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Information Requirements for Natural Resource Management with Regard to Remote Sensing

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Approved by

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Contents

Abstract

The overall objective of this study is to:

- identify information requirements of potential user groups of IIASA's Sustainable Boreal Forest Resources (FOR) Project; and
- discuss critical aspects of remote sensing technology transfer.

An internal workshop, including researchers of the Institutional Framework Group (Case Study I) and the Carbon Group (Case Study II), was designed as a platform to identify information requirements specific to these groups. The critical aspects of remote sensing technology transfer that were identified served as guidelines for the workshop design. The workshop is evaluated using the results of a questionnaire provided to the participants.

The results of this study could be used as a decision-support with regard to future remote sensing activities within the FOR project. The critical aspects of remote sensing technology transfer that were identified could serve as guidance for the remote sensing community to improve the potential for remote sensing applications.

The author conducted this work during a three-month period as a participant of IIASA's 1999 Young Scientists Summer Program.

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About the Author

Wolfgang Vrzal attended the Young Scientists Summer Program at IIASA in 1999. His work was accomplished during this three-month period. The author studied Forestry at the University of Agricultural Sciences in Vienna, Austria. He attended the University of British Columbia (UBC) in Vancouver, Canada, as a post-graduate student. Currently Mr. Vrzal is associated with the Institute of Surveying, Remote Sensing, and Land Information at the University of Agricultural Sciences in Vienna.

Information Requirements for Natural Resource Management with Regard to Remote Sensing

Wolfgang Vrzal

1. Introduction

Information requirements of remote sensing user groups are frequently ill represented in the implementation of remote sensing projects. The identification of information requirements is an essential part of any strategy to resolve problems in natural resource management. The motivation to conduct this study was to examine the shortcomings both from theoretical and practical points of view.

The following tasks were undertaken for the theoretical part:

- Characterization of the background of information requirements in remote sensing; and
- Description of critical aspects of the technology transfer problem in the field of remote sensing.

The following tasks were undertaken for the practical part:

- Identification of information needs of potential user groups of IIASA's Forestry (FOR) Project within the frame of an internal information requirement workshop; and
- Linkage of critical aspects of technology transfer to internal workshop.

The following section deals with the background of information requirements in the context of remote sensing.

2. Background of Information Requirements

A myriad of projects related to natural resource management is presently carried out and a vast number of reports and papers have been published as a result of completed research. Nonetheless, scientists, politicians, and the general public raise the question of why human society has so far failed to effectively prevent resource-destruction — a phenomenon frequently associated with poor resource management — despite the financial resources and technical advances allocated to addressing these problems during the last few centuries.

The question raised has been addressed in a number of approaches, i.e., by Ludwig (1994). As guidance to better deal with the issue of resource destruction, Ludwig (1994) proposes to:

- point out the interplay between environmental and social problems;
- clarify the uncertainty in the decision making process;
- be aware of the impossibility to achieve conservation goals by management that attempts to achieve economic optima; and
- recognize the potential ineffectiveness of technical approaches to some problems.

Each of the considerations listed above represent separate research fields. The focus for this study is on remote sensing; a tool frequently used to approach problems relating to resource management in a technical way. A study overview, positioning remote sensing in the context of problems related to resource management, is given in *Figure 1*.

