Chapter 12

Use and Users

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Introduction

Geoinformation systems and information products need to be adjusted to their uses and users. This can be considered as a design process to which we can apply a systematic approach (see Figure 12.1). Who exactly are *users* of spatial information? One view could be that users are those who use a system without the complete technical expertise required to fully understand that system. As most GIS and EO applications are complex, and since almost all maps today are produced by some combination of GISs and EO methods, by this definition virtually anyone who has ever looked at a map is a user: there will be components of the hardware, software, and management or data systems that even an expert is unlikely to fully understand.

At the same time, it would be wrong to think of a user as somebody who sits at the end of the research chain and is only fed information from various flows of observed or derived data. After all, as a recipient of spatial information, the user could have an important role in defining what information should be generated, as well as in what form it should be presented. Moreover, it is often difficult to distinguish the producer of information from the consumer of that information. Perhaps the term stakeholder, which has also been used in the discussion on governance in Chapter 1, is more appropriate, as it connects the use of spatial data and information to an identified issue for which access to and use of spatial data and information are considered to be relevant and important.

It is clear that enormous volumes of data are being generated. This phenomena was identified by the editors of a special 125th anniversary issue of the prestigious science journal *Science* entitled "What we don't know" as a significant scientific challenge.

Among other things, the editors posed 25 key scientific questions, one of which was "How will big pictures emerge from a sea of biological data?" [90]. Such a question can be easily broadened to "How will big pictures emerge from a sea of data"!

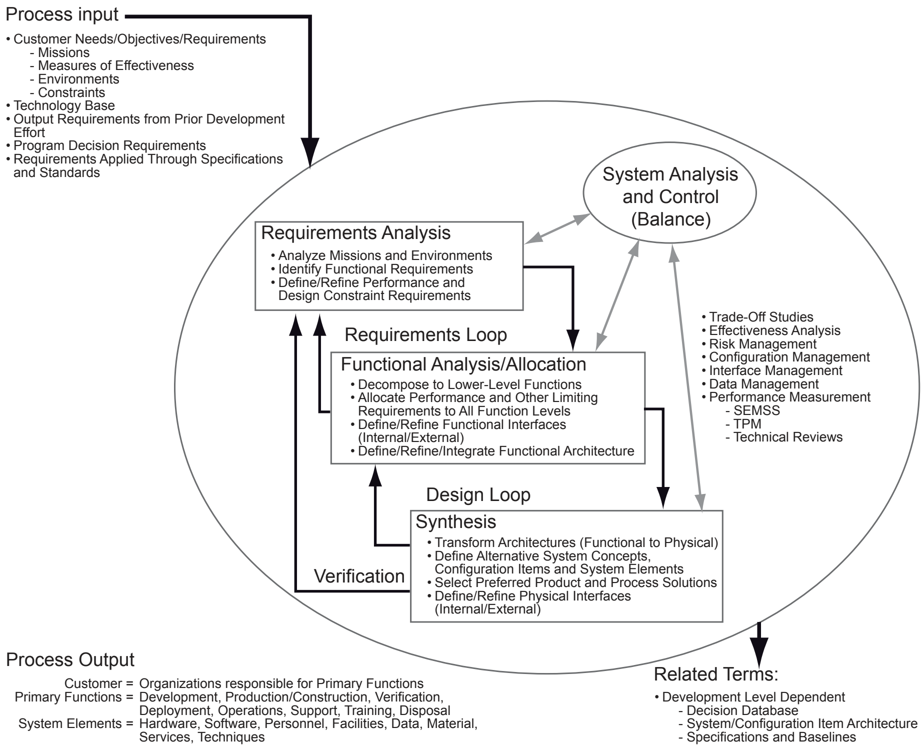

Figure 12.1
Systematic approach to the design of a new product for the consumer market

The objective of this chapter is to illustrate the enormous variety in applications of spatial information in daily life. Each application is of course derived from people perceiving a lack of spatial information related to a specific problem. After reading this chapter you will be able to explain a number of problems for which the solutions require spatial information. You also will be able to identify the stakeholders involved and their information needs. Each section in this chapter on *Uses and users* will, therefore, define the problem, describe characteristics of stakeholders involved and discuss responses or, where applicable, possible solutions. It is important to note that the usability of any system's products is determined by how practical and convenient the capability of that system is for users. In other words, a specific geoscience application becomes truly useful only when it provides a solution to a broad societal problem (such as a navigational aid, as described in one of the following sections, helps us optimizing our travel between locations given constraints such as road and traffic conditions.

