# Telecommunications & Environment



HE ENVIRONMENT is no longer a side issue but is central to government policy throughout the world. Everyone is aware that time is running out: resources are being degraded and destroyed, global warming is threatening future crop production and even the very existence of some island nations. The world is beginning to take action, but much more help is needed. This section of *Telecommunications in Action* looks at how those responsible for protecting and managing the environment in the developing world can use telecom applications to help quantify and deal with the problems facing them. Information and communication technologies, in particular geographic information systems, are proposed as essential tools for policy makers, planners and those dealing directly with environmental issues, both responding to existing situations and trying to prevent future problems. A number of case studies from around the world highlight what is being done in various environmental fields, and working models of how to implement geographic information systems give further detail. Advice is also given on financing applications of information and communication technology for environmental protection and management, and costs and benefits are summarized.



The ENVIRONMENT is a collective good and the state of the environment concerns the entire international community. The ratification of a number of environmental conventions is proof of the world's commitment to environmentally sustainable development, but the environment remains a pressing concern. Environmental problems may seem selfevident, but in order to deal with them rationally actions are needed in monitoring, measuring, correcting and preventing further problems. Lester Brown, President of the Worldwatch Institute, has described the pressures on the Earth's natural systems and resources, and the preventive action that needs to be taken. Air, land and water are becoming increasingly polluted, and natural resources such as wood, paper, grain and fish are being consumed at a rapidly increasing rate. "The...reality is that the economy continues to expand, but the ecosystem upon which it depends does not, creating an increasingly stressed relationship."<sup>1</sup> Brown calls upon governments to "calculate the sustainable yield of aquifers, fisheries, forests and

**CORPORATE VIEW** 

### **Reducing risk**

A NALYTICAL Graphics, with headquarters in Malvern, Philadelphia, in the United States, is a pioneer in commercial off-the-shelf analysis software for the aerospace industry. Founded in 1989, the company revolutionized satellite systems analysis with a product that offers increased productivity and reduced risk. Known as Satellite Tool Kit (STK), this interactive software tool dramatically reduces the time and cost associated with custom software development, supporting end-to-end satellite mission processes, from design and build to launch and operations.

It recently played a critical role in salvaging a spacecraft in a rescue manoeuvre performed by Hughes Global Services to save its AsiaSat 3 satellite (now called HGS-1). Using the software, Hughes Global Services developed a series of moves that swung the spacecraft around the moon twice and positioned it in a more practical plane.

HGS-1 controllers fired the satellite's on-board rocket motor several times to raise its altitude. The final firing commands were sent to the spacecraft while out of view of the ground stations. Fortunately, controllers were able to confirm the motor firing within about half an hour, and within another hour verified that HGS-1 was on the correct trajectory.

The software enabled Hughes' engineers to determine the fuel burns necessary to boost the satellite's orbital level and allow each swing-by of the moon. Although the National Aeronautics and Space Administration (NASA) has used the moon during previous missions, this is the first time the moon was used for a commercial mission.

Since its introduction, the STK name has expanded to encompass a whole family of products that support the specialized needs of a diverse customer base. Products include a complete line of over 20 add-on modules that extend the core functionality of the product range to address in-depth questions ranging from analysing communication links to determining coverage over time.

With capabilities that can be applied to areas ranging from communications, intelligence and navigation to space exploration, STK has been adopted as the standard software platform of over 16,000 users. Users span all major organizations involved in space, from government agencies to universities to commercial industries. The growing user base includes customers such as NASA, Lockheed Martin, Boeing, Alcatel Espace, TRW, Los Alamos National Laboratories and the United States Air Force Academy.

> Analytical Graphics E-mail: spistrit@stk.com Website: http://www.stk.com For further information see Annex B

### telecommunications & Environment

rangeland, noting the commitment to future generations not to exceed these yield levels."<sup>2</sup> Calculating sustainable yield – the amount that can be harvested without destroying the resource base – as well as monitoring the environment to anticipate and deal with natural disasters and working to reverse the effects of environmental degradation, requires effective systems of environmental and natural resource management. These management systems demand accurate, useful and timely information and tools for decision making, and such tools are explored in this section of *Telecommunications in Action*.