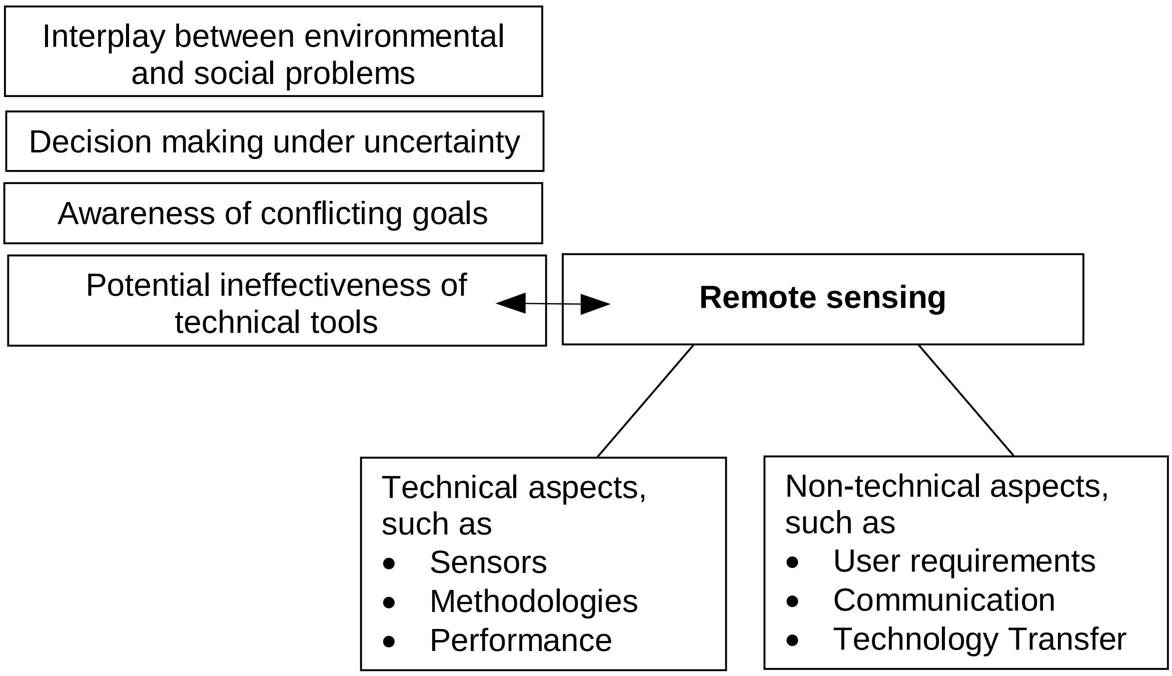

Figure 1: Scope of the study in the context of problems related to natural resource management.

Remote sensing has emerged as a valuable source of information for a broad range of resource-related applications over the last few decades. With the availability of powerful and affordable computers, the development of user-friendly software for image processing, and industry's promise to provide high resolution data (pixel-sizes in the range of 0.5 m) in the near future, the expectations for (satellite) remote sensing as a means for assisting in resource management still grow.

From the point of view of remote sensing, a clearly technical field, it would be obvious to focus on technical aspects of resolving environmental problems. One could examine if the remote sensing tools used for a given problem are appropriate or how effectively the tools are used. This is the center of investigation for many disciplines.

For this study, however, the question is further narrowed to a non-technical issue focussing on the interplay between the provider and user of information generated by remote sensing (Figure 1).

As opposed to widely used approaches of providing information where the focus is on the supply of information rather than on the demand, I started with the information requirements of the user and worked towards an optimal solution to the information requirement by repeating the cycle (*Figure 2*). The ultimate goal was to generate a requirement-driven product instead of a technique-driven product. From this point of view, the success of the transfer of information from the user to the provider of information greatly depends on the communication between the parties involved.

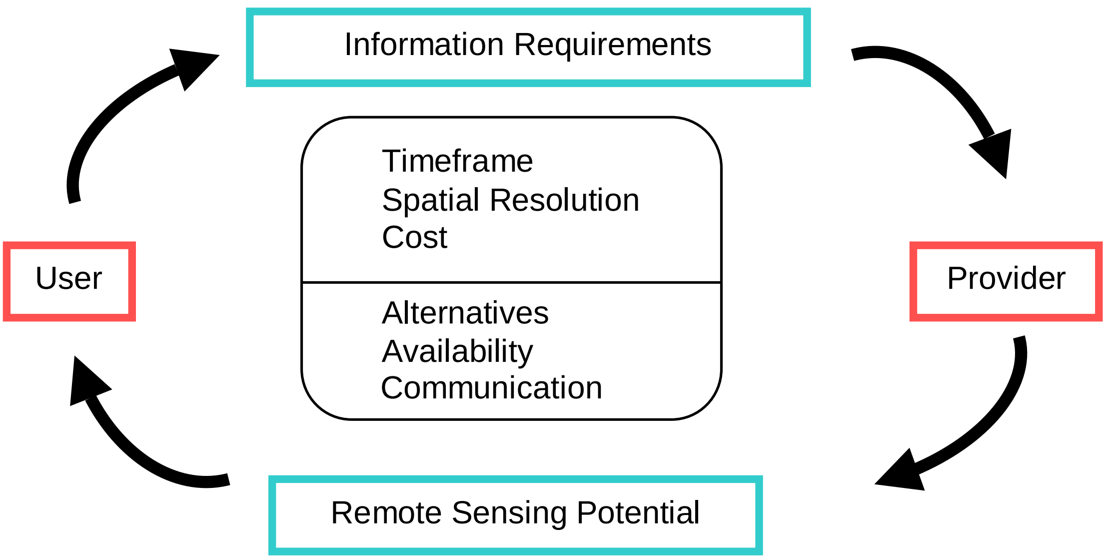

Figure 2: Interplay between the provider and user of information.

