 1950 and 2015, the *rural* population will less than *double*.

These statistics on urban population have, of course, great methodological problems (which we cannot discuss here). But there can be no doubt, that a considerable proportion of the world population is already living in urban areas (about 45%). It is also undisputed that -- on a global scale -- the population of cities and urban agglomerates is growing *much faster* than that of rural areas. The United Nations, for instance, is monitoring the population of 370 selected cities worldwide since 1950. It more than tripled between 1950 and 1995 (from 303 to 967 million) and is projected to further increase to 1.4 billion by the year 2015.

This spectacular growth of urban and city populations must have affected land-use patterns during the past few decades and it is quite likely that it will also affect future land-use. A simple "back-of the envelop" calculation can help to assess the scale of this impact. Currently we have an urban world population of about 2.5 billion which has used (according to the above mentioned IGBP report) an area of some 2.5 million square kilometers for *urban* settlements (I think there is *more* urban-related land use than that, but for the sake of argument I stick with the IGBP estimate in table 1). If we believe the UN projections we have to expect an expansion of urban land to -- at least -- 4.1 million square kilometers by the year 2015. In 2025 the urban population is projected to reach 5.1 billion. Without any per capita increase of space (a very "conservative" assumption) this would mean an urban settlement area of 5.1 million square kilometers -- which is somewhat less than *one third* of the current global cropland area. If we add to this the land area used for *rural* settlements, we have to conclude that settlements of all kinds and their infrastructure are, in fact, very significant factors of land use change.

Of course, not all land in urban areas is sealed off by houses or roads. There is often a high proportion of land which looks rather "rural" or "natural", such as parks, gardens, golf courses or vegetation belts between highway lanes. Wealthy suburbs can often maintain a very "green" appearance, reminding their inhabitants of the rural world their ancestors once lived in. Clever city and regional planning, in fact, can manage to build an urban environment which looks remarkably "natural". People are often surprised, how "green" and "untouched" the land appears from an air plane -- even within (or in close distance to) urban agglomerates. This, of course, is a fake impression. It is not the *appearance* of land, but the *purpose* of its use, which determines how it has to be classified. The purpose of agricultural land is *production* of food and other agricultural products, it serves the rural population as a source of food and income. *Urban* land, on the other hand, no matter how "green" it is, provides space for housing, consumption, mobility, recreation, education or entertainment to people who raise their income

in ***non***-agricultural sectors (even if they grow some tomatoes in their cottage house garden).

Some researchers would not deny the relevance of *urban* land-use in highly developed industrialized countries, but they consider it irrelevant for most of the developing world. In these predominantly rural societies, so they argue, agriculture and livestock production are still the dominant economic activities which shape the land. While this is probably true for much of Siberia and parts of Africa there is indication that urbanization is a major factor of land-use change in most parts of Latin America and Asia.

A case in point is China which has long been the prototype of a rural society. The government's closed city policy effectively prevented rapid urbanization and 72% of the population are still classified as *rural*[16] living from agriculture and livestock production. So one would expect China's future land use change to be simply a function of increasing food demand due to population growth. But there are indicators that *other* types of land use will increase.

China's spectacular economic growth is *not* driven by the agricultural sector, but by its (light) industry which is serving the World Market -- especially the USA. In 1993 more than 50% of the national income was generated by the *industrial sector*, another 28% by *construction* and *commerce*. The huge agriculture just generated 25% of the national income.[17] The south-eastern part of the country which is close to Hong Kong is already in a process of massive industrialization. Labor-intensive industrial production with high wages attracts rural excess population and is generating a spectacular urban growth (which we know very well from the period of European industrialization). It is estimated, that Beijing already has an "illegal" floating population of at least 2 million, coming to the capital in search for work.

There is *no alternative* to urbanization in China because of demographic and economic reasons. China's peasants will go urban. Between today and the year 2050 the country is expecting a population increase of about 400 million and it is very unlikely that these people can be absorbed in the agricultural sector. China's agriculture was already modernized during the last 15 years: There was a ten-fold increase of agricultural machinery and a twelve-fold increase of nitrogen fertilizer use. The *labor* intensity in this sector will probably stagnate or even *decline*, as China moves further towards modern agricultural production methods. Population growth and stagnating agricultural labor demand will cause a multi-million rural excess population. This is probably one reason, why the most recent United Nations Population Projections have estimated a 1 *billion urban* population for China in 2050 -- two thirds of the total population. In 1950 China's urban population was 61 million. Quite frankly -- it is very hard to believe that this 940 million increase in city dwellers would not cause a major *urban* land-use expansion.