There is a great deal of geographically referenced data available that is generated by Earth Observation, as well as other sources such as censuses and field observations. These data need, firstly, to be grouped, analysed and processed in order to generate useful information. In other words, to provide answers to *how*, *what*, *where* and *when* questions. The application of data and information allows us to answer *how* questions—for example, we can show *how* a remotely measured indicator such as the NDVI (Chapter 9) is related to green vegetation biomass (i.e. a linear relationship that saturates with an asymptote at higher levels of green vegetation biomass). The next level is an understanding of *why* a phenomenon occurs—for example, *why* NDVI is linearly related to green vegetation biomass. *Where* and *when* questions are of course the obvious ones in a GI Science context. Finally, we can use this understanding to come to a "wise" conclusion, such as predicting food production in an area and, if a food shortage threatens, to carefully consider options for short-term and long-term alleviation of that shortage. Such information products are therefore important inputs for the governance of famine relief efforts.

Applications may vary in their level of complexity. Multiple users may access geoinformation generated for applications as diverse as the assessment of flooding hazards, monitoring the condition of coastal defences, or managing nature conservation areas. Sometimes access is structured via GIS interfaces, specifically designed for multiple users. These issues are discussed in some detail in Sections 12.2-12.4. In Section 12.5 a further level of complexity is illustrated with the description of a flexible geoinformation application designed to allow multiple users in the Netherlands who are interested in spatial planning to exchange digital spatial plans at a national level.

12.4 Nature conservation

12.4.1 Introduction in nature conservation

Nature conservation aims to conserve nature areas and the ecosystems they contain. If not properly protected, nature areas could be converted into agricultural land or subjected to urban sprawl. Or they could be utilized to an extent that structurally damages the functioning of the ecosystem, for example through deforestation or overgrazing. Sometimes, "new" nature is created when agricultural areas are abandoned, when land is reclaimed from the sea, or when reforestation projects are carried out in degraded areas. Then, these areas also need proper management and protection. Overall, in all nature areas, nature conservation aims at ensuring that biodiversity in these areas is maintained, that natural processes in the system continue and that ecosystem benefits are retained.

Two situations are often found in nature areas. In the first situation, nature areas cover large expanses such as African game parks. In the second situation, nature areas are embedded in a land-use matrix of areas that are intensively or extensively used by humans. In the latter case, agricultural areas often surround the nature areas, although urban sprawl sometimes surrounds a park (e.g. Nairobi National Park). In both situations, to effectively conserve these areas, spatial information is essential for making the right management and conservation decisions. Spatial information can help in monitoring the status of the system, prioritizing areas requiring the most attention or investigating the connectivity and remoteness of isolated nature patches in the landscape matrix.

Collecting relevant spatial information for nature conservation is, however, not an easy task. Firstly, nature areas can cover large expanses of land or be embedded among other types of land use. In either case information covering large areas is required. Earth observation from aircraft and satellites has revolutionized the way data from large areas are collected in a consistent and repeatable manner. Secondly, changes in nature areas are often slow, making those changes difficult to observe instantaneously. Collection of long (in the order of decades) series of data is then necessary to quantify the rate of change in a natural system. Historical archives containing aerial photos and old satellite images provide a valuable resource for assessing the state of natural systems in the past. Finally, collecting field information based on point observations is often only useful when the point's exact geographical position is known—to be able to relate it later on to other spatial data sets. In nature areas, however, landmarks are not always readily available, making it difficult to pinpoint one's position. With the advance of small hand-held devices that can receive GPS signals, this task has been considerably simplified and accuracy improved. In short, geographical information is essential for nature conservation and collecting this kind of information has become easier and its quality higher with the advance of EO sensors and GPS devices.