A number of critical publications on the role of information requirements stem from within the remote sensing community and reach further back to the late 1970s when Aldrich (1979), for example, identified an “oversell” of remote sensing due to “overly enthusiastic individuals and their agencies” and a credibility gap between the remote sensing community and the user community due to “speculative statements at the end of inconclusive studies quoted out of context”. The author based his conclusions on an extensive review of photographic and non-photographic data (including microwave, radar, thermal infrared, ultraviolet and multispectral scanner) in the context of information requirements for the management of wildland resources.

Holmgren and Thuresson (1998) present another more recent critical review of satellite remote sensing in the context of forest planning.

In describing missed opportunities due to a lack of involvement of the ultimate user in the design and implementation stages of information systems, Baskerville and Moore (1988) suggest to "…spend time and effort in discovering the information needs across decision levels". Analogies to the problematic in remote sensing are obvious and the suggestions by the authors of how to improve the system could — at least in some cases — be well adapted to the field of remote sensing.

3. Critical Aspects of Remote Sensing Technology Transfer

Technology transfer is usually seen as the transfer of the results of research from one organization to another. These organizations may encompass universities, research and development laboratories, government, or the commercial sector, to name a few. Technology transfer processes may take place on different scales encompassing local, regional, national and international levels. Actors on the local level could, for example, be a small consulting enterprise generating a vegetation map from aerial photographs and implementing the map in a GIS system for a local landowner. Actors on an international level, on the other hand, could be a multi-national research consortium involved in technology transfer to some other country.

In addition to the scales described above, another dimension is added to the problem of technology transfer by the nature of remote sensing. Remote sensing can be characterized as a discipline that is highly technical with applications in many different areas. This diversity, both in operation as well as in implementation, makes the problem of technology transfer from the provider of the information to the end user a complex task.

Transfer processes in remote sensing are manifold due to the different organizations involved, and the scales and diversity of applications. An ideal transfer process can be characterized as follows: In the first phase, image pixel values are transformed into meaningful spatial information (e.g., land use categories). This is a largely technical process with both provider and user of the information collaborating. In the second phase, the focus shifts from the provider to the user of the information, who then implements the product on a level of decision-making. This may result in management plans or policy recommendations, to name a few.

Bearing in mind the process outlined above, it becomes clear that discontinuities in the information flow between provider and user of information must be avoided in order to carry out the transformation process successfully. A key issue in remote sensing — how to bring the information to the user — crucially impacts the success of technology transfer.

In the following section critical aspects of remote sensing technology transfer, which were previously identified and then used for designing the user requirement workshop, are highlighted with the aim of providing a useful perspective on the system.

3.1 Transfer Mechanisms

Mechanisms of technology transfer can be grouped into a number of classes according to the intensity of collaboration between the partners involved in the process. A characterization of technology transfer mechanisms can be found in *Table 1*.

Table 1: Technology transfer mechanisms (modified from NTCC, 1999).

Mechanism	Expectation	Format
Collegial Exchange of Information	Informal and free exchange of information	Publication Presentation at Conferences Workshops
Consulting to an institution	Party from outside an institution provides advice and/or information	Formal contract, generally short term
Consulting by an institution	Consultation provided to a party outside an institution	Formal contract, generally short term
Exchange Program	Exchange expertise and information	Transfer of personnel either to or from the institution, usually for a longer period of time
Contract	Provide supplies or services	Long term contract

The mechanisms, ranging from the informal exchange of information to formal contracts, represent a set of opportunities for the remote sensing community of how to collaborate with the customer. The format of collaboration will largely depend upon the scope of the project or on the project stage.

Collaboration is especially important in the early stages of a project where organizational aspects must be identified and goals defined. One such collaboration could be a workshop where information requirements and the potential of remote sensing to meet the needs specified by the customer are identified. However, collaboration could also be within the frame of a short term consultation provided by the project partner or result in the transfer of personnel for a longer period of time.

From a remote sensing point of view, it might be not only useful but also necessary for a successful project to establish a mechanism of technology transfer with potential users of remote sensing information. This is due to the multidisciplinary nature of remote sensing. Remotely sensed information is obtained in the form of electromagnetic signals. For most applications, this ‘raw material’ must be translated into information that is meaningful to the end user — a task that can be pursued in two ways. Either the technical — remote sensing — personnel has competence in natural sciences, or the customer provides the required expert knowledge, covering the natural aspects.

