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focus

FOCUS No 3/07

Geographic Information Technologies for Natural Resource Management

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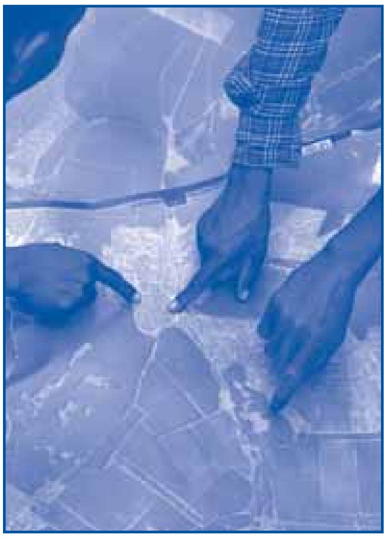

Ogiek People in Kenya map their ancestral territories on enlarged aerial photographs. The GIS-based Ogiek Peoples Ancestral Territories Atlas will help the Ogiek community to assert its territorial claims. (Photo by Albrecht Ehrensperger)

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NRM challenges and the capabilities of Geographic Information Technologies

Information and knowledge: a prerequisite for NRM

In Laikipia District conflict between small-holder farmers and raiding elephants from Kenya's second largest elephant population is a substantial problem. Elephants threaten the livelihoods of poor farmers while human population growth, the expansion of cropped areas and increased water scarcity exert pressure on elephant habitats. Elephants are shot, bringing conservationists into the picture. The human-elephant conflict is becoming an issue of political and economic significance and land rights debates are flaring up.

Building Capacity to Alleviate Human-Elephant Conflict in North Kenya
www.geog.cam.ac.uk/research/projects/heccapacity

Pioneering Animal Tracking Project using mobile phone technology
www.save-the-elephants.org/display.asp?linkID=15&displayID=16

This is just one not untypical example of current challenges in natural resource management (NRM). Land and land resources are increasingly subject to great human-induced pressure. In order to find pathways for harmonising the complementary but often conflicting goals of production and environmental protection, a comprehensive understanding of complex human – ecosystem interactions is crucial. In this respect it is important to integrate:

- Location-specific information from different disciplines (agriculture, forestry, soil science, hydrology, etc.) with information on cultural, social and economic settings and dynamics,
- Traditional knowledge of local people about NRM with the science-based external knowledge of researchers or government staff,
- Information at different scales, e.g. local land use information has to be related to national agricultural policy or analysed with regard to global change, and vice-versa.

Integration of all information is ideally conceived as a learning process of all stakeholders and builds a basis for equitable planning, negotiation and decision-making processes. This can only succeed if information is communicated effectively to all stakeholders and knowledge is shared equitably, thereby enhancing transparency and accountability.
What potential do Geographic Information Technologies have to better inform and involve farmers, communities and governments as well as international panels in planning and negotiation processes? How can these technologies support stakeholders in sustainability-oriented decision-making? What concerns have to be carefully taken into consideration when using Geographic Information Technologies in developing countries? These questions are addressed in the following few pages.

Geographic Information Technologies: a means for spatial analysis

Geographic Information Technologies (GIT) are a set of specialized Information and Communication Technologies (ICT) which help to collect, manage, and analyze data about the resources, landscape features, and socio-economic characteristics of an area in both space and time. Their capability to visualize spatial information is an important feature for communication, dissemination and knowledge sharing.
GIT include the following tools:

For more detailed descriptions see Glossary on page 12.

Documents mentioned in the margin are annotated in the list of references.

Of the different introductions to GIS available on-line, a comprehensive overview can be found at:

http://en.wikipedia.org/wiki/Geographic_information_system

The Mesoamerican Regional Visualization and Monitoring System (SERVIR) is a web-based service. Its objective is to improve environmental decision-making. It can be used to monitor and forecast ecological changes, e.g. forest fires and tropical storms.

SERVIR
http://servir.nsstc.nasa.gov/index.html

GIT used to map human-elephant conflicts in Kenya
This diagram illustrates the integration of different GIT and ICT. Satellite images (A) are used to elaborate land cover maps showing cultivated areas and settlements. These images are geo-referenced with the help of control points collected with a GPS receiver (B). Some elephants are equipped with GPS collars that measure the animals' locations at regular intervals and send the coordinates as a SMS, whenever the elephants are within reach of the cell phone network (C). Outputs from A, B and C are analyzed in a GIS (D) and combined to make human – elephant conflict maps. The maps are used for planning of community-based mitigation strategies.

Pioneering Animal Tracking Project using mobile phone technology
www.save-the-elephants.org/display.asp?linkID=15&displayID=16

The Global Landcover Facility is one of several providers offering free downloads of remote sensing data.