### WHAT TELECOMS CAN DO

### CONSUMPTION PRESSURE

Consumption pressure of whole country (million pressure units)



Source: Living Planet Report 1998, WWF

Telecom-Environment is an initiative of the International Telecommunication Union's Telecommunication Development Bureau (BDT) to demonstrate the importance of the role played by information and communication technologies in the protection of the environment. As part of this initiative, five pilot projects are being prepared in collaboration with ITU members and partners in the industrialized countries. The pilots range from natural resources management with a focus on telecommunications and control of bush fires in Senegal, to an information server on the environment of the countries of the southern Mediterranean. A proposal for a satellite-based network for the remote monitoring of the quality of sea water in Tunisia has already received formal backing to the amount of US\$20,000 from British Telecom (United Kingdom) for funding of the computer resources component, and an offer has been received from Final Analysis (United States) for the provision of assistance in the installation of the laboratory buoys and free access to the experimental satellite FAISAT-2v for a period of six months.

ITU has also been involved in the preliminary discussions and planning for training of developing country personnel in the promotion and use of new technologies for protection of the environment and sustainable development. The project is to hold five training seminars in each of the five African regions (Central, East, North, South and West) at a total cost of some US\$430,000 for:

- training and sensitizing those in charge of national environmental matters and their technical personnel in order to develop good environmental information exchange policies using new information and communication technologies to ensure sustainable development together with environmental protection;
- setting up national virtual nodes of environmental knowledge to open up existing knowledge and facilitate agreement and coordination of national environmental programmes.

To date, the ITU partners in the discussion and planning phase have been the United Nations Institute for Training and Research, the Observatoire du Sahara et du Sahel, the Secrétariat exécutif de la Convention sur la lutte contre la désertification, the World Meteorological Organization and the United Nations Economic Commission for Africa. The implementation phase is planned to start with the holding of the first seminar in the West Africa region.

Some of the most innovative and effective solutions to environmental problems have come with the advent of new communication technologies.

Consumption pressure per person (pressure units)

# telecommunications *in Action*

Powerful new computerized systems have been developed which greatly improve the ability to collect, store, analyse and disseminate information about the environment across the globe.<sup>3</sup> Sources of information anywhere in the world can be accessed through the Internet. Such information – on soil conditions, water management techniques or storm warnings, for example – is therefore accessible to anyone on the network. For example, super-computers at the Geophysical Fluid Dynamics Laboratory in Princeton, United States, have been programmed to simulate the effects of continued increases in greenhouse gas emissions on the global climate. Results show an increase in ambient temperatures causing a rise in sea levels due to polar ice melting, which would result in flooding of coastal plains and the submergence of many coastal cities and populations. Erratic rainfall patterns would also result and these could cause agricultural devastation and the migration or extinction of certain animal life.<sup>4</sup> Scientists are able to provide forecasts so that policy changes can be made now to protect the future of the world environment.

**CORPORATE VIEW** 

### An infrastructure challenge

**G** REENLAND has a first-class, well-developed, modern national and international telecommunication system despite the fact that the island, which is the world's biggest, poses some of the toughest infrastructure challenges anywhere on the globe.

Its 56,000 people live in 16 towns and more than 70 isolated settlements. The population of each settlement ranges from just four people to 550, and many of these habitations are on small islands or in deep fjords along a 39,000-kilometre coastline. The island covers an area of 2.2 million square kilometres of which only 341,700 are ice free, has mountains up to 3,700 metres high and extremes of polar cold and great heat and humidity.

In such a demanding environment, and one where there are no roads or railways between towns, the presence of first-class reliable telecommunication links is quite literally a matter of life or death to the whole community.

Standard solutions simply cannot meet the extraordinary and varying demands of Greenland's requirements. So providing this infrastructure has involved using cutting-edge telecommunication technologies and solutions which have to be tailor-made for the number of people, the distance from the nearest town or radiolink station, the terrain and the extremes of climate.

For example, supplying the electric power to 25 unmanned and inaccessible mountain-top repeater stations was a major challenge. The solution devised by TELE Greenland was to use a combination of thermoelectric generators, wind generators and small diesel generators, backed up by storage batteries that can withstand the most severe weather conditions.