3.2 Technical aspects

Technical aspects of remote sensing technology transfer relate to issues around hard- and software for data processing, data transfer to the end user, data products and their format, etc.

More detailed information on technical issues of remote sensing technology transfer can be found in Specter (1989).

3.3 Non-Technical Aspects

In addition to the technical issues associated with technology transfer, environmental aspects should be considered in order to make the transfer effective. These are non-technical in the sense that they concern issues relating to communication, organizations, and competition rather than remote sensing technology questions. The importance of these non-technical aspects is stressed by Specter (1989) who proposes a “broader view of the transfer process”.

Such aspects include the ability to:

- identify research or information needs;
- establish and maintain linkages to potential project partners (communication);
- produce high quality products;
- establish and maintain trust; and
- compete on the market-place.

Each of these issues is addressed in detail below.

3.3.1 Identification of research or information needs

Research needs must be identified to ensure that the technology, methodology, or information developed matches the customer’s needs. In this context, it has to be known what research relevant to the field is taking place. This, in turn, is important in seeking alternative solutions.

It is furthermore important to involve potential customers in the early stage of research where research definition takes place. The process of identifying research and information needs could represent a good starting point for building communication networks.

Efforts in establishing channels of communication to bring the information requirements into the remote sensing institutions have been made recently through workshops.

A user requirement workshop was held in 1994 by the Committee on Earth Observation Satellites resulting in the "Database on User Requirements and Space Capabilities" (CEOS, 1999). The primary focus of the database is to "establish a bridge between information providers and users". This is realized by having the user-community submit information requirements to the database and space agencies supply information on programs, systems and instruments. An effort to establish a common language between the two parties has been made by defining guidelines that contain agreed definitions of required and offered parameters. The database is updated continually and revised in intervals and can be transferred to a local computer system via the Internet.

A user requirements study for remote sensing based spatial information for the sustainable management of forests was carried out by ITC (ITC, 1998). The objective of the study was to assess the information needs of identified stakeholders and to translate these needs into system requirements. The extent to which the identified information requirements can be met by both present and future remote sensing technology was assessed. To review the results of the user requirements study in detail would be behind the scope of this study. This is due to the diversity of both the information needs identified and the remote sensing systems relevant for applications in sustainable forest management. For more detailed information see Work-Package 6 of ITC (1998a).

3.3.2 Communication

If the focus of development is on products that can be implemented, then emphasis is placed on communication between provider and user of information. Information channels and networks should be established between the remote sensing community and its partners involved in technology transfer activities. Communication can take place in different forms, ranging from informal meetings to written reports. It should be handled flexibly and has to be clear throughout the whole the project.

Concepts adapted from the Technical Communication field (a field that combines elements of writing, teaching, science, technology, multimedia, and business) could be applied to the communication problem at hand.

The basic guidelines that technical communicators endeavor to follow (Anderson, 1998) are to:

- understand the needs, values, background knowledge, fears, and general situation of their counterpart; and

- communicate these factors to their audience.

This translates more or less into making information very accessible and easy to understand. Ways to achieve this are to include only relevant information for the particular situation, include only relevant information for the particular audience in question, and respond to the particular problems, concerns, and fears of the audience.

Applied to the relation between the end-user and the provider of information (such as remote sensing agencies, research institutes involved in processing remote sensing data, consulting companies, etc.) the concepts outlined above could contribute to improved dialogue between the parties involved. It is assumed that the dialogue, in turn, will help to develop trust between the parties involved and lead to a better product despite the time, cost and effort caused by the dialogue.

3.3.3 Quality of the product

Dean (1995) stresses the importance of quality as a major factor in competitive advantage.

The quality of a product is determined by the standards set by the customer and by the ability of the provider to meet the customer's needs. These standards could be specified in terms of land cover categories to be identified, timeframes set for the provider to generate the information requested, or descriptive measures such as image classification accuracy, to name a few. A product may still be of high quality from a scientific or market point of view, but if it does not meet the needs specified by the user it cannot be regarded as a high quality product in the context of user requirements.

3.3.4 Trust

Technology transfer is an activity carried out by people. Therefore it can only be successful if the parties involved trust each other. The issue of trust relates directly to communication, both impact each other. Finegan (1994) elaborates in a case study of technology transfer on negative preconceptions that build barriers to technology transfer. These barriers include, among others:

a) The reluctance to accept the experience of other disciplines (also referred to as the "not one of us" syndrome, or the "not invented here" syndrome).

b) The belief that universities still live in an ivory tower world, and as such cannot have an understanding of the needs of the "real world".