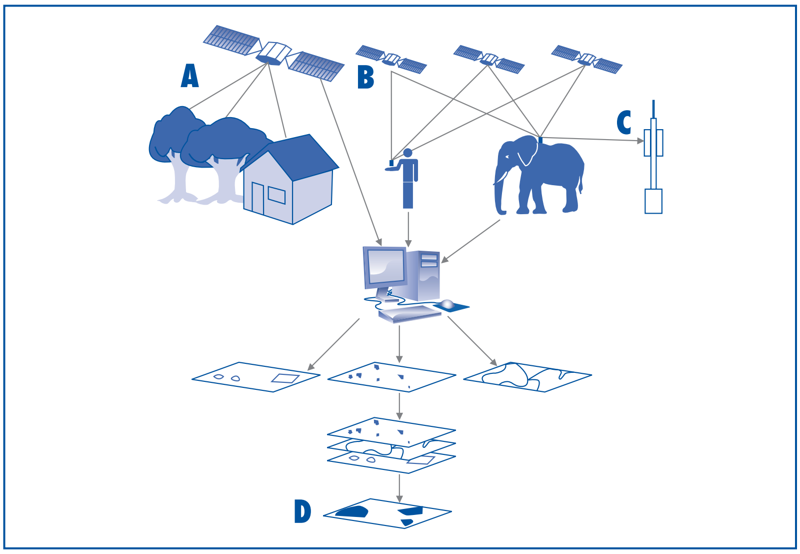
Global Landcover Facility
www.landcover.org

High resolution images on Google Earth allow Amazon natives in Suriname, Brazil, and Colombia to monitor deforestation and prevent illegal incursions on their land.

Amazon natives use Google Earth, GPS to protect rainforest home
http://news.mongabay.com/2006/1114-google_earth-act.html

- **Geographic Information Systems** (GIS) help to store, manage, and analyze geographically referenced data. GIS integrate common database operations with unique means of visualization and the geographic and analysis potentials of maps. GIS assist users in statistical analysis and provide a base for interpreting how physical, social and economic factors interact in space.
- **Global Positioning Systems** (GPS) are satellite-based positioning systems for capturing locations of sample points (households, plots, river or road junctions, etc.), which can be used to reference satellite images or other spatial data layers.
- **Remote Sensing** (RS) in modern usage means the sensing of the Earth's surface from satellites and airplanes by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects. Remote sensing provides images of the Earth's surface that enable the classification of different types of land cover and the monitoring of land cover and land use change.
- **Web-based tools**, such as Google Earth, provide new ways of sharing information and visualizing real-time data.

GIT are increasingly used in combination. The strengths of each technology are applied to achieve integrated approaches.



Trends in technology and spatial information

Since the first appearance of GIT, when only highly qualified professionals could handle them, advances in technology have been tremendous. Today a wide range of GIS is available; from high-cost, server-based to low-cost, user-friendly desktop software. Open source software for data handling and analysis is increasingly accessible online. The availability of spatial data has also been boosted. The spatial and temporal resolution of remote sensing data has increased impressively; more and more data are available free of charge, if not the most current data or the highest resolution is needed. Data and software availability have increased to a point where some people even speak of democratization of access to information, particularly in developed but also more and more in developing countries. In this context the development of web GIS can be regarded as a major advancement. It opens many new opportunities, such as realtime maps, more frequent and cheaper updates of data, and sharing of spatial information by users all over the world.

GIT applications from local to global scales

Sustainable management of natural resources calls for the integration of stakeholders from different decision-making levels in planning, negotiation and implementation and requires a deep understanding of ecosystem processes at different scales. The use of spatial information management tools can support multi-stakeholder and multi-level approaches in the field of natural resource management. In what follows we focus on pertinent potentials of GIT at the local, national, trans-national and global scales.

Integrating knowledge at the local scale

Since 1997 the Ogiek community has been involved in litigation against the Kenyan government several times concerning their eviction from the Eastern Mau Forest and the resettlement into this area of farmers from other parts of the country. So far, their claims have been dismissed. Lack of concrete information pertaining to their territorial claims has contributed to this unfavourable outcome. A project to map the ancestral territories of 23 Ogiek clans in the Eastern Mau Forest with the help of aerial photographs and use of a participatory mapping approach was launched in 2005. The resulting Ogiek Peoples' Ancestral Territories (OPAT) Atlas will be used by Ogiek representatives as an information and negotiation tool in the context of litigation bringing claims against the government.

This example shows that with the help of a participatory GIS approach (PGIS) different types of knowledge (e.g. 'lay' and 'scientific', or 'traditional' and 'modern') can be integrated into one planning and negotiation instrument and made to look the same. This provides the same degree of validity to all of them and therewith the means to empower marginalised communities whose views are usually ignored in planning processes. For example, traditional concepts such as sacred forests have a greater chance of being included in a regional development plan if they appear on maps than if they are only mentioned by stakeholders during a meeting.

GIT also help to enhance spatial accuracy by using GPS or high-resolution satellite images for resource mapping, and by the fact that participants in GIT-based negotiation processes are induced to provide more precise and transparent information. The latter represents a more reliable source for planning processes than information from narration or imprecise sketch maps. In this way, GIT help to improve the durability of planning and decision-making processes, as more precise information helps reduce the risks of conflicting interpretations and subsequent withdrawal from agreements.

By means of GIS overlay functions, knowledge from different disciplines are brought together, which enables spatial modelling of the processes and dynamics of local human-ecosystem inter-linkages. This overlay helps to identify spatial relations that can be interpreted, and causalities can be analysed between relevant parameters. For example, management of protected areas increasingly relies on GIT to understand linkages between natural or human-induced changes (climatic change, introduction of new species, etc.) and ecosystem responses.