Today, Greenland's telecommunication system includes a 2,000-kilometre radio link, 11 satellite Earth stations, 24 public telephone exchanges, rural systems for the 70 settlements, maritime and aeronautical radio stations, and transmitters for radio and television broadcasts. The 11 satellite stations provide digital radio links within the island, and between it and Denmark, as well as with the rest of the world, via the international gateway in Copenhagen. The digital telephone network can handle both analogue and ISDN (integrated services digital network) subscriber lines. All the outlying towns and areas can receive high-quality, real-time colour television programmes from Nuuk, the capital. There is also access to the Internet.

What works in Greenland can work anywhere else in the world. TELE Greenland is using its experience and expertise to provide a range of advanced telecommunication solutions to other places facing tough challenges, among them Africa, China, East Asia, the Russian Federation and Viet Nam.

> **TELE Greenland** E-mail: ac@tele.gl Website: http://www.tele.gl *For further information see Annex B*

# telecommunications & *Environment*

LIVING PLANET INDEX, 1970-1995

ecosystems)

(a measure of the health of the world's natural

As the information revolution accelerates, it is important that universal access to these new technologies be given high priority in the pursuit of sustainable development. Without such initiatives, people in developing countries "risk being even more marginalized in the world economy".<sup>5</sup> As Robert T. Watson, Director of the World Bank's Environment Department, states, developing countries are generally more affected by poverty and less well equipped to deal with environmental problems than industrial countries.<sup>6</sup> The potential benefits of using information and communication technologies for sustainable development are therefore far reaching for developing countries with limited resources to spend on combating environmental problems.

As data resources expand, it is becoming easier and cheaper to utilize new technologies for monitoring the environment all over the world. The current flagship technology is the geographic information system, or GIS. Environmental applications make up a large part of the market which is growing at a rate of 15-24 per cent each year.<sup>7</sup> A few of the many possible uses of GIS include site assessment and clean-up, wildlife management, pollution monitoring, risk analysis, vegetation mapping and public information.<sup>8</sup> The power and flexibility of the GIS technology are such that it has potential applications in a large proportion of today's environmental problems. Its predominance is evident in the case studies and examples which follow.

### An introduction to geographic information systems (GIS)

GIS is a computer-based tool for mapping and analysing particular geographic phenomena: things that exist and events that happen on Earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. It is a powerful database system with specific capabilities for organizing, manipulating and analysing spatially referenced data. A GIS displays geographic data as a series of transparent maps which can be overlaid on each other, and which can then be used in a multitude of applications to explain events, predict future outcomes and assist in planning strategies.<sup>o</sup> A GIS can also link to data that are not in the GIS, such as reports, images, videos or other databases. This is a very powerful feature, since it allows other computerized data to be accessed remotely without making another copy.

Although the primary GIS "product" is a map (or series of maps), it is different from conventional maps because:

- it is a graphical display conveying spatial information about the underlying data that can be interactively modified by the user;
- the map scale is completely variable; this has significant implications regarding location data accuracy;
- GIS data can be shared, i.e. accessed by different users in different ways at the same time.

GIS workstations are often specifically geared for a particular purpose and a particular organization. They must be designed to provide the desired information about real-world phenomena in concert with the organization's specific operational practices. For this reason, configuring the system is a job for a specialist. Training is the next step, and also a critical one in the success of any

The primary GIS "product" is a map, or series of maps. This land cover map was produced using satellite data.





GIS application as GIS technology is of limited value without qualified users to manage it. In most cases, the GIS software vendor provides these services.

### The hardware and software

GIS can operate on a variety of hardware systems, from network servers to desktop computers. Hardware consists of:

- computers;
- file servers;
- workstations;
- digitizers (to capture data);
- plotters (for graphic output);
- terminals;
- printers.

New software has been developed to serve the growing demand for GIS. This software contains the following components:

- computer operating systems (network or desktop);
- the GIS program;
- a database management system;
- special application packages (e.g. network analysis, digital terrain modelling).

### Access to data is the key

Above all, the user must have access to data for a GIS to be of any use. "GIS analyses depend on the availability, quality and compatibility of digital geographic data. Accurate and current geospatial data is crucial and requires data sharing between agencies."<sup>10</sup> The lack of information infrastructure and the scarcity of data in developing countries has so far prevented the widespread use of GIS. Intensive data gathering and analysis can be costly, but once the essential basic data have been collected they can be reused by GIS applications for any number of different purposes. An increasing amount of data is now available on the World Wide Web and elsewhere for free use and this will open up the possibility of GIS solutions to many more users. In order to facilitate a growth of spatial data in the developing countries many data products have been produced, and a few are highlighted below. Other useful website addresses are listed at the end of this section.