The issue of trust not only applies to the human dimension of technology transfer as described above, but also to the product itself. From this point of view, it translates into a question of confidence in the product, which can be described in various ways. One such description, in a statistical sense, is by measuring the classification accuracy of satellite images. It should also be considered that a more "general" level of confidence in a product, which is not expressed by numbers and therefore difficult to capture, might be described by evaluating the basis of the product.

A high level of confidence in the product could, for example, result from the trust that the product is based on a sound fundament (which may include information requirements identified by the user). Avoiding black-box situations by providing background information (work-progress, etc.) to the user of information may also foster trust.

3.3.5 Competitive advantage

The critical aspects of technology transfer outlined above are interrelated. The identification of the user's needs goes hand in hand with the establishment of communication networks, the quality of the information channels in turn impacts the level of trust that is created. Each of these factors contributes to the competitiveness on the market. Therefore, competitiveness could be seen as a product of these factors with additional entrepreneurial elements, such as a commitment to innovation or an adequate relationship to risk playing a role.

Opportunities, such as access to unique and/or cheaper data sources or the association with an already existing and successful research consortium, could lead to competitive advantages.

Another important driving factor on the market is cost. In order to be competitive, the product must usually have either lower cost or higher quality to withstand competition. With regard to remote sensing, it will be seen in the near future if the anticipated reduction of data costs (Reichhardt, 1999) will translate into competitive advantages for the remote sensing community.

In order to produce a high quality product, highly qualified staff is needed. Looking at the competitive advantage from this point of view, it is easy to understand that there are challenges of education, training and organizational structure associated with it (Forster, 1990). Not only awareness of the problems associated with technology transfer is required, but also training and education has to be provided in this specific field. An assessment of needs, demands and priorities of specific target organizations in the domain of Sustainable Forest Management was carried out in an international framework by the International Institute for Aerospace Survey and Earth Sciences (ITC, 1998b) in order to develop its educational and research strategy for the future.

3.3 Conclusion

Technology transfer not only includes issues of technical capabilities of remote sensing, it is rather a discipline with a strong human component, making the process of technology transfer even more complex.

Critical aspects of remote sensing technology transfer are

- identification of research or information needs;
- communication;

- quality of the product;
- trust; and
- competitive advantage.

Remote sensing technology transfer can only be successful if these critical aspects are considered.

4. Information Needs of Potential User Groups of IIASA's Sustainable Boreal Forest Resources (FOR) Project

4.1 Introduction

This section is organized with regard to satellite remote sensing in the context of research issues of IIASA's FOR[1] Project. The question of what are the information requirements of the Institutional Framework Group (referred to as Case Study I) and the Carbon Group (referred to as Case Study II), is addressed.

The importance of giving information requirements adequate attention in the context of natural resource management was outlined in previous chapters. For IIASA's FOR Project, the primary aim of the information requirement study is to provide information requirements of the specific fields chosen. The study could furthermore provide guidance to:

- assist in identifying information requirements of future fields of activities, and
- help to keep the focus primarily on information requirements and not on tools or technically available methods to extract information from any sources.

4.2 Information Requirement Workshop

4.2.1 Purpose

The information requirement study was designed in a way that it used the experience of potential users of remote sensing products in the frame of an IIASA internal workshop. The active involvement of the user was a core aspect of the study.

The motivation to include two different user groups was based on the following facts:

- Representatives of both groups were available for collaboration at IIASA during the period of study, which represented a unique opportunity.
- Different user groups represented a wide range of information requirements. Designing the workshop according to a number of groups rather than

[1] For more information see: http://www.iiasa.ac.at/for

concentrating on one specific group made conclusions of general aspects such as technology transfer issues, communication, etc., valid for a broader range of applications.

4.2.2 Design

The workshop organized for this study was designed not only as a source of information to define information requirements, but also as a platform to bring together the technically trained specialist with the ecologically oriented user or political scientist. Issues such as language barriers due to training in different fields, as an example, could be addressed.

A catalogue of questions was created to assist the user in identifying information requirements (Appendix 1). Issues such as area of interest, updating-cycle, and application, etc., are covered in this list. The function of the question-catalogue was to serve as a guideline for the user and not as a filter between the provider of the information and the user.

In addition to the questions covered in the catalogue, other important considerations were:

- the given timeframe to complete the task;
- the cost involved in obtaining and processing data;
- the availability of human resources and infrastructure to process the data or information; and
- the potential for alternative options to obtain the information desired.