Ogiek Peoples Ancestral Territories Atlas
The development process of the atlas and the potentials and risk related to the application of GIS in order to map ancestral territories are described in detail in:

Potentials, Limitations and Risks of Geo-Information Technology for Sustainable Development Approaches in Kenya
www.cde.unibe.ch/CDE/PubMed_Detail2_CD.asp?ID=1073

"Leading people to think spatially imposes a level of rigour on their thought – thus, for example, generic comments about 'poor air quality' at the beginning of a meeting – when mapped – lead to preciseness as to where, and in that preciseness lies a start to understanding the divergences between 'lay', scientific (and legal) 'knowledge'. (…)"

Public Involvement, Environment and Health: Evaluating GIS for Participation
www.phn-bradford.nhs.uk/NR/rdonlyres/8A807884-310A-450C-AF7A-026B755E406A/0/PublicInvolvement.pdf

"In the light of growing development pressures, agreements making use of sketch maps and non-technical descriptions appear to be short-lived because these are prone to subjective interpretations."

Bringing the vertical dimension to the negotiating table
www.iapad.org/publications/ppgis/p3dm_conflict_resolution.pdf

Adding spatial dimension to national development plans

Socioeconomic Atlas of Vietnam
www.north-south.unibe.ch/content.php/publication/id/1712

The socioeconomic atlas of Vietnam provides around 50 spatially differentiated indicators. Census data and a household survey were used in combination with spatial modelling to calculate indicator values at the level of roughly 10,000 communes. High resolution maps show distribution patterns e.g. for poverty. Spatial analysis brought to light a strong correlation between poverty and ethnic background. Currently, the atlas is used by the government and donors to orient their poverty reduction initiatives but also for educational purposes.

Until recently, census and other statistical data were commonly used by government agencies to help formulate development targets. For example, statistical information on welfare was used as guidance for the distribution of development funds and subsidies at the district or commune level. The example of the socio-economic atlas of Vietnam shows that governments are increasingly using GIT as a way of enhancing the value of statistical information. GIT use offers a unique opportunity to establish unambiguous links between map features and statistical databases. In this way, spatial patterns may emerge that remain hidden when information is displayed as tables or charts. Pockets of poverty may, for example, appear on a map and give clues about regional factors influencing welfare.

Since 1995 the Kenya Forest Working Group has been monitoring forest cover dynamics in the country using satellite imagery and aerial photographs. Results are made available to the government for decision-making. Forest status reports and maps are available to the public through the organisation's website. The organisation is also making use of this information to support advocacy of ethnic minority groups in the country and lobby for environmental concerns.

Kenya Forest Working Group
www.kenyaforests.org

Non-governmental organisations also contribute to the elaboration and maintenance of national spatial databases; in some cases with the aim of complementing and supporting government efforts, and in others to provide alternative insights into matters of national concern. In the latter case, NGOs increasingly rely on GIT in combination with the Internet to enhance availability of information and speed of dissemination. The use of GIT has helped to support this process by providing graphic information that is understandable by and easily communicated to a wider range of stakeholders than text documents or statistics. Thus GIT are sometimes used for lobbying and advocacy of concerns that conflict with state policy.

Coordinating and monitoring trans-national cooperation

The Mekong River Commission
www.mrcmekong.org

The Mekong River Commission Secretariat carried out a GIS-based topographic classification and analysis in order to back up land use and land cover recommendations for the entire Lower Mekong Basin. These recommendations aim to protect water and soil resources in the upper reaches of tributaries and regularize surface runoff in the basin. At the same time the Secretariat established a forest cover map on the basis of satellite images and aerial photographs. The overlay of both data layers allows identification of critical areas in terms of soil and water conservation, thereby enhancing regional priority setting for natural resource management.

At the trans-national scale, countries aim to cooperate in the management of natural resources, as illustrated in this example. Transparent information is crucial for planning and attaining consensus, especially on the use

of trans-boundary areas such as mountain ranges, protected areas, and river or lake basins, etc. GIT use can contribute to this transparency, for example through regular remotely sensed monitoring of land use and land cover dynamics. Visualisations of these dynamics have a great potential for awareness creation and are a powerful tool for parties to verify implementation of commonly identified goals. Satellite images provide precise information on forest cover dynamics, which can provide the basis for modelling future scenarios using parameters such as protection status, reforestation policies, accessibility, etc.
It is not only at the trans-national scale that the use of GIT contributes to linking field-based information with regional patterns or global trends and concerns. Thus, natural resource use at village level can be analysed in the perspective of national or regional conservation policies, while the latter can be assessed in terms of their impact at the local level.

ICIMOD provides spatial information in map format with a comprehensive meta-database on trans-boundary protected areas in the Hindu Kush-Himalaya region.

Mountain Environment and Natural Resources' Information System
http:// menris.icimod.net/index.php

Assessing global trends and formulating strategies

EarthTrends is an integrated desktop and web-enabled tool featuring an online collection of information about the environmental, social, and economic trends that shape our world. The website is introduced as being committed to the principle that accurate information drives responsible decisions by governments and individuals and that EarthTrends therefore offers the public a large breadth of statistical, graphic, and analytical data in easily accessible formats. Although EarthTrends does not offer the option of interactive map composition like other global mapping tools (e.g. the UN sponsored DevInfo or FAO's GeoNetwork), its map collection is comprehensively annotated, thus providing valuable baseline information on many NRM issues.