### Examples of data available for Africa

- A population density map has been generated for all of Africa, using census data from individual countries and producing an algorithm that projects population growth into the future. This can be found on the website of UNEP/GRID under their Environmental Data Sets Available On-Line. Data on climate, soils and vegetation are also available. The website at <a href="http://grid2.cr.usgs.gov">http://grid2.cr.usgs.gov</a>> has the UNEP and United States Geological Survey (USGS) data sets.
- Land use/land cover data have been derived from satellite imagery at the Eros Data Center. The website provides the maps of two images from Landsat taken several years apart. The site has excellent tools, guidance and





Getting the data: a detail of the African coastline photographed from space (top) and a satellite view of the Earth.

### telecommunications & Environment

articles about countries and issues: <http://edcwww.cr.usgs.gov/earthshots/ slow/tableofcontents>.

The World Resources Institute (WRI) has compiled a catalogue and CD of several data layers – roads, political boundaries and protected areas – for Africa. All of these data are available free or at a reduced price on a 1:1,000,000 scale (1 kilometre square resolution at the Equator).

### Examples of other environmental data available

Global geospatial indicators on environmental conditions in digital format include:

- Reef locations and reefs at risk (by human development) produced jointly at WRI and ICLARM (International Centre for Living Aquatic Resources Management) in the Philippines.
- Last forest frontiers: global coverage of the last pristine forests around the world – produced at WRI.

**CORPORATE VIEW** 

### People on the move

**S** PANNING the globe, Station Africa Telecoms provides telecommunication facilities through satellite transmission services. This technology has had a powerful impact on the lives of the many people working, living or travelling in areas previously denied access to these services because of the lack of terrestrial infrastructure. Now, providing the user has a "line of sight" to the satellite, a telephone call can succeed without expensive infrastructure.

City centres, the majority of which already have reliable networks, are generally not served by this technology as high buildings act as buffers between the caller and the satellite and so interfere with the signals. On the other hand satellites, which are able to operate extremely effectively over large areas of land and water, play a crucial role in bringing telecommunication services to some of the world's most inhospitable locations.

Any network can only be as reliable as the equipment used by the caller to make the connection. With this in mind Station Africa has selected a broad range of efficient, stable equipment to satisfy its customers.

The Min-M terminal has been designed for people on the move. Doctors, engineers, surveyors, explorers, journalists and tourists will be able to make telephone calls, send and receive e-mails and faxes, and transfer data from the terminal which may be comfortably stored in a conventional briefcase. Rechargeable ni-cad batteries ensure 48 hours of listening time and two and a half hours of talking time, and the terminal can be charged either from mains voltage or from a vehicle battery.

Problems with "line of sight" are overcome by means of a small, flat-panel antenna which can be located up to 70 metres from the basic telephone. A built-in signal strength indicator simplifies the process of lining up the aerial, and an optional bracket enables fixing for regular use. Alternative kits are available for vehicle mounting, and one of Station Africa's products will even track the satellite, allowing communications on the move.

The Capsat maritime telephone works extremely effectively from coastal waters and the high seas of the northern hemisphere. An additional advantage is the efficient remote alarm/distress box which will transmit an alarm and verify the precise position of the vessel at the touch of a button. Solar panel charging keeps the equipment working at all times.

> Station Africa Telecoms E-mail: hq@stationafrica.com Website: http://www.stationafrica.com For further information see Annex B

telecommunications *in Action* 

Digital elevation model: global coverage topographical information at 1:1,000,000 (1 kilometre square resolution). This quantitative data set is extremely important for generating derivative data sets, such as slope, stream networks and watershed boundaries. Available at the Eros Data Center, on-line at: <a href="http://edcwww.cr.usgs.gov/earthshots/slow/tableofcontents>">http://edcwww.cr.usgs.gov/earthshots/slow/tableofcontents></a>.