Table 4: Structure of Lost Cultivated Land in China: 1988 and 1989

	1988		*1989*	
	1000 Ha	*Percent*	*1000 Ha*	*Percent*
Total Loss of Cultivated Land	**676.3**	**100**	**417.3**	**100**
State Construction City, towns, factories, railway, highway, hydroelectic projects, other.	71.2	10.5	51.2	12.3
Collective Construction Roads, irrigation, TVEs, farmer housing, other	29	4.3	22.7	5.4
Agricultural Restructuring For fruit trees, forests, grassland, fishponds.	394.8	58.4	231.1	55.4
Natural Disaster Related	159.4	23.6	97	23.2

Source: The World Bank (1993): China. Urban Land Management in an Emerging Market Economy. Washington, DC. p. 95

In 1988/89 China lost more than 1 million hectares of its cultivated land. Most of it was due to agricultural restructuring (about 56%) and natural disasters (some 24%); but 15 to 18 percent of the losses were due to urban growth and infrastructure construction (see table 4). This was seven years ago, when the current infrastructure boom had barely started. There are no statistics available for today, but the losses of cultivated land due to urban and infrastructure expansion must have multiplied.

2.2 Mass-Tourism

Mass tourism is another trend in modern societies that triggers widespread modification of the earth's surface. The tourist industry strives to open up the last "untouched" areas of the globe for the leisure and excitement of tourists from affluent societies. A travel agency in Bavaria, Germany, organizes bus tours for elderly women across the Sahara or to Katmandu. These special buses equipped with air condition, cooking facilities and sleeping trailer, can be encountered in the middle of African or Australian deserts - carrying an exhilarated group of elderly widows. They also organize special bus trips to the reserves of Aboriginals in the Northwest of Australia's "Outback". Trekking tours in the Himalaja, (photo) safaris to the Tsavo National Park in Kenya, or sight-seeing tours to the Maya temples in Tikal can be booked in almost any travel agency in Europe. Thirty years ago Sulawesi - then Celebes - was a remote place were a handful endogenous tribes lived in a society not much different from those of the later Stone-age -- untouched by the outside world. Since then the Javanese settlers of the Indonesian government's "transmigrasi" program have greatly changed the place by steadily expanding their (quite infertile) fields into the

island's rain forest. But the long-term impact on the island of the rapidly expanding adventure tourism may prove even more severe. Today, when traditional villagers perform their colorful cremation ceremonies, often thousands of visitors line the dirt roads, and camera teams of European tourists crowd the procession.

Tourists can affect land-use in multiple ways: They need *additional* infrastructure (hotels, airports, roads) both in their home land and the receiving country. They expect certain services, such as entertainment and recreation; and they require special facilities and products, such as clean drinking water, air condition, or proper sanitation and waste disposal. Providing all these services, facilities and products affects the land -- either *directly* through the consumption of local land areas for water reservoirs, power plants, golf courses or shopping centers; or *indirectly* through the trigger effect of modernization. This indirect effect is hard to trace, but there can be no doubt that it exists. Without tourism many places in the Third World would not have been confronted so massively with the products of land-consuming "western" lifestyles -- including cars, motor bikes, soft drinks, and "hamburgers". (We will discuss in a moment what "soft drinks" and "hamburgers" have to do with land-use change). Around the emerging tourist center there is often also a kind of *secondary* land reclamation which can be easily observed in places like Bali, Thailand, or the Maledives. As new job opportunities emerge rural population migrates to these tourist centers expanding them further with their own settlements.

2.3 Transportation and Supply Infrastructure

The conversion of natural land into streets, railroads, airports, harbors, water reservoirs and other man-made structures *for transportation and supply* accounts for only a small fraction of the worldwide land cover change. Accurate statistics are not available, but they might be in the order of 2 percent of the earth's *usable* surface. If this is correct, then the *amount* of land we use for transportation and supply is negligible on a global scale. Yet, I claim, it is precisely this kind of land-use that is of *paramount importance* for the alteration of the globe's surface.