EarthTrends
http://earthtrends.wri.org

Numerous aspects of sustainable development depend on complex processes interacting at the global scale. In recent years, global climate change has taken centre stage, but other processes such as forest cover dynamics, water scarcity, soil degradation, desertification, population dynamics, health hazards, etc. are also crucial for sustainable development. Through graphic representation and spatial analysis, the use of GIT helps to make such processes understandable to decision-makers and lay persons. It can also help, through pattern recognition, to identify regions in which similar natural and socio-economic processes are taking place and subsequently to design situation-specific mitigation strategies for sustainable development.
The growing availability of global data and the high speed of data processing and dissemination also represent a major potential for monitoring global trends, identifying global challenges and defining global goals. This growing availability of data also facilitates the development of global initiatives to monitor indicator trends over a period of time. High temporal resolution of some satellites (i.e. the time elapsed until the satellite passes over the same area again) has made remote sensing – in combination with GIS – an extremely useful tool for rapid mapping in support of disaster relief, as was the case during the tsunami in South-East Asia in December 2004.

Open access global spatial databases are increasingly available online:

World Water & Climate Atlas
www.iwmi.cgiar.org/WAtlas

SERTIT *(Service Régional de Traitement d'Image et de Télédétection) of the University of Strasbourg offers spatial analysis of areas affected by crisis and natural hazards.*
http://sertit.u-strasbg.fr/english/en_welcome.htm

Key issues in GIT implementation

The digital divide is a global-scale phenomenon (the island of Manhattan has more fixed telephone lines than the entire continent of Africa); at a continental scale (in Africa 90% of all computers connected to the Internet are located in the South-African Republic); and at a national scale (only 20% of the population in Kenya has access to electricity).

The examples above give insight into the broad scope of opportunities provided by the use of GIT for NRM at various scales. It goes without saying that any technology also entails critical aspects that need to be carefully addressed. Critics have pointed to the "technology bias" of GIT. They argue that GIT is incompatible with participatory approaches, GIT-based projects are not lasting, and information disseminated with GIT lacks local content. They also express the growing power imbalances between "information rich" and "information poor". Hence, the key issues outlined below need to be addressed.

Relevance of content

The Nakuru Local Urban Observatory Project was initiated in order to provide the community and local authorities with a GIT-based urban development information system. In order to guarantee relevant content, a survey was carried out among different stakeholders to assess their needs in terms of urban development and access to information. Later, community members participated in mapping and establishment of an urban development database, and were trained in the use of GIT. This participatory approach helped many stakeholders to become active seekers of information.

Nakuru Local Urban Observatory: Involving stakeholders in data generation helps to keep content relevant.

Potentials, Limitations and Risks of Geo-Information Technology for Sustainable Development Approaches in Kenya
www.cde.unibe.ch/CDE/PubMed_Detail2_CD.asp?ID=1073

When content is defined by external stakeholders, they often fail to address local concerns and gradually eliminate local perspectives from the development discourse. This risk is not specific to the use of GIT; to a great extent, Western concepts of "sustainable development," rather than the concepts of local stakeholders, define the approaches and activities of development cooperation projects. As shown by the example above, the relevance of content can be enhanced by integrating local perspectives through participatory GIS approaches.
However, such integration is not sufficient. The use of GIT can lead to overemphasis on spatial data at the expense of other, locally relevant types of information. Although space and time are crucial dimensions of NRM and are ideally handled through GIT, other types of information, including traditional, symbolic, religious and institutional data, can play an important role in local decision-making. The risk of overemphasising spatial data grows with its availability, which makes it tempting to focus on the preparation of maps at the expense of a more holistic assessment of local situations. Therefore, by starting from local perspectives and knowledge, and by subsequently integrating external views, multi-stakeholder approaches should be used for the problem definition and priority setting stages of any project. GIT should be considered as one of several planning and decision-making tools.

Appropriate technology

The Fundación Salvadoreña para la Reconstrucción y el Desarrollo (REDES) and its Risk Management and Planning Unit made efforts to establish a GIS Unit. A participatory assessment enabled them to select an appropriate GIS technology in order to increase their technological autonomy and decrease their dependence on expensive commercial software. The Integration of GIS technology in the work of REDES offered an opportunity to empower the organisation and its partner.

There are many ways of defining adapted GIT, depending on the contexts in which they are used. Below is a non-comprehensive selection of important aspects pertaining to technical solutions.

A crucial aspect of successful GIT implementation is **accessibility** – including costs – of hardware, software and data. Contrary to widespread assumptions, hardware and software costs are usually minor when compared to costs for personnel, data acquisition, maintenance and organisational development. Today, a wide range of freeware, low-cost open source and high-cost commercial applications is available. Choosing appropriate off-the-shelf products or developing tailor-made solutions requires good knowledge of the market. Therefore, adequate expertise should be sought before taking decisions on setting up GIT infrastructure.

Another important aspect is **usability.** User friendliness has increased significantly in recent decades. Especially easy-to-use desktop GIS for data input, display, analysis, and processing have been developed, also allowing field staff and literate farmers to manage basic information in the field of natural resources management. Nevertheless, concept development, set-up and maintenance of applications require multi-technical skills and analytical competence. Interpretation of geo-information and deducing of relevant decision-making bases is not trivial. Not only thematic know-how but also knowledge about mathematical and logical methods is needed.

Finally, the way in which a GIT solution can **integrate** other tools and data is of increasing importance, as multi-disciplinary approaches have become a prerequisite for many NRM tasks. For example, river water management has to integrate information on the resource itself (hydrological data) with analyses of its interaction with other resources, and with notions about its use by human and wildlife communities. International efforts aim to define common data standards and formats, which will help to integrate the different types of data coming from various sources with a view to enhancing possibilities of visualisation and analysis.