12.4.2 Users and user requirements related to nature conservation

Nature conservation usually involves various stakeholders. To facilitate discussion between all stakeholders, to quantify the impacts on and from nature areas, and to prioritize areas and actions by the different stakeholders, nowadays it is essential to have access to spatial data from the nature areas and their surroundings. As they provide the means for processing that spatial data, GI Science tools have acquired a pivotal role in optimizing nature conservation.

Typical stakeholders in the field of nature conservation are non-governmental organizations (i.e. NGOs such as WWF and Conservation International). Other important players are national and lower-order governmental bodies (e.g. a state forestry department) and international bodies that originate from supra-national organizations such as the UN (e.g. the International Union for Conservation of Nature IUCN). These kinds of parties all have conservation of nature as a common goal.

There are other stakeholders that make claims on nature areas but they do not have nature conservation as one of their primary objectives. Indigenous people, for example, often claim land-use rights or ownership of areas that have been assigned a nature conservation status. Additionally, within a national government different ministries can claim responsibility for, and therefore authority over, the same piece of nature, e.g. a ministry of agriculture and a ministry of forestry. Next to various parties that make direct claims on using or managing nature areas, there are many parties that live next to these areas that are directly or indirectly affected by the natural processes occurring in these areas. For example, cattle herders living next to game parks sometimes experience loss of livestock by predators from the neighbouring game park, representing a negative effect of nature areas on surrounding communities. Positive examples of nature areas exist as well, for example where villagers are protected from landslides by forested slopes that retain and regulate the runoff of rainwater in a catchment area.

Surrounding communities often have a negative impact on nature areas, caused, for example, by poaching or illegal collection of fuel wood. But positive benefits also exist, for example where communities earn revenues as tourist guides and in return actively help in protecting the area. Finally, often research organizations also have an interest in nature areas: they often try to gain access to data from these areas and acquire permission to perform experiments and gather observations from within these areas.

For stakeholders with nature conservation as their primary objective, GI Science provides important tools for conservation management. In their discussions with other stakeholders, it often serves as a useful tool for communication and for making arrangements, e.g. to negotiate access rights to specific areas. And for the research community, spatial information often helps in finding relationships between natural processes that occur at the same locations.

Applications of GI Science in nature conservation are extremely diverse. Therefore it is impossible to describe all of them. This Section illustrates three examples of use and users of GIS and RS applications. Each of them deals with one of the major stakeholders in nature conservation: an NGO (Subsection 12.4.3), a government organization (Subsection 12.4.4) and a research organization (Subsection 12.4.5).

12.4.3 Use of spatial information by an NGO: Natuurmonumenten's vegetation-structure map of Witte Veen.

Natuurmonumenten is an NGO with 880,000 Dutch members. They manage over 100,000 ha of nature areas in the Netherlands. One such nature area is the Witte Veen, 10 km south of Enschede, which links up with a nature area in Germany. Hans Gronert, employed by Natuurmonumenten, explains: "Together with German colleagues we are trying to connect this area to the nearby nature areas of Aamsveen and Haaksbergerveen, as well as other neighbouring nature areas. Our management approaches are grazing with Scottish Highland cattle to keep the area open, removal of topsoil to maintain the nutrient-poor environment and the promotion of frog pools in agriculture areas as stepping stones for amphibians. To be able to set up our management plans and to monitor their effect we need vegetation-structure maps. A few examples of rare species that can be found in the Witte Veen area are the European tree frog, common cotton grass and blue gentian."

Hans Gronert, a forester employed by Natuurmonumenten, is involved in nature management of the nature area of Witte Veen. His main task is to optimize and maintain the biodiversity of this area.