Consider, what a small road can do to a remote forest area. It might open it up for loggers, oil explorers, poor farmers, land speculators, gold diggers, prostitutes, butterfly catchers, tourists. They will flood the area and change it within a few years. Thus the construction of a road -- a small intervention with minor direct loss of natural vegetation and animal life -- can result in alteration many times the multiple of the original impact.[18]

Rail roads were probably the single most important man-made structures for the conversion of earth surface in the last 150 years. Since February 1804, when Richard Trevithick for the first time put a steam engine on rails, this technical device has changed the world. Railroads opened up the North American continent. They made it possible to efficiently exploit the European colonies in

Africa and Asia. Railroads built by the English colonists are still the backbone of India's transportation system. The Dutch-built railroad from Jakarta to Bandung and Surabaya made Java's interior highland accessible, triggering a massive conversion of natural land into plantations.

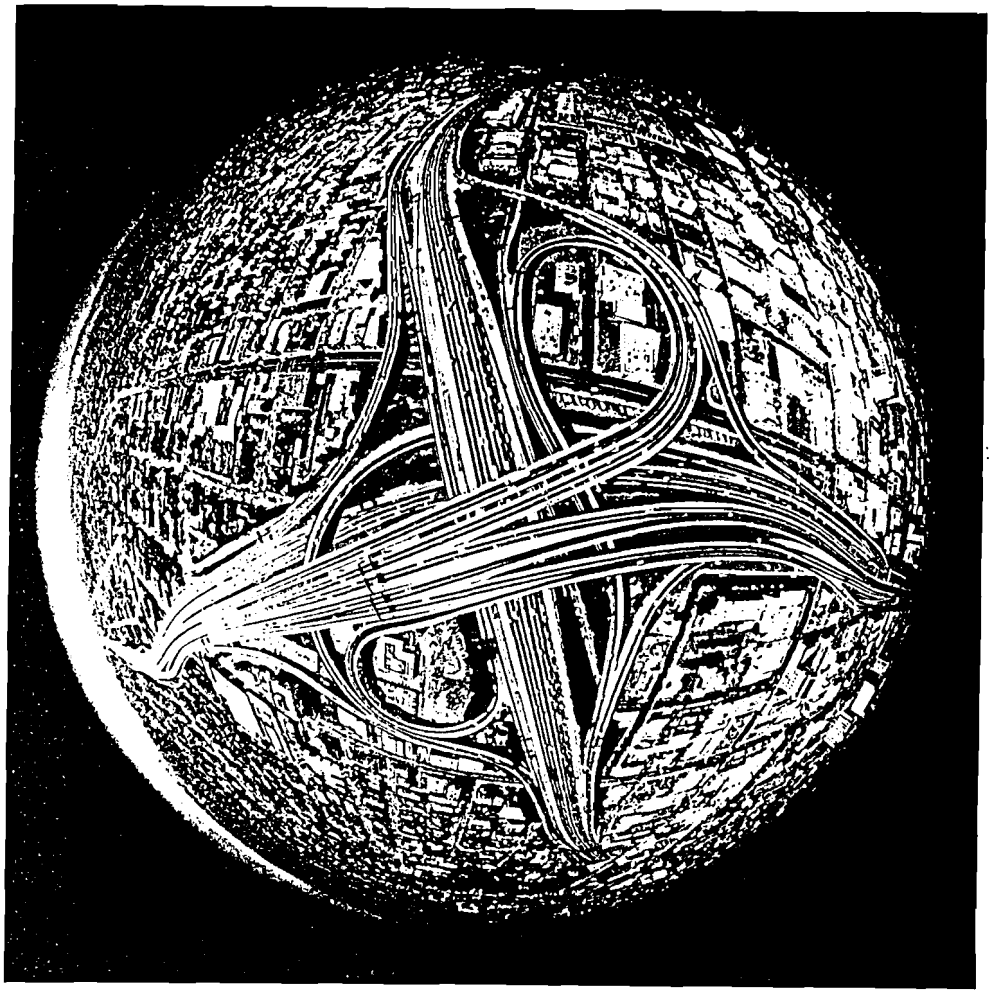
It is interesting to note in this context that very often the original motive for building transportation infrastructure is unrelated to the subsequent land development. *Military considerations,* for instance, play a crucial role in opening up remote areas. The knowledge that adequate transportation infrastructure is essential for rapid deployment of troops is as old as war itself. The Roman and Napoleonic empires could dominate huge areas only because they devoted great resources to the construction and maintenance of road systems, which then stimulated the development of peripheral regions. Twentieth-century examples are numerous. Modern governments wanting to control separist movements or guerrilla activities developed road systems in the forests of northern Guatemala, northwestern Thailand, and Nicaragua. The Nazi government constructed the network of "Autobahns" to facilitate access to Germany's border regions in anticipation of war. Likewise, construction by the Czarist government of the Trans-Siberian Railway, connecting the west and the far east of Russia, was driven by military considerations.