Canadian Initiatives in Developing GIS through Cooperation
www.cuso.org/_files/urisa_cuso_en.pdf

Budget Ogiek Ancestral Territory Mapping

Preparation of five draft maps. Staff members were already trained in GIS application, no extra training needed.
Duration: Jan. 2006 – Dec. 2006
Source: Internal ESAPP Project Report, 2006

	Cost in Swiss Franks
Hardware (GPS, and hard disc) not including computer and software (already available)	490
Data acquisition	2,680
Fieldwork, labour costs including formation of clan-based mapping teams, training of mapping teams in PGIS	8,520
Labour costs, preparation of preliminary map	1,610
Transport costs (field trips)	2,550
Overhead	510
Total	16,360

Open Source Geospatial Foundation
Description of more or less elaborate GIS (GRASS, OSSIM, etc.) software that is available free on the Internet
www.osgeo.org

Bridging power gaps and digital divides

First Nation *is a Canadian term, that refers to the aboriginal peoples located in Canada.*

A survey conducted in 2001 among 109 First Nation organisations revealed that 44% were using GIS. The Aboriginal Mapping Network is a website that was established in order to support indigenous people dealing with issues such as land claims, treaty negotiations and resource development. The website features several aboriginal maps and links to First Nation websites making use of GIT for NRM, land ownership claims and empowerment. One example is the Lands Management Plan of the Poplar River First Nation, which features numerous GIS analyses for NRM.

The Aboriginal Mapping Network
www.nativemaps.org

Criticism of the use of GIT for sustainable development and NRM is based on the awareness that a head start in ICT access can lead to greater information and power gaps, for example between elites and marginalised stakeholders. Access to spatial information, on land titling and tenure, for instance, can provide an advantage to speculators, while lack of such information exposes others to the risk of being cheated. In other words, critics fear that information and findings from GIT implementation will often end up in the wrong hands. They also fear that while information on local communities is often disseminated to a wider public through modern means of communication, information on relevant external or global issues rarely reaches local communities.

The above example shows that First Nations in North America are aware that empowerment depends on the ability to access information and inform others about one's condition. In other parts of the world this awareness is not yet present to the same extent, and the means to access and disseminate information are lacking. State policies are often directly involved, especially through pricing and monopolies on ICT, taxation, and lack of support for ICT-based training and education. Government agencies in charge of communication and ICT policies therefore have a major role to play in helping to reduce information and power gaps.

In Eritrea, 1 hour of Internet use per day costs 540 Nakfa per month. This is one third of the monthly salary of a teacher, and one sixth of the salary of a university professor.

It should be noted that enhancing exchange of and access to information with the purpose of empowering marginalised stakeholders should only be done if copyright and intellectual property issues are carefully addressed at the same time. It would be of little use to the above-mentioned First Nation organisations if the information they provide about their land is used by other interested parties, e.g. to gain access to that land's resources at the expense of the First Nation communities.

Institutionalisation of GIT

In the 1990s the National Forest Office of Costa Rica aimed to stimulate better forest policies and transparent monitoring of forest land use by implementing GIS. During this time forest policy underwent several reforms – from top-down, to market-driven and finally to participatory approaches – focusing on different scales of intervention. These different measures had implications for GIS implementation and created parallel competing GIS building efforts which failed in the end to integrate the different GIS data models in a meaningful way. The case study showed that GIS building is part and parcel of organisational and political considerations.

"…'information is power'; GIS projects are strategic for many institutions and often used to promote institutional change. …
GIS implementation is a process of reorganising people and institutional practices, and improving implementation in order to understand the context in which GIS is applied."

Planning Styles and Scales
www.sls.wau.nl/tad/staff/HugodeVos/CERESCT3.pdf

In some cases GIT are used to provide specific support to project activities. The management of GIT remains in the hands of external project partners. In other cases they are meant to support NRM on a long-term basis, beyond the duration of externally funded projects. In such cases GIT need to be integrated into the working procedures and budgets of local institutions to ensure their sustainability. Coincidentally, this is one of the major challenges when building up GIT capacity and infrastructure. Lack of durability of GIT-based projects is therefore often brought up as a critical point.

Cases are known to the authors, in which e.g. the soil department of a public service institution acquires a GIT infrastructure, while the only relevant data layer that institution works with is a soil layer. Such situations lead to drastic under-use of the infrastructure and have a negative impact on the motivation of technical staff.

An additional challenge and an opportunity of NRM projects is the need for collaboration across disciplines. Hence GIT infrastructure should be designed as a support tool for different departments or disciplines. This allows pooling of resources and better use of synergies, and is likely to lead to greater motivation among technical staff as tasks become more diversified and interesting. Beyond mere design, achieving genuine institutional commitment for the implementation of GIT is a crucial aspect of institutionalisation, as it ultimately leads to availing of adequate budgets and implementation of required organisational restructuring. Capacity development and awareness creation about long-term benefits can also help to overcome individual reluctance to adopt GIT. Finally, one should also consider the strengthening of stakeholders' motivation to work together, e.g. across sectoral ministries or departments.

If GIT implementation is understood as a process of reorganising people and institutional practices it can support innovative and integrative forms of collaboration needed for sustainable natural resource management.