### CASE STUDY

### Conserving genetic diversity

### **OBJECTIVE**

■ To assist the government of Turkey in its efforts to establish areas set aside to protect rare plant species in their natural context (in situ). This effort complements the ongoing programme of the government to preserve genetic material in gene banks (ex situ).

**BACKGROUND** Turkey is one of the most significant areas of the world for plant genetic diversity, being the original domestication centre for a number of species vital to the viability of agricultural production, notably wheat, barley, plum and chickpea. The combination of diverse geographic and climatic conditions has also given rise to a number of unique crop and tree species found nowhere else. Recognizing that the preservation of Turkey's significant plant genetic diversity is essential to long-term global food security, the World Bank, through the Global Environment Facility (GEF), has recently completed a five-year programme, the In-Situ Conservation of Genetic Diversity project.

**DESCRIPTION** The project utilized data management and geographic information systems (GIS) throughout, notably in the selection of gene management zones. This selection, which was a classic application of GIS, involved a wide variety of criteria including level of species' diversity, land ownership, degree of threat and so on. Assembling these data required the close cooperation of a number of agencies and the integration of diverse data types and formats.

**COSTS** At approximately US\$3 million, the bulk of which was for construction of a building, this project represents one of the most significant investments the World Bank has ever made in GIS-related technology. Interestingly, the success of the project relates more to the inclusion of a significant training and technical assistance component – often overlooked in similar initiatives. An approximate cost breakdown is as follows:

	US\$
Training and consultant technical assistance	e 300,000
Hardware and software total	250,000
Including:	
ARC/INFO (the main system)	
c.8 workstations	60,000
ARCVIEW (for the end-user,	
c.10 copies of the software) 15	,000-20,000
ERDAS Imagine software	16,000
Scanners, each	2,000
Satellite receiver station to receive National	I
Oceanic and Atmospheric Administration d	lata 50,000

**RESULTS** The 22 areas chosen have been surveyed, inventories taken, and the results entered into the existing National Plant Genetic Resource Information System and a related GIS, allowing mapping of the target species and providing the basis for detailed management plans. The latter has been carried out at the multi-agency GIS centre established in Ankara to provide analytical support and the long-term monitoring capacity required by the project, and to ensure that future projects in related fields (e.g. forestry) benefit from the expertise and data resources now available.

The centre, which primarily uses the ARC/INFO GIS software and ARCVIEW, a related mapping product, as well as the ERDAS image processing software (for processing of satellite data), draws on the data holdings and skills of a number of agencies, both governmental and non-governmental. These specialized agencies (e.g. the Aegean Agricultural Research Institute in Izmir) have been provided with limited GIS/data management capacity to enable their contribution, and long-term cooperation and data exchange are guaranteed by a protocol signed by all project agencies. Current efforts are focusing on physical integration of the centre with the specialized agencies through fibre-optic links (upgrading their current modem connections), as part of the Turkish government's ambitious information technology plan.

### CONTACT

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- Watersheds of the world: global coverage derivative data from the digital elevation model mentioned in the previous paragraph. All processing of this information took place at the University of Texas in Austin, United States, and is available at the Eros Data Center as above.
- Land use/land cover: global coverage interpreted data from high-resolution satellite imagery. Available as above, at 1 kilometre square resolution.

### Remote sensing for environmental data

Many of the data required for GIS are obtained by remote sensing. Remote sensing is any process in which information is gathered about an object, area or phenomenon without being in contact with it. Remote sensing can include satellite imagery, aerial photography, radar, video and more. Remote sensors utilize different bands on the electromagnetic spectrum. The green, red and near-infrared wavelengths all provide good environmental data. Chlorophyll, for example, is a very strong absorber of red wavelengths. With

**CORPORATE VIEW** 

### Damage limitation

THERE ARE 17 operational, commercial satellite systems orbiting the Earth today. These Earthobserving sensors provide worldwide access to satellite imaging systems that were previously inaccessible to those countries unable to participate in space technology. This valuable tool is now universally available for those wishing to accurately assess and monitor changes or developments in their environments.

Imagery Exploitation Services provides its clients with detailed and accurate satellite images and an interpretation and analysis of the data they contain. It also runs training courses ranging from basic imagery and radar imagery interpretation to advanced training and instruction in specialized fields. Satellite imagery, which can be applied to any number of situations, is an accurate, cost-effective and quick way to assess population growth, climatic changes, the feasibility of developing new infrastructure, industry growth, forestry and agricultural development, and areas affected by natural disasters.