Private profit is also a strong motive for building transportation infrastructure. During the colonial era many parts of the Third World were opened-up for private or semi-private exploitation through development of such infrastructure, which in turn triggered further colonization. Railroad systems in Africa and India are good examples.

Currently, Asia experiences an unprecedented boom in infrastructure construction. Thailand, Singapore, Malaysia, China, Hong Kong, South Korea, Taiwan, Indonesia and the Philippines are at the forefront of this process which will change the face of Asia. In 1994 the Asian Development Bank estimated that the region's emerging nations would spend US$ 1 *trillion* by the year 2000, primarily on infrastructure for energy generation, transport and communication.[19] This estimate has been recently revised as "too conservative" by the Hong Kong based Peregrine Group which estimated that the region will at least invest US$ 1.9 *trillion* (!) in its infrastructure within the next *five* years.[20]

Some of the gigantic projects have already eaten up scarce arable land, especially in China. There is, for instance, a new six-lane highway from Guangzhou to Shenzhen at the border to Hong Kong, which cuts through most productive former rice paddies.[21] A new railway link from Beijing to Guangzhou (Guangdong Province), currently under construction, will run all the way down the Heartland of China. A 2380 km railway is also going to be built between Beijing and Kowloon (Hong Kong). The Three Gorges Dam hydroelectric project will create, if ever realized, one of the most gigantic water reservoirs. There is massive infrastructure construction in Pudong, Shanghai's new development zone.

Chart 1: The intersection of the Santa Monica and Harbour freeways in Los Angeles.



Source: Lay, M.G. (1992): Ways of the World: A History of the World's Roads and of the Vehicles that Used Them. New Brunswick (Rutgers University Press)

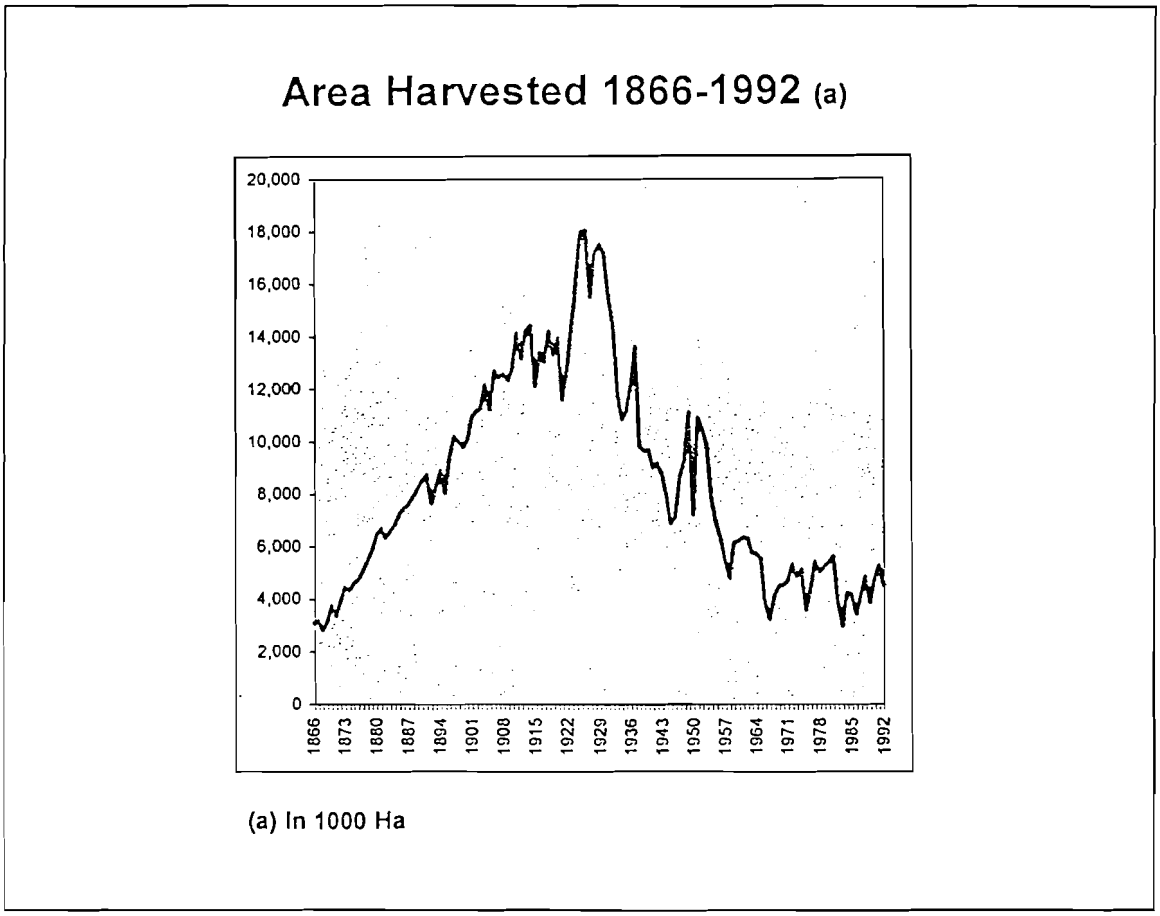
If European and American patterns of industrial transport and *individual* mobility ("Mass Tourism") were adopted by Asian countries (with a projected population of 10 billion), *world-wide* transportation and recreation infrastructure (including road networks, railways, airports, and recreation areas) had to be expanded enormously (see chart 1). The "Honda"-Revolution is already well on its way in Indonesia, Malaysia, Thailand, South Korea and the Philippines; and it is not impossible that double-digit economic growth rates in China will generate the *largest* car market on earth in the foreseeable future -- and thus trigger enormous changes in the use of land.