Glossary

Term	Description
Geographic Information Systems (GIS)	Computer aided tools used to collect, process, manipulate, analyse, store and display spatial information. A GIS usually includes hardware, software, data, personnel and methods / processes. Two of the main strengths of the GIS concept are: • the unequivocal linking of spatial elements with tabular data and • analysis within and between data layers of overlay (intersection), proximity and neighbourhood relationships, patterns and statistics.
Geographic Information Technologies (GIT)	Is an umbrella term for a set of ICT tools (GIS, GPS ,RS) used to collect, store, edit, query, manage, analyse and display geographically referenced information in order to map phenomena, and understand spatial relationships among phenomena. GIT include tools for modelling of spatial processes over time.
Global Positioning System (GPS)	Device allowing instant geographic positioning with the aid of satellite signals. GPS is used in conjunction with GIS for the building up of spatial databases and in conjunction with remote sensing for the geo-referencing of satellite imagery and aerial photography.
Information and Communication Technology (ICT)	All technology that is used to send, receive, exchange and store information for the purpose of interpersonal or mass communication. ICT includes a wide range of technologies such as phone, radio, TV, Internet, computers, cell-phones, etc. It also includes GIS, GPS, and RS.
Participatory Geographic Information Systems (PGIS)	Merges methods of Participatory Learning and Action (PLA) with Geographic Information Technologies (GIT). PGIS facilitates the representation of local people's knowledge and empowerment and inclusion of marginalised groups through geographic technology education and participation. PGIS maps can be used in decision-making processes and support communication and community advocacy.
Remote Sensing (RS)	The capture, processing, analysis and display of remotely sensed information, mainly satellite images, radar images and aerial photographs. In the field of natural resource management RS is mainly used for analysis and monitoring of land cover and land use status and change. RS is greatly supported by GPS, with which reference points can be identified (e.g. a point in the field representing a particular land cover category, and that is recognizable on a satellite image), from which classes can be extrapolated.

Recommended reading

The following list features a documented and targeted selection of print documents and Internet sites of relevance to "Geographic Information Technologies for Natural Resource Management". For easier reading they have been allocated to four rubrics: ***Overview, Policy, Instruments, Case studies.***
The documents are listed by title in alphabetical order. Most of them are available online (accessed on 24 October 2007).

Case studies
Instruments

The Aboriginal Mapping Network

www.nativemaps.org

The aim of this network is to provide support to indigenous populations that often face similar problems: territorial conflicts, negotiation of agreements, and development of resources. Among other things, it makes available to its members instruments such as GIS mapping and other information systems, and provides them with information about training and relevant events as well as other publications.

Rett A. Butler. November 2006

Case studies

Amazon natives use Google Earth, GPS to protect rainforest home

http://news.mongabay.com/2006/1114-google_earth-act.html

The Amazon conservation Team (ACT), an American NGO, supports the indigenous population of the Amazon Region in monitoring illegal activities in the rain forest. With the help of Google Earth and Global Positioning System (GPS), the indigenous population maps its own land and can thus record and preserve traditional knowledge as well as track illegal activities in the region. Those responsible for the project believe that regions monitored and managed by local populations in this way can be protected better than nature reserves.

Giacomo Rambaldi et al. 2002

Case studies

Bringing the vertical dimension to the negotiating table

Preliminary assessment of a conflict resolution case in the Philippines.

Presented at the 6th seminar on GIS and developing countries, "Governance and the Use of GIS in Developing Countries", 2002. International Institute for Aerospace Survey and Earth Sciences, ITC, The Netherlands. 15 p.

www.iapad.org/publications/ppgis/p3dm_conflict_resolution.pdf

This article describes negotiations among different indigenous populations in the Philippines aimed at resolving territorial conflicts. The use of aerial photos that were developed into three-dimensional models by means of a participatory method made a significant contribution to conflict resolution. Of particular interest is the second part of the document, which presents the advantages of modern technology: common understanding and language, support for mutual learning and setting of priorities, greater transparence, etc.

Case studies

Building Capacity to Alleviate Human-Elephant Conflict in North Kenya

University of Cambridge, Department of Geography. www.geog.cam.ac.uk/research/projects/heccapacity/

see also: Pioneering Animal Tracking Project using mobile phone technology

www.save-the-elephants.org/display.asp?linkID=15&displayID=16

A research project investigates and monitors the movement of elephants in Kenya, in cooperation with Save the Elephants, an international NGO. Several geographical information technologies are used in the process: mobile GPS are attached to elephants; mobile phones transmit data, and GIS is used to superimpose land use cards on elephant movements. The goal of the project – an innovative example of the integration of different information technologies – is to help resolve conflict between people and animals.

CUSO. 2006

Case studies

Canadian Initiatives in Developing GIS through Cooperation

Paper presented at the URISA's Third Caribbean GIS Conference. 17 p. www.cuso.org/_files/urisa_cuso_en.pdf

New options for international development arise from the availability of inexpensive geographical information systems and data, illustrated by two Canadian projects in Central America discussed here. The projects are concerned with early warning about, response to, and recovery from natural disasters. The main focus of the article is on the process of selection of appropriate GIS infrastructure and its institutionalisation in the respective context. This aspect receives little attention in the literature. The article is thus addressed primarily to persons who need to develop GIS projects such as this one and the necessary infrastructure.

Instruments
Overview

EarthTrends

http://earthtrends.wri.org

EarthTrends is an integrated web-enabled tool featuring an open access database on ten topics related to environmental, social, and economic trends that shape our world. The website is introduced as being committed to the principle that accurate information drives responsible decisions by governments and individuals. Although EarthTrends does not offer the option of interactive map composition like other global mapping tools (e.g. the UN-sponsored DevInfo or FAO's GeoNetwork), its map collection is comprehensively annotated, providing valuable baseline information on NRM issues such as water resources, climate and atmosphere, energy, forests, biodiversity, agriculture and food.