Natural disasters can cause unexpected deaths as well as a total breakdown in vital communication systems and the collapse of essential infrastructure. Satellite imagery is paramount to the successful operation of an efficient relief programme. By delivering a quick assessment of the area, it reduces preparation time and assists in monitoring the rescue operation's progress. This technology undeniably helps to save lives.

Many unpredictable and dangerous natural disasters are related to volcanic activity. Dormant volcanoes can explode with tremendous force, devastating large areas. Disaster response teams rely heavily on radar imagery to prepare efficiently and quickly for life-saving exercises. As areas affected by volcanoes are usually covered by a cloud of steam and dust, normal imaging flights or standard optical satellite pictures are of little use. Radar imagery, however, is effective in the most adverse weather conditions and operates efficiently without sunlight. Similar to black-and-white photographs, these images – produced using radar technology – provide enough detailed information to enable an accurate assessment of any situation.

Radar images played a key role in formulating an effective disaster response when an eruption occurred on the island of Montserrat in the Caribbean in 1997. Radar imagery provided an initial overview of the island, defining the regions that were directly affected. With the use of corresponding maps, the locating and plotting of inhabited areas and the likely direction of the lava flows were easily applied. It was then possible to plan and activate emergency exit routes in and out of the affected areas, minimizing loss of life. To this end, remote sensing, when used as a monitoring tool, is a key asset now and will increasingly be so in the future.

> Imagery Exploitation Services E-mail: chiasson@ies.ca Website: http://www.ies.ca For further information see Annex B

# telecommunications *in Action*

this knowledge, anyone can look at a remotely sensed image and determine where there is an abundance of chlorophyll-filled plant life. By comparing a 1999 image with a 1989 image taken at the same time of year, it is possible to determine if and where such plant life has disappeared, perhaps due to human-imposed changes to the ecosystem.<sup>11</sup>

Data from remote sensing are fed into computer systems. Though satellites may beam down an extremely large amount of data about Earth each day, the information is useless until processed by computers on the ground. It is at this stage that data become useful knowledge. For example, analysis from Earth Observing Satellite EOS AM-1 allowed scientists to conclude that about half of the mineral dust concentrations in the atmosphere arose as a result of human activity including overgrazing, deforestation and cultivation. And, in a more recent project, scientists are using new satellite technology to create crop production models and to examine the effect of El Niño and other phenomena on global agricultural productivity.<sup>12</sup>

### **CORPORATE VIEW**

### Digital maps

WITH THE enormous growth in wireless networks, telecommunication companies are demanding accurate databases of high-quality digital maps. Istar of France, the world's leading cartography company, is an expert in digital map production. Among its customers are over 50 of the major global telecommunication companies including Ericsson, France Telecom, Motorola, Nortel and Vodafone. Engaged in producing digital maps of over 2,000 cities in 80 countries, the company is focusing on areas where existing telecommunication systems need to be expanded or upgraded. Working in partnership with Spot Image, Istar has access to its archive of 5 million images gathered by a network of orbiting satellites and 22 ground receiving stations.

In 1996 Istar published a catalogue which contained off-the-shelf telecommunication data sets aimed at the wireless market. This information enabled radio design engineers to have extremely accurate and up-to-date maps at their fingertips. Publication of the catalogue was an innovative move, proving the company's worth as a market leader in its field.

To be able to design efficient wireless networks in dense urban areas, it is essential to have extremely accurate detail regarding the height of the buildings and the lie of the terrain. Istar and Spot Image have developed a data package which contains three-dimensional height information.

While these databases can be adapted to suit the client's specific requirements, the company has also

produced a library of city maps which are available off the shelf.

Although there is a demand for information of this kind all over the developing world, there is a particularly large market for digital maps in Latin America where wireless technology is increasingly being used to deliver telecommunication services to customers, and demand is predicted to increase dramatically by the year 2002. The data, which is marketed as a "dense urban package" contains four compatible files based on aerial photography, cutting-edge techniques and satellite data. Ground surface elevation, topography, location and the shapes of obstacles that may impact on wireless transmission are included in the package, while clutter maps illustrate both natural and man-made features which could affect transmission.