2.4 Lifestyles / food preferences

Many languages have words and sayings that could tell us a story about the relationship between lifestyles and global land-use patterns. The "Silk road"

refers to the ancient trading connection that opened-up contacts between the Far East and Europe, and it is a reminder that *clothing fashion* has been a driving force of land-use change throughout history. The Mulberry tree that feeds the silkworm came first from India to southern Europe at the time of Trajan (AD 52-117). It spread rapidly in the 10th century as Europe's noble classes came to favor silk dresses. The tree also spread to large areas in China where silkworm breeding flourished in the 12th century - due in part to increasing demand from Europe. Even more instructive is the spread of the *cotton* plant. Until the modern era clothing relied heavily on products of animals - wool, skin, fur. Cotton became the cloth of the masses only during the seventeenth century in Southern France; eventually, huge areas worldwide were transformed into cotton plantations.

Chart 2: Cotton Area Harvested in the United States, 1866-1992



Source: Mitchell, B.R. (1993): International Historical Statistics. The Americas, 1750-1988. Second Edition. New York (Stockton Press)

Changes in *food preferences* also have an important impact on global land-use patterns. Before 1450 the coffee bush was an unnoticed plant in Ethiopia. Historical documents show that people began to drink coffee during the fifteenth century in Aden and in Mecca. During the seventeenth century the habit spread to most of the Islamic world. Citizens of Venice had their first cup of coffee around 1615 and people in Paris first enjoyed this stimulant in 1643.[22] In 1991 coffee plantations worldwide took up some 11.2 million hectares.[23]

Coffee is not the only stimulant that affected global land-use patterns. In 1610 a ship of the East India Company brought the first tea leaves to Amsterdam. The British - who became promotion agents for this Asian product during the following centuries -- learned about the new fashion around 1657, when their coffee houses began to introduce the new drink.[24] In the eighteenth century tea became a product of mass consumption, changing the landscapes of Sri Lanka (formerly Ceylon) and northern India. Today, tea plantations cover some 2.5 million hectares worldwide.[25]

In many countries contemporary diets are quite different from diets just a few generations earlier. Chocolate, for instance, whether liquid or solid, was rare in Europe until the nineteenth century. In late eighteenth century Paris only the noble class drank chocolate. There are no records on how much land was used in Mexico (from where the product was imported) for growing cocoa beans at that time, but it was certainly not much. Today, some 5.4 million hectares worldwide are used to grow cocoa beans in order to satisfy the mass appetite for the host of products made from cocoa.

Mass consumption of refined sugar is also a relatively modern phenomenon. Sugarcane was first cultivated in eighth-century China. Starting in the sixteenth century refined sugar was considered food in Europe; earlier it was used in small quantities as medicine. But sugar consumption began to boom only in the twentieth century. Between 1961 and 1990 the harvest area of sugarcane more than doubled. Today, an estimated 17.2 million hectares worldwide are used for growing sugarcane.