Albrecht Ehrensperger and Solomon Mbuguah. 2004

Case studies

Fostering sustainable urban development in Nakuru, Kenya Rift Valley

Mountain Research and Development (MRD), Volume 24, Nr. 3, 210–214.

www.bioone.org/perlserv/?request=get-toc&issn=0276-4741&volume=24&issue=3

This is a good example of the use of GIS applications to support urban development in Nakuru, Kenya. GIS application offers access to current, reliable information and indicators for use in urban planning in Nakuru. It also provides a common basis for sound dialogue between decision-makers and the people directly concerned. The success of this project depends on three factors: acceptance by the population, regular updating of information, and firm commitment on the part of the local authorities.

Overview

Wikipedia
Geographic Information System
http://en.wikipedia.org/wiki/Geographic_information_system#Techniques_used_in_GIS
Wikipedia, the free-of-charge encyclopedia, offers a comprehensive overview of GIS: history, methods, software and potentials are discussed and complemented by numerous links.

Instruments
Overview

Global Landcover Facility GLCF
www.landcover.org
The GLCF is an on-line service that makes remote sensing data available as a free download to all users. The service aims to promote understanding of land cover change and its impacts on the earth system.

Instruments

Google Earth
http://earth.google.com/intl/en/
Google Earth combines the options offered by Google Search with satellite data, digital maps and terrain models. It is an on-line tool for compiling, observing and disseminating site-specific data. Data can be ascertained with the help of an interactive and visually intuitive interface. The simplest version of Google Earth can be downloaded free of charge, although GIS data can only be integrated with the professional version.

Overview
Instruments

ESRI
The Guide to Geographic Information Systems
www.gis.com/index.html
This website, designed by software developer ESRI, provides an on-line introduction to GIS that is also easy for lay persons to understand. It shows the different options for application – primarily in an American context, unfortunately – and offers a series of "learning links." No particular attention is given to the areas of international development and natural resource management.

Case studies

Kenya Forest Working Group
www.kenyaforests.org and www.kenyaforests.org/reports/changesNOV2006rvs6.pdf
The primary goal of this network of different non-governmental organisations is sustainable management of Kenya's forests. The network pursues the following activity lines: advocacy and awareness creation, monitoring, compiling and exchange of information, and activities at the community level. Air and satellite photos provide the basis for monitoring forests and their condition. These verified data support civil society in the struggles in which it is engaged.

Overview
Case studies

IIED and CTA. 2006
Mapping for change: practice, technologies and communication
Participatory Learning and Action no 54. 150 p. www.iied.org/NR/agbioliv/pla_notes/pla_54_CDRom.html
This comprehensive publication provides an overview of the state of the art regarding the practice of Participatory GIS (PGIS). It shows that digital mapping can be reconciled with participatory approaches and value can be added to each approach. But this comes at a cost: First, the demand for human capacity is high, and second, the ethical issues are challenging. In the introductory chapter the editors explain the concept of PGIS. The chapter is followed by tool-based and issue-based case studies. The last part reflects on ethical questions such as: To whom do the maps and data belong; precision for whom, etc.

Overview
Case studies

Mekong River Commission
www.mrcmekong.org
The trans-boundary catchment area of the Mekong River is to be managed sustainably according to the principles of the integrated water resource management approach. This is the goal of the Mekong River Commission, a partnership between Cambodia, Laos, Thailand and Vietnam, which has relations with China and Myanmar. The Commission has a rich database on natural resources – particularly water and water use – at its disposal. Integrated GIS is important for the administration, analysis and transfer of spatial and non-spatial data. This provides support for planning and decision-making processes in the Commission, as well as specific information which national officials can draw upon. The MRC Information System portal, which is still under construction, will make it possible for different users to search for, look at, and download interactive data and maps (see also http://portal.mrcmekong.org).

Instruments

The Mesoamerican Regional Visualization and Monitoring System (SERVIR)

http://servir.nsstc.nasa.gov/index.html

SERVIR is a regional on-line visualisation and monitoring system for Central America. It provides free access to satellite images and earth observation data and interactive maps, as well as opportunities for three-dimensional visualization, for scientists, decision-makers and interested members of the public. Thematic classification is done according to the categories used by the Global Earth Observation System (GEOSS): natural disasters, ecosystems, biodiversity, weather, water, climate, oceans, health, agriculture and energy.

ICIMOD

Instruments

Mountain Environment and Natural Resource Information System (MENRIS)

http://menris.icimod.net/index.php, http://arcsde.icimod.org.np:8080/geonetwork/srv/en/main.home

The MENRIS portal is operated by ICIMOD as part of the UNEP Environment Knowledge Hub Initiative. The main goal is foster sustainable development of the Hindu Kush-Himalaya Region through capacity building, provision of thematic databanks and map banks, and development of thematic applications and decision support systems. A GIS-based infrastructure forms the backbone of the system. This provides a polyvalent information instrument for the region that also supports dialogue among partners and decision-making processes.

Instruments

Open Source Geospatial Foundation

www.osgeo.org

OSGeo is a not-for-profit organisation founded in 2006 to promote joint processing of spatial data and develop appropriate software that is accessible free of charge. Exchange takes place by means of Internet and Intranet. This platform is of interest primarily for people interested in the technical aspects of GIS. The portal offers descriptions and links to free GIS software such as GRASS, OSSIM and Quantum GIS.