The Province of Overijssel needed to create new nature areas to establish the National Ecological Network (EHS), which has been set up to connect existing nature areas in the Netherlands. A large part of existing and future nature areas have been assigned as Natura 2000 areas. Natura 2000, the centre piece of EU nature & biodiversity policy, is an EU-wide network of nature protection areas established under the 1992 *Habitats Directive*. The aim of the network is to assure the long-term survival of Europe's most-threatened and valuable species and habitats. It comprises Special Areas of Conservation (SAC) designated by Member States under the Habitats Directive and also incorporates Special Protection Areas (SPAs), which they designate under the 1979 *Birds Directive*. Natura 2000 is not a system of strict nature reserves where all human activities are excluded. Although the network will certainly include nature reserves, most of the land is likely to continue to be privately owned and the emphasis will be on ensuring that future management is sustainable, both ecologically and economically. The establishment of such networks of protected areas is an obligation that the Netherlands need to fulfil under the UN Convention on Biological Diversity. Natuurmonumenten, the state forestry department, the provincial government dealing with nature areas and other conservation organisations work together to achieve this.

Natura 2000

One of the requirements for managing nature areas is baseline information such as insight in the spatial distribution of different vegetation types. Vegetation structure is an important habitat characteristic for many species and in support of biodiversity it is important to maintain diversity in vegetation structure. The vegetation structure map of the Witte Veen is shown in Figure 12.21. This map was produced by visual interpretation of an aerial photograph mosaic downloaded from Google Earth.

12.4.4 Use of spatial information by a government organization: the forest-cover map of Rwanda

The National Action Plan for Forests 2006–2008 in Rwanda was aimed at research and operationalization of the use of RS in forest inventories. More specifically the plan prescribed mapping forest resources in Rwanda at 1:25,000 scale. This included:

- making an inventory and estimate the location, area (of at least 0.5 ha in size), floristic composition, age, type (natural or not; public or private), soil type, density and health status of forests/woodlands using existing maps, aerial photography, satellite imagery and field data collection;
- monitor changes in the occupation of forest land over time;
- inventory, organize, standardize and centralize national geographic and other available databases on forests in Rwanda to allow interested institutions and

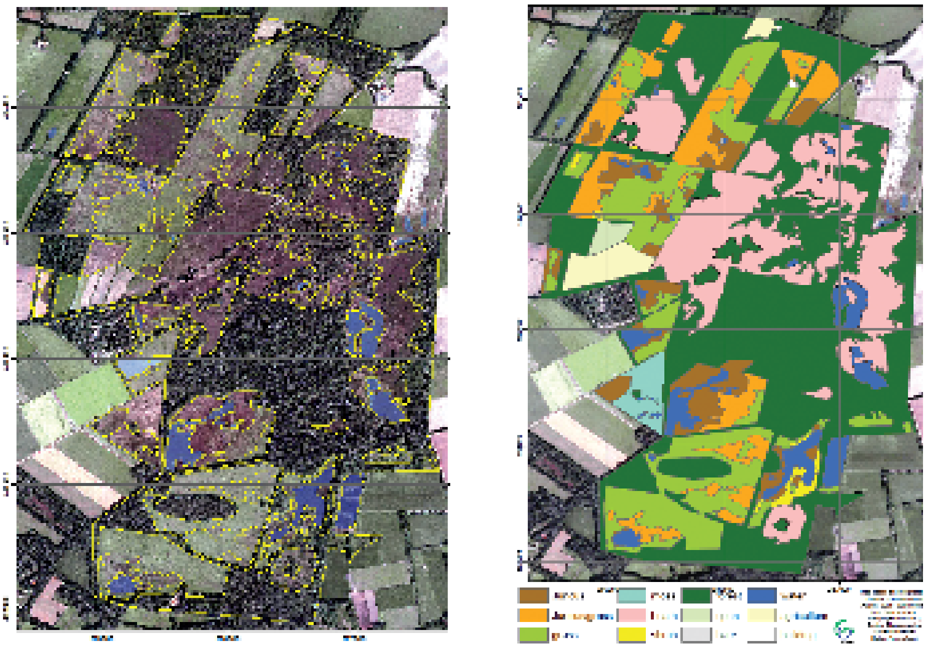

Figure 12.21
Delineation of mapping units (yellow) based on interpretation of an image obtained from Google Earth (left) and vegetation-structure map (right) after data collection in the field using mobile GIS.

decision-makers to easily access and update information that is critical for decision-making processes;

- develop a national GIS/RS-based information system for forests in Rwanda;
- develop capacity building in the application of RS and GIS tools and methods for forest inventory and mapping.