Table 5: Lifestyle-related Agricultural Production, 1961-1990

Product	Area harvested (1000 ha)		Percent growth 1961/63–1989/91	Area harvested (percent of total arable land)		Per capita production (kg)		Percent growth 1961/63–1989/91
	1961/63	1989/91		1961/63	1989/91	1961/63	1989/91	
Tobacco leaves	3,620	4,767	31.7	0.3	0.4	1.2	1.4	9
Hops	60	80	33.1	0.0	0.0	0.0	0.0	-11
Tea	1,333	2,454	84.1	0.1	0.2	0.3	0.5	51
Coffee	10,101	11,194	10.8	0.8	0.8	1.4	1.1	-19
Cocoa beans	4,157	5,430	30.6	0.3	0.4	0.4	0.5	22
Sugar beets	7,118	8,599	20.8	0.6	0.6	50.4	57.1	13
Sugarcane	8,993	17,220	91.5	0.7	1.3	140.9	198.2	41
Flax fiber	2,042	1,113	-45.5	0.2	0.1	0.2	0.1	-40
Hemp fiber	703	245	-65.1	0.1	0.0	0.1	0.0	-74
Jute, jute-like fibers	2,471	2,188	-11.4	0.2	0.2	1.0	0.7	-32
Linseed	7,842	3,924	-50.0	0.6	0.3	1.1	0.5	-54
Rapeseed	6,315	18,127	187.0	0.5	1.3	1.1	4.7	313
Sunflower seed	6,855	16,288	137.6	0.5	1.2	2.2	4.2	92
Seed cotton	32,351	33,447	3.4	2.6	2.5	9.4	10.3	10
Sesame seed	5,289	6,451	22.0	0.4	0.5	0.5	0.4	-12
Soybeans	23,998	56,150	134.0	1.9	4.2	8.7	20.1	130
Castor beans	1,287	1,600	24.4	0.1	0.1	0.2	0.2	16
Groundnuts	17,362	20,359	17.3	1.4	1.5	4.8	4.4	-7
Total	141,896	209,635	47.7	11.3	15.6	—	—	—

I have already mentioned the worldwide trend to animal food. Especially in Asia, where many countries have a long vegetarian tradition, a fundamental shift in food preferences is occurring. For instance, in the Far East (which includes all developing countries of East and Southeast Asia) the production of slaughtered meat, hen eggs, and milk increased by 470, 436, and 172 percent, respectively, between 1961/63 and 1989/91 (while the population grew by 80 percent).[26]

Changing food preferences continue to trigger widespread land-use change. Currently the demand for vegetable oils is booming (since dietitians have declared animal fats a risk to our health). As a consequence the sunflower cultivation area more than doubled since 1961, form 6.1 to about 16.2 million hectares worldwide in 1989/91. Cultivation of other oilseeds is also expanding rapidly.

Even China's people are rapidly changing their **food preferences**. In the 1960s the population lived from a diet of rice and starchy roots. 80% of the average daily calorie supply came from these two agricultural products. Meat was extremely rare: it covered just 2% of the daily calorie supply. While animal products contributed just 3.5% to the daily food calorie supply of a Chinese, it made up between 30 and 40% of a European or North American diet. This, however, has changed dramatically. China has increased its meat production almost 10-fold. Today, 8.4 percent of the average per capita calorie consumption in China comes from meat -- mainly pig meat. There is no reason, why China's improvement of living standards should not further change the Chinese diet, which in turn will certainly affect the countries land use patterns.

Table 6: Estimates of World-wide Drug-related Land Use: Cultivation Areas (in Ha)

Worldwide Cultivation Areas, 1993 (in Ha)

	US State Departement (Washington): Cultivated Areas	*United Nations, International Drug Control Program (Vienna): Personal Communication*	Factor
Southwest Asia/1: Opium	27,306	*68,265*	*2.5*
Southeast Asia/2: Opium	195,324	*488,310*	*2.5*
Total Others/3: Opium	42,905	*107,263*	*2.5*
Anden Region/4: Coca	198,893	*497,233*	*2.5*
All Regions/5: Marijuana	27,440	*137,200*	*5*
Total Area (in Ha)	**491,868**	***1,298,270***	

/1 Afghanistan, Pakistan
/2 Burma, Laos, Thailand
/3 Total Others = Colombia, Lebanon, Guatemala, Mexico
/4 Bolivia, Columbia, Peru
/5 Mexico, Colombia, Jamaica, Belize, Others

Source: United States Department of State, Bureau of International Narcotics Matters (1994): The International Narcotics Control Strategy Report. April 1994, Washington; and private communication with members of the UN International Drug Control Program, Vienna.