CTA. September 2005

Case studies

Participatory GIS

ICT Update, a current awareness bulletin for ACP agriculture. Issue 27. http://ictupdate.cta.int/en/(issue)/27

This issue of the on-line bulletin is completely devoted to the topic of participatory GIS (PGIS). The main focus is on questions of implementing PGIS. Numerous examples of projects are presented which provide insight into the advantages of the method as well as a number of potential stumbling blocks, such as insufficient infrastructure, poorly defined processes of participation and decision-making, lack of sustainable funding, computer incompatibility, unsuitable map scales, etc. An annotated list of links is also provided.

Hugo de Vos. 2003

Case studies

Overview

Planning Styles and Scales: Some Reflections on the Use of Cultural Theory in Understanding Institutional Aspects of GIS Implementation and Governance

In: Faces of Poverty: Capabilities, Mobilization and Institutional Transformation, Proceedings of the International CERES Summerschool 23–26 June. 2003, KIT/AGIDS, Amsterdam. 12 p.
www.sls.wau.nl/tad/staff/HugodeVos/CERESCT3.pdf

The author of this study examines how different forest policy reforms in Costa Rica have made it more difficult to implement GIS in forestry and have led to unsatisfactory results. He concludes that it is important to understand implementation of GIS as a part of institutional development and carry out a comprehensive analysis of the institutional context in advance.

Albrecht Ehrensperger. 2006

Case studies

Overview

Potentials, Limitations and Risks of Geo-Information Technology for Sustainable Development Approaches in Kenya

PhD Thesis. Centre for Development and Environment, Institute of Geography Berne. 301 p.
www.cde.unibe.ch/CDE/PubMed_Detail2_CD.asp?ID=1073

This innovative dissertation examines ways in which geographical information technology can contribute to sustainable development, illustrated by three concrete case studies from Kenya: a local urban observatory in Nakuru, the Ewaso Ngiro Water Information Platform, and the Ogiek Ancestral Territories Atlas. The potentials and risks of GIT are analysed differentially with reference to the following project stages: concept development, data compilation, data analysis, dissemination and application of knowledge. Risk is present above all during the concept and output phases when available data and technologies rather than actual problems determine project orientation and results. At the same time, empirical analysis shows that the perceived value of information (and not the medium) is decisive for the sustainability of a project when GIS technologies are used.

J. M. Forrester, L. Potts, P. J. Rosen and S. Cinderby. 2003

Case studies

Public Involvement, Environment and Health: Evaluating GIS for Participation

Full report on research activities and results. Economic and Social Research Council (ESRC), 9 p.

www.phn-bradford.nhs.uk/NR/rdonlyres/8A807884-310A-450C-AF7A-026B755E406A/0/PublicInvolvement.pdf

The authors of this study wanted to find out whether participatory GIS methods can help to merge lay knowledge of spatial aspects with scientific findings, thereby improving communication about environmental and health-related problems and risks between these groups. Air quality, breast cancer and aspects of environmental regeneration were used as examples. Although the study was carried out in the North and had no connection with developing countries, the results are also of interest to development cooperation.

Instruments

SERTIT Regional Service of image treatment and remote sensing

http://sertit.u-strasbg.fr/english/en_welcome.htm

SERTIT was created in 1987 with the aim of processing and making available data and information from earth observation systems. In addition to the solid experience it has in the area of remote sensing and prevention of crises and disasters, the service is also active in the areas of national and regional planning, environmental protection, and natural resource management.

Michael Epprecht and Andreas Heinimann (eds). 2004

Case studies
Overview

Socioeconomic Atlas of Vietnam: A Depiction of the 1999 Population and Housing Census

Swiss National Centre of Competence in Research (NCCR) North-South and Geographica Bernensia, Bern

www.north-south.unibe.ch/content.php/publication/id/1712

This is the first atlas of Vietnam that gives details about the country's socio-economic aspects, thanks to the help of GIS technology. Data on population, education and living conditions are presented by community, thereby making it possible to identify spatial patterns. The Atlas is addressed primarily to decision-makers in the government and in non-governmental organisations, as well as to researchers and students, with the aim of improving planning and decision-making on the basis of well-founded, differentiated spatial information.

International Water Management Institute

Overview
Case studies

World Water & Climate Atlas

www.iwmi.cgiar.org/WAtlas/

The aim of this Atlas is to provide support for agricultural planning through rapid access to current data. Using the software provided, users can make their own analyses without needing to be specialists in GIS. Data are available on climate and moisture, land use, river catchment areas, and population density.

***InfoResources Focus** provides a general overview of pertinent and topical subjects to guide one through the information jungle. Each issue focuses on a current theme relative to forests, agriculture, natural resources and the environment, in the context of international development cooperation. Each theme is viewed from several angles:*

- *Policies and strategies*
- *Implementation and practical experiences*

The first section of InfoResources Focus proposes a brief introduction to each subject, highlights specific problems, compares theoretical approaches and opinions, and reports past experiences. The second section presents a selective and commented choice of documents, books, CD ROMs and Internet sites. The range of documents presented reaches from basic introductions, through instruments, methods and case studies, to conceptual texts. ***Back issues of InfoResources Focus*** *can be ordered from the address given on page 2 or downloaded from www.inforesources.ch.*