Claudien Habimana (right), Director of the Forest Unit, Ministry of Lands, Environment, Forestry, Water and Mines (Minitère), Rwanda, is listening to an explanation being given by a local farmer (left).

The satellite data used to map Rwanda's forests were ASTER, SPOT and TM images, the most recent (at the time of the described project) and cloud-free images being selected (see Figure 12.22).

From discussions with the Ministry officers, criteria for distinguishing forest types were drawn up. Forests in the humid region of the country were defined as areas larger than 0.5 ha with a tree cover greater than 20% and trees higher than 7 m. In the dry region (Akagera), areas in which trees were higher than 5 m were considered as forest. Coppices and young forest plantation, the latter comprising trees of less

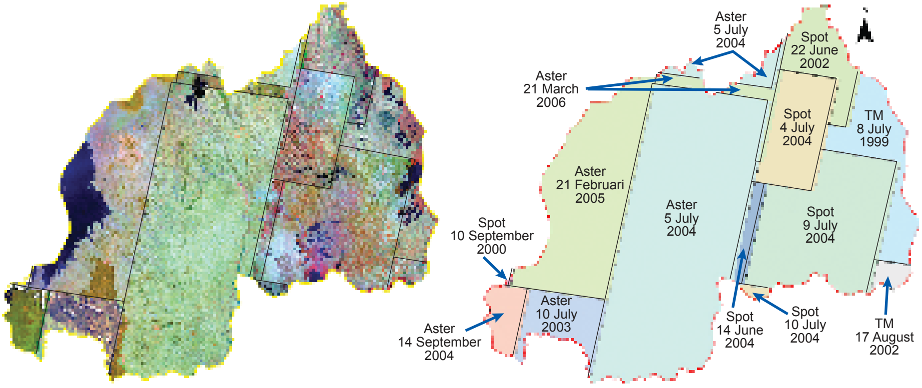

Figure 12.22
Coverage of most recent satellite images (at the time of the project) used for the forest classification in Rwanda.

than 7 m and covering 10–40% of the area, or trees higher than 7 m and covering 10–20%, were only found in the humid region. Bush was only found in the larger humid natural forests. In the case of bush, tree cover was defined to be less than 20% and in practice mostly less than 10%, with shrub covering more than 20% and high herbs and grasses. Bamboo and bush ridge forests were only found in the Parc National des Volcans. In summary, the following forest types were distinguished:

1. humid natural forest;
2. dry natural forest;
3. eucalyptus plantation forest;
4. pine plantation forest;
5. coppices or young forest plantation;
6. bush;
7. bamboo forest;
8. bush ridge forest.

Because of the substantial differences in terrain elevation, the images needed to be corrected with a DEM. Geocoding was done from topographical maps in accordance with the Rwandan coordinate system. The images were each classified separately with ERDAS IMAGINE into several classes and then re-coded into two classes: *forest* and *non-forest*. The large forest areas were selected from this classification and classified separately into the forest types listed above. Field data collection was carried out using hand-held GIS and GPS devices, allowing the location to be seen in the field in relation to the polygons, with the satellite image in the background. These data, collected over 4 missions, were classified into the forest-cover classes.

Based on the field observations and a first classification of images, the definition of classes was adjusted and a completely new classification of all images was made. New spectral signatures were selected and several classifications were made until the forest was sufficiently accurate classified. The occurrence of each forest type, expressed in km^2, is shown in Table 12.1.

Table 12.1
The combination of natural forest, bamboo forest, bush ridge forest and forest plantations can be considered collectively as "forest". Hence, the proportion of forest covering the total area is 6.8%; bush cannot be considered as forest.

Forest type	**No. of polygons**	**Area (km^2)**	**Fraction** (%)
Non-forest	699	23,252	91.9
Bush	5584	343	1.4
Bamboo forest	8	44	0.2
Bush ridge forest	5	30	0.1
Dry natural forest	664	37	0.1
Humid natural forest	1430	798	3.2
Eucalyptus forest plantation	1164	306	1.2
Pine forest plantation	663	110	0.4
Young forest plantation or coppices	22768	392	1.5
Total	43,426	25,312	100.0
All forest	37,143	1717	6.8