Many other fashions and habits affect global patterns of land use. Just a few centuries ago the noble elite in Europe began to enjoy a strange form of stimulation (which they learned from the "primitive" people in their colonies): they burned leaves rolled in thin paper and inhaled the smoke. In 1992 tobacco plants occupied some 4.8 million hectares worldwide. It is not known how much arable land farmers devote to the cultivation of coca, opium and other drug plants. By some estimates in a number of countries such plants represent a major claim on arable land. The US Department of State has estimated that the worldwide cultivation area of drugs is close to half a million hectares -- other experts believe it is more than twice as large. Whatever statistics are correct, drug consumption has become a multi-billion-dollar business in Northern America and Europe and has significantly affected land-use patterns in northern Thailand, Burma, Colombia, and a number of other countries.

At least 50 million hectares worldwide are used for the production of lifestyle-related products, such as stimulants, sugar, tobacco, and drugs (see table 5). This is equivalent to some 4 percent of the world's arable land. If the area used for production of oilseeds (such as rape seed and sunflower) is also included, close to 70 million hectares worldwide are taken up by lifestyle-related production. This estimate does not include lands devoted to the production of Soya beans, a crop primarily used for feeding animals. A shift of diets involving heavy consumption of meat is a trend of the twentieth century. Altogether it is not unlikely that some 20 percent of arable land worldwide is cultivated for lifestyle-related products.

In the process of economic modernization many other trends have emerged that can affect global land-use patterns. We should, for instance, investigate the impact of (excessive) packaging and "personal printing" (a side effect of the PC-revolution) on the worldwide paper demand which, in turn, is a important factor of forestry. Not long ago we used to blow our nose or clean the kitchen table with a piece of re-usable cotton; today a huge industry is supplying us with "Kleenex" tissue, toilet paper, paper kitchen towels and a whole range of paper-based sanitary products. We should also study the various types of city and regional development -- ranging from laisse-fair urban sprawl to strictly regulated planning. Limitation of (publishing) space, however, prevents the further discussion of these trends. They are only mentioned to remind the reader that global land-use change is a process which far exceeds the *rural* world of agriculture and forestry.

Conclusion

Let us come back to our initial question: *Who* is changing the land? One thing is certain: it is *not only* the slash-and-burn farmers in tropical rain forests or the logging companies or the high-tech agribusinesses. The list has to be *expanded* to many other sectors and professions. It has to include city planners, tourist managers, land-administration officials, regional planners, drug dealers, food

processing companies, restaurant chains, inventors of high speed personal printers, military planners, mining companies, highway planners, sports and entertainment companies, and many more. Restricting the analysis of land-use change to the three sectors of agriculture, livestock production and forestry would be a serious misconception of the problem.

Perhaps it is better not to ask *who* is changing the land -- because it seems we *all* do it to some degree -- but *which of our (economic) activities* and *preferences* are most relevant to *global* land use change. There is indication that three trends are very important: (1) the worldwide process of urbanization and industrialization; (2) the explosion of individual mobility, trade and tourism; and (3) the fundamental changes in lifestyles, such as the changes in food preferences.

Urbanization causes an *expansion* of build-up areas -- but this is certainly only a *minor* change in terms of the *size* of land affected. Much more important are the *indirect* land-use change effects of a growing urban population. City dwellers need a much more *expanded* supply and service infrastructure than rural populations -- from shopping centers to water reservoirs. They usually cannot build their houses with local products (such as clay or wood) -- steel mills and cement factories are necessary for urban construction. They cannot collect firewood for cooking and heating, but depend on the production and distribution of *commercial* energy. The high *per capita* consumption of energy and material in urban areas affects the urban hinterland in may ways. Cities also need special areas for sewage treatment and waste disposal -- in a village this is often done by reserving a certain spot behind the house.

Industrialization and urbanization are just two sides of a coin. As industrial centers and new labor opportunities emerge rural population moves to the cities. Since industrial wages are usually much higher than rural incomes there is more to spend for the urban population. This growing consumption in turn fuels the growth of a service sector (and administrative bureaucracy). New industrial sites not only need additional space. They also have to be supplied with resources, such as energy, water, minerals. They need expanded transportation infrastructure (roads, railways, harbors), and they produce waste. All of this requires large areas of land. During economic modernization the *primary* function of *land* -- generating the supply of food -- becomes less and less important.

As **consumption** patterns change in more developed (post-industrial) countries new types of land use emerge. People begin to use more land for private houses and recreation; they develop **lifestyles** and **food preferences** which trigger a change in far-away agriculture, such as the increase in the consumption of sugar, stimulants, meat, vegetable oils, or drugs. Higher incomes and increasing leisure time lead to an explosion of tourism and leisure *mobility*. This fuels the further expansion of transportation infrastructures (roads, airports) and the emergence of large tourist areas.