Digital maps of this quality are vitally important to obtain an accurate picture of any geographical area. This technology has wide-reaching benefits for developing countries where large infrastructure programmes are planned. A detailed and accurate record provided by digital maps will show cost and efficiency benefits in the early stages and result in a better end-product.

> Istar E-mail: lanchon@istar.fr Website: http://www.istar.com For further information see Annex B

### Groundwater clean-up

GIS SOLUTIONS can be developed for cleaning up polluted sites. One successful pioneering example is ENVEIS - the Environmental Engineering Information System - which was set up to support the work of the environmental remediation team at the United States Naval Air Engineering Station at Lakehurst. The site had been put on the National Priority List of polluted sites in 1987. In 1992 the station developed a GIS solution to enable the remediation team to make more effective use of the data generated by the cleanup operations and thus increase the effectiveness of their efforts. Semcor Inc., in conjunction with station staff, developed ENVEIS using GIS software from the Environmental Systems Research Institute (ESRI), database software from Oracle Corporation and modelling software from EarthVisions Corporation. Remediation teams used the new system to model data and estimate the effects of

different remediation techniques, and were able to achieve their goals more guickly and cheaply. For example, 3D visualization (which provides the ability to see what the groundwater pockets look like underground) and predictive modelling (which enables users to judge in advance what will happen if certain actions are taken) allowed the remediation team to see how contaminants move over time, and how they would respond to various pumping scenarios. ENVEIS has helped the station to bring its remediation programme near to completion and has matured into an ever-growing repository of information on soils, wetlands, flood plains, wildlife and rare species, topography, site history, buildings, utilities and much more, that is used to monitor and manage the station environment. Similar GIS solutions could be developed to deal with similar problems related to cleaning up polluted sites anywhere in the world.13

Figures 1 and 2 show an example of how ENVEIS was used to support environmental remediation action, in this case groundwater clean-up.



**Figure 1:** An aerial photograph overlaid with roads, property lines and well sites. The area is covered with dense vegetation as well as wetlands and streams, and some areas are practically inaccessible. ENVEIS was used to find out the well sites that best supported the investigation while accounting for access constraints.



**Figure 2:** An underground cross-section of the contaminant plume generated from well data stored in the system with base roads and runways shown on the surface. ENVEIS visualization was used to gain regulatory and public approval for natural attenuation, saving the millions of dollars needed for a groundwater treatment system.

**Figures 3 and 4** show an example of how ENVEIS is used to support environmental impact assessment studies for proposed new developments. Various views of different types of information can be combined, viewed and analysed to see the impact a proposed development will have on a given area. Without a GIS this task would be close to impossible because of the difficulties in assembling and compiling the volumes of necessary data.



**Figure 3**: Soils and wetland data with relation to the main runways.



**Figure 4**: Topography and rare species information for the same area as Figure 3.

### TELECOM APPLICATIONS

# GIS applications for environmental protection andmanagement

GIS is the key tool in using data and information for environmental protection and management. "Protecting and managing the environment continues to propel the development of GIS applications. GIS technology provides the means to conduct a more rational analysis of the factors that impact the environment, including the risk management models now being developed," says Sara Moola, Environmental Industry Manager at the Environmental Systems Research Institute (ESRI).<sup>14</sup>

She goes on to explain how recent developments in computing support the spread of GIS because desktop computers are cheap and powerful, and reliable, user-friendly desktop GIS solutions are now available, and to describe what makes GIS so helpful for environmental applications: "The ability to handle large data sets from multiple databases makes GIS well suited to environmental management tasks. Complex models created using

### CASE STUDY

### Assessing risk

### **OBJECTIVES**

■ To find out which crops were most susceptible to damage by bad weather and other natural events.

■ To find out which roads and other facilities used for agricultural distribution were most vulnerable to hazards.

■ To discover where the government should put in place mitigation measures to protect rural income, employment and investment.

BACKGROUND Ecuador's agricultural sector provides a high percentage of the country's gross national product but is very vulnerable to natural hazards, particularly floods and droughts. These can damage both the crops and the agricultural infrastructure, causing losses of more than US\$100 million in any one year.