The information requirements were identified in an iterative process. After the first workshop sessions, the user groups received feedback from the provider of information (represented by the conductor of the study) on the feasibility to derive the parameters identified from remote sensing. Then, the user groups and the provider entered into dialogue again and worked towards a refinement of the previous approximation to the solution.

In order to evaluate the critical aspects of remote sensing technology transfer with regard to this study, the results of the workshop and a questionnaire designed specifically for this study (Appendix 2) are used. The results are summarized in Section 4.5.

4.3 Case Study I — Information Requirements of the Institutional Framework Group

4.3.1 Background

IIASA's Institutional Framework Group is involved in a series of case studies in the Russian Federation analyzing institutional issues of the forest sector.

The participants of the information requirement workshop conducted interviews with forest representatives. The insights into the institutional issues gained through these interviews are translated into information requirements for this study.

4.3.2 Information requirements identified

The information requirements that were identified are shown in *Table 2*. The requirements are ranked by priority. The potential of remote sensing to meet the user's information need is grouped into the categories feasible (F), partially feasible (P), and not feasible (N).

Table 2: Information requirements identified.

Information Requirement	Remote Sensing Assessment
Forest Industry Information *production by individual industry,* *location and number of industries,*	P
Independent Check of Harvest Areas *check by type (clear-cut, sanitation, etc.)* *and volume*	F
Forest Fires and Diseases	F
Forest Pollution *source, type and area damaged*	P
Transportation Infrastructure *location and condition of roads, railways,* *seaports, rivers, etc.*	F
Market Information for producer *not resource related, but customer related* *information*	N
Single Source of Information for Potential Investors *"information package" with economic-,* *legislative-, and transportation parameters*	P
Forest Growing Stock	F

4.3.3 Discussion

The information requirements identified can be divided into two major groups encompassing parameters that can be:

- measured directly using remote sensing methods (e.g., location of forest fires), and
- inferred from remote sensing measures (e.g., information for foreign investors).

Most parameters identified by the group do not relate directly to forest resources, but rather to the social system and institutional issues. Most of these socio-economic parameters do not represent themselves spatially on the surface and are therefore difficult to measure using remote sensing.

An important factor in the context of communication that deserves attention is the expectation of the user versus the remote sensing capabilities to meet the needs identified. For this study, the user's expectations in remote sensing can be considered high. This is reflected in the information requirements identified, e.g., "Market information for producer". The high expectations are an indicator of the importance of the dialogue between the provider and the user of remote sensing information.

4.3.4 Conclusions

The results of the workshop show that remote sensing has low capabilities to serve as a data source for institutional framework issues. Only a limited number of information requirements can be satisfied using remote sensing techniques. The socio-economic parameters, in particular, cannot be assessed directly by using remote sensing. Statements regarding these information needs can be made when the parameters under investigation are linked to measures which can be inferred directly via remote sensing. Infrastructure, such as roads, is among the exceptions.

An evaluation of critical aspects of remote sensing technology transfer is given is Section 4.5.

4.4 Case Study II — Information Requirements of the Carbon Group

4.4.1 Background

In the framework of the Kyoto Protocol and the UN Framework Convention on Climate Change, IIASA's Sustainable Boreal Forest Resources (FOR) Project is carrying out a full carbon account for Russia, Austria, and Ukraine in collaboration with the Environmentally Compatible Energy Strategies (ECS) Project.

The full carbon account is defined by Jonas *et al*., (1999) as a "full carbon budget that encompasses and integrates all (carbon-related) components of all terrestrial ecosystems and is applied continuously in time (past, present and future)." It is, in contrast to partial carbon accounting as promoted by the Intergovernmental Panel on Climate Change (IPCC), a holistic approach (see *Table 3* for comparison). For more details on full carbon accounting see Jonas *et al*., (1999).

Table 3: Characteristics of carbon accounting systems (from Nilsson, 1999)

Partial Carbon Account (IPCC)	Full Carbon Account (IIASA)
• only accounts for fluxes into the atmosphere • does not measure pools • only estimates human-impact areas	• Integrates all terrestrial ecosystem pools and fluxes

Satellite remote sensing is a potential source of information for assessing carbon pools and fluxes. It may furthermore play an important role in reducing uncertainty referring to both data status, e.g., level of accuracy of forest inventory, and data processing, e.g., level of consistency of land-use/cover databases (Jonas *et al*., 1999).