Tables / Charts / Boxes

Box 1: Check List for Studying Land-use Change: **Sectors**

1. Agriculture / Livestock

1.1 ***Expansion* of Cropland**
Globally, there is only *minor expansion* of cropland; on a regional level there is expansion of slash and burn farming into highly sensitive tropical rain forests

1.2 ***Intensification* of Agriculture**
Qualitative changes in land-use: Increase of agricultural inputs, irrigation

1.3 ***Expansion* of Rangeland / Pastures**
Growth of animal populations in East Africa: extensive cattle ranging

1.4 ***Intensification* of livestock production**
Industrial-size production units for pigs and cows: local manure problems

2. Forestry

2.1 **Deforestation**
Clear-cut logging can permanently destroy the forest cover: it can trigger a degradation into marginal land (sometimes into bare rock)
Conversion into arable land, urban areas, sites of infrastructure

2.2 **Modification / Degradation** of forests due to inadequate forest management
Crude logging practices (clear-cut logging in patches); Take-out higher than natural recovery or plantation; changes of ecological quality (age of forest) due to plantation

3. Urban Areas / Cities / Rural Settlements

3.1 **Housing Stock Expansion / Urban Growth**
The urbanization of Asia: 1 Billion urban population in China?

3.2 **Land-use *Quality*** of Urban Areas
Building density, height of buildings, proportion of parks, "green city belts"
zoning laws, minimum acreage,

4. Infrastructure

4.1 **Transportation** Infrastructure
Highways, power lines, dams, pipelines, canals,

4.2 **Supply and Disposal** infrastructure
Water reservoirs, landfills, sewage treatment plants, trade fairs, markets,

4.3 **Recreation Infrastructure**
Golf courses, amusement centres, zoos, parks, gambling caissons, ski slopes, sport stadiums, race tracks, swimming halls, ice skating rings, beach hotels, tourist centres

5. Industry / Resources

5.1 **Production Sites**
Factories, warehouses, car-testing sites

5.2 **Resource Exploitation**
Open pit mining, pipelines, oil wells, oil spills

5.3 Areas of intense **industrial emission / waste deposition**
Areas of nuclear or chemical contamination (*hazardous* waste dumps), (Tschernobyl)

6. Military

6.1 **Military Installations**: barracks, storage sites,

6.2 **Restricted Areas** for combat training, shooting ranges, military research,

6.3 **Combat Zones**: Destruction of vegetation due to military actions (defoliants, massive bombing); areas of restricted access due to the remains of combat (such as mine fields)

6.4 Areas contaminated by **testing of nuclear or chemical weapons**

Box 2: Check List for Studying Land-use Change: **Human Behavior / Lifestyles**

1. Changing Food Preferences

1.1 World-wide increase in consumption of stimulants: Coffee, Tea
1.2 Massive increase of meat consumption in Asia (especially in China), the "MacDonald's" revolution
1.3 Worldwide increase of sugar consumption: Coca Cola; Candy Bars, Milkshakes
1.4 Cholesterol Diets: Transition from animal to vegetable fat

2. Drug Consumption

2.1 Alcohol: Vineyards, hops, tobacco
2.2 Coca, Marihuana, Opium

3. Individual (Leisure) Mobility

3.1 Airports for Mass Tourism, Tourist Centres (Costa del Sol), beaches
3.2 "Go for a ride", Shopping Centres,
3.3 "Taking the Children to School"

4. Sports and Entertainment

4.1 Golf Courses, Race Tracks
4.3 Stadions, Ski Slopes
4.3 Amusement Centres ("Disney Lands"), Zoos, Parks, Gambling Casinos

5. Information and Communication Explosion

5.1 Books, Newspapers / Magazines
5.2 "Personal Printing" (Increase of paper consumption caused by world-wide Personal Computer revolution)

6. Trends in Clothing

6.1 Cotton

7. Hygiene / Sanitation Transition

7.1 Toilet Paper, Kleenex, Paper Kitchen Towels

8. Other

8.1 Excessive wrapping and packaging, chop sticks, advertisements

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[1] Small parts of this text were previously published by the author in: Heilig, G.K. (1994): Neglected Dimensions of Global Land-use Change: Refelctions and Data. In: Population and Development Review, Vol. 20, No. 4, 831-859

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