4.4.2 Information requirements identified

The following information requirements have been identified (*Table 4*).

The requirements are ranked by priority and the potential of remote sensing to meet the user's information need is assessed in the same manner as for the Institutional Framework Group.

Table 4: Information requirements identified.

Information Requirement	Remote Sensing Assessment
Land use/land cover classification Agriculture — Pasture — Meadow — Arable land Forestry — type: conifer deciduous Wetlands — swamps — bogs	F
Forest growing stock	P
Disturbances in forestry — harvesting — fire	F
Changes in agricultural land use	F
Amount of harvesting in agriculture	F
Litterfall	N
Soil organic matter	P
Soil carbon content	P
Annual increment forest stands	N
(Direct) measures of carbon content	P
Carbon contents of trees, needles, sub-terrestrial biomass	N

"F" indicates feasible, "P" partially feasible, and "N" not feasible.

4.4.3 Discussion

Carbon accounting requires an accurate representation of the land surface. Furthermore, resolution determines the accuracy of the land surface representation, among other things, the accuracy of carbon modeling processes.

Not only the actual land cover, but also disturbances caused by fire or harvesting is of interest to the Carbon Group.

The requirement for accurate measures of forest growing stock, annual increment of forest stands and litterfall is rooted in the need to convert these changes into carbon measures.

Different levels of resolution may require the implementation of multi-sensor approaches. For large-scale categories, such as forest, low-resolution sensors may be sufficiently accurate. One weakness of low-resolution satellite data (e.g., AVHRR) though is the insufficient spatial allocation of features, which are too small to be captured but relevant for a given problem. In the case of carbon accounting, swamps and bogs are important features is due to their high carbon content. A multi sensor approach, allowing the integration of high-resolution sensors is needed in this case to adequately describe the land use/land cover categories.

With the potential to reconstruct land cover patterns using archived data, remote sensing has the potential to assess changes in land use/land cover using multi-temporal data sets. Disturbances caused by fire or harvesting in forestry can be estimated using remote sensing.

Requirements such as the carbon content of trees, needles, sub-terrestrial biomass or direct measurements of soil carbon contents indicate that the expectations for the remote sensing potential were extremely high.

4.4.4 Conclusions

Based on the results of the workshop, it can be stated that remote sensing has much potential to support carbon accounting. The information requirements associated with carbon accounting, as identified in this study, can be fulfilled partly by remote sensing.

Remote sensing for carbon accounting has not only potential in the assessment of ecosystem categories and the changes to these categories, but also in the quantification and reduction of uncertainties associated with existing data. Advanced remote sensing inventory techniques could contribute to a more accurate reflection of reality resulting in more accurate modeling results of biospheric processes relevant to full carbon accounting. Other aspects of uncertainties in carbon accounting, such as issues that are specific to the Kyoto Protocol, individual and combined effects of uncertainties, or up-scaling of data to higher spatial levels are discussed in Jonas *et al*., (1999).

An evaluation of critical aspects of remote sensing technology is given in the following section.

4.5 Evaluation of Some Critical Aspects of Remote Sensing Technology Transfer

In this section, some conclusions are drawn from the evaluation of the questionnaire that was provided to the workshop participants (Appendix 2). Despite the high return rate of 83%, it should be stated that the results are limited to this study for the most part due to the relatively low number of participants involved in the workshop. On the other hand, one could put forward that the number of workshop participants (for this study, six) is within the range of an average-sized remote sensing project. This is true even for larger sized projects, if the different groups involved are considered by one or two representatives.

The overall rating for the quality of the dialogue between the provider and the user of the information is very good. There is an indication of communication problems due to different professional backgrounds and technical languages used.

It is assumed that the overall satisfaction of the user with the presentations during the workshop, the material provided, and the organization of the workshop contributes to a high level of trust.

5. General Significance of the Study

Institutions involved in remote sensing face the challenge to continually renew their research agendas due to the dynamic nature of both remote sensing and the environment. With regard to remote sensing, it should be considered that the development of remote sensing systems and data processing methods is an ongoing process. Advances in remote sensing, such as the implementation of high-resolution sensors, are examples of how quickly the focus of our environmental considerations can change.

With respect to the environment, we should bear in mind that our scientific understanding and furthermore our awareness (including our information needs) are subject to change, sometimes influenced by trends. Moreover, changes do not only occur from the human perspective, even the objects under investigation, the environmental states and processes, change over time at different rates.

In light of these dynamic aspects of remote sensing applications, it is obvious that the assessment of information requirements of potential remote sensing user groups is an essential component of any remote sensing institution's strategy to outline competitive advantages and define fields of research activities. The critical aspects identified during the course of the workshop could serve as guidance for the remote sensing community to improve the potential for remote sensing applications. Giving adequate attention to these critical aspects could provide a better understanding of the issues relating to remote sensing information requirements and technology transfer.

Information requirement studies could furthermore contribute to the definition of specifications for monitoring performance of existing remote sensing systems and the design of remote sensing systems for specific applications relating to natural resource management.

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Appendix 1: Catalogue of Questions to Assist the User in the Identification of Information Requirements

Characteristic of the Information Requirement	Description, Example
Qualitative	Species composition of forest stand
Quantitative	Growth rate
Descriptive	Interpretation of aerial photos
Information Carrier	Analog – paper map Digital – GIS dataset
Measurement Scale	Hectare
Accuracy	High, medium, low
Spatial Scale	1:10.000
Area of Interest	Whole region, local application
Period of Validity of Information	1 month, 5 years
Timeframe to provide information	1 month,
Up-dating cycle	5 years
Frequency	Mono-temporal, multi-temporal
Temporal Variability	Reflects current situation or expresses potential
Cause	Dynamic, static
Nature of characteristic	Human, natural
Application (why is the information needed)	Assessment, planning, mapping,
How will the information be used	Combined with other data
User of the information	Scientist, policy maker

Appendix 2: Evaluation of the Questionnaire

The participants of the workshop are referred to as “users of information” and the conductor of the workshop is referred to as the “provider of the information”.

The ranking is defined as follows:

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

“Replies” indicates the number of people that assigned the corresponding ranking to the respective question.

I) Presentations / Introductions

I was satisfied with regard to the content of the presentations.	Ranking	1	2	3	4
	Replies	**1**	**4**		
I was satisfied with the quality of the material presented.	Ranking	1	2	3	4
	Replies	**2**	**3**		
The role of the workshop within the overall project was defined clearly.	Ranking	1	2	3	4
	Replies	**1**	**2**	**2**	
The statement of the goals and objectives of the workshop was understandable.	Ranking	1	2	3	4
	Replies	**1**	**4**		
The user’s role was defined clearly.	Ranking	1	2	3	4
	Replies	**1**	**4**		

II) Material Provided

The material provided was sufficient.	Ranking	1	2	3	4
	Replies	**1**	**3**	**1**	
I would have preferred more background information.	Ranking	1	2	3	4
	Replies	**1**	**1**	**3**	
I would have preferred a more thorough information process before the workshop.	Ranking	1	2	3	4
	Replies		**1**	**3**	**1**

III) Organization of the Workshop

The way the workshop was carried out was too formal.	Ranking	1	2	3	4
	Replies		**1**	**2**	**2**
I was satisfied with the roles and responsibilities I had during the workshop.	Ranking	1	2	3	4
	Replies	**3**	**1**		
The schedule was adequate (time for discussion, group-work, etc.).	Ranking	1	2	3	4
	Replies	**1**	**1**	**2**	

IV) Discussion / Dialogue

The quality of discussion (dialogue between provider and user of information was good).	Ranking	1	2	3	4
	Replies	**2**	**3**		
There was a communication problem due to the technical (remote sensing) language used.	Ranking	1	2	3	4
	Replies		**2**	**2**	**1**
There was a communication problem due to the technical language you used to describe your information needs.	Ranking	1	2	3	4
	Replies		**2**	**3**	
Sufficient time was allowed for discussion.	Ranking	1	2	3	4
	Replies	**4**	**1**		
Guidance of the discussion was good.	Ranking	1	2	3	4
	Replies	**4**	**1**		
I had sufficient opportunities to express my opinion.	Ranking	1	2	3	4
	Replies	**4**		**1**	
I would trust the provider of the information and accept him as a research partner in a project covering the remote sensing part.	Ranking	1	2	3	4
	Replies	**2**	**2**		

V) General Issues

The topic / workshop was relevant to my summer-project at IIASA.	Ranking	1	2	3	4
	Replies	**2**		**3**	
The workshop did actually contribute to my ongoing project.	Ranking	1	2	3	4
	Replies	**1**	**1**	**3**	
The topic/workshop is relevant for my future work.	Ranking	1	2	3	4
	Replies	**1**	**3**	**1**	

What have I learned that I did not know before:	“some ideas about remote sensing”. “capacity of remote sensing”. “possibility of using remote sensing”. “technology transfer”.