**DESCRIPTION** The Ministry of Agriculture acquired a desktop geographic information system (GIS) workstation and spreadsheet software to analyse data for Ecuador's 20 provinces. For each province, the GIS combined data on 26 production systems, 14 crops and related infrastructure – storage facilities, irrigation systems, road networks – with data on droughts, erosion, volcanoes, floods, landslides and seismic hazards. Data on five economic indicators – income, employment, foreign exchange earnings, investment and food security – were then introduced.<sup>15</sup>

**COSTS** This project was a relatively early application of GIS solutions for risk assessment. A realistic estimate of the costs to carry out a similar project today would be around US\$7,500-10,000 for the basic software for the GIS workstation that drives the system and US\$1,500-2,000 for the viewing software for each end-user. The costs of researching and configuring the data, where these do not already exist, will be the most expensive elements of such a project.

**RESULTS** The analysis identified 49 critical situations that required action to lessen the vulnerability to natural hazards. These included:
The impact of drought on banana production in El Oro province posed the greatest threat to Ecuador's foreign exchange earnings from agriculture.

■ Flood hazards in Guayas province and erosion hazards in Tungurahua province posed the greatest threat to agricultural employment in Ecuador.

■ Erosion hazards were likely to damage a potato growing area that, at the time of the study, accounted for 43 per cent of the national income from potato production and 80 per cent of income in Carchi province.

Based on the information, the Ministry prepared a technical cooperation proposal to reduce risks from natural hazards. It also formulated new investment policies and technical assistance activities in the agricultural sector.

Natural hazards pose a major threat to the agricultural sector in many developing countries. Analyses similar to this one could be used in other countries based on existing data and using a desktop workstation.

### CONTACT

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### telecommunications & Environment

GIS can easily be updated. Environmental regulators and policy makers receive better information more quickly, and can manage natural resources more wisely by using GIS for planning, modelling and monitoring activities."

GIS applications for environmental protection and management are being developed all the time. The three examples that follow give some idea of the range.

- An existing GIS implementation was extended to perform risk assessment and flood modelling to help mitigate the impact of El Niño. Planners modelled multiple flood scenarios and were able, as a result, to map flood plains. This information allowed them to take pre-emptive measures to minimize the impact of storms and plan effective response.<sup>16</sup>
- RAISON-GIS is a software system that is used to analyse the quality of drinking water. Developed by the International Development Research Centre, this integrated package combines information from different

### **CORPORATE VIEW**

### Project management

**P**ROVIDING infrastructure, installation and implementation services to telecommunication operators, carriers, equipment providers and system integrators, Italian-based Celant offers expert technological, financial and commercial solutions to the industry's needs.

The electronic revolution is bringing enormous benefits to people in remote locations but, at the same time, the relatively fragile components inherent in these new networks must be protected from the rigours of the environment. Celant is an established reference point for the provision of project management and engineering expertise to the telecommunication industry and, through its associated companies, it is able to provide comprehensive quality services. Esatech manufactures shelters and devices to cool equipment without the need for an external power source. Omnishelter supplies selfcooled shelters, cabinets and air-conditioned shelters while Frola offers naturally ventilated shelters, earthing systems, high-voltage protection and telephone boxes. Coer provides power plants and Gechelin and IPC offer solar and hybrid power systems. Fimo supplies cable entries, clamps and fittings while Powerflex manufactures damping and shock-absorbing systems. Calzavara provides mobile stations; Fer offers both mobile stations and telephone boxes; Omp provides racks and cabinets; and Hiross-Denco supplies air conditioners.

The installation and development of new telecommunication networks, particularly in developing countries, often take place in climatically and physically challenging regions. In order to counteract and prevent damage to systems, service providers are constantly looking for ways to overcome potential damage and delivery interruption from the outset. For most locations and, particularly remote locations without infrastructure, energy-saving cooling is of paramount importance. Most component failures are caused by overheating and many medium- to high-powered applications produce enormous quantities of heat which must be cost-effectively dissipated.

Celant has proven experience in engineering passive and semi-passive systems and is ideally positioned to offer a range of technically advanced construction products to control the environment surrounding the delicate components vital to the efficient operation of today's sophisticated networks. Drawing on the expertise, experience and practical know-how of its associates, the company provides solutions to ensure that components are durable, fire resistant, corrosion and water resistant and can withstand winds of 160 kilometres per hour. Maintenance over a 20-year period will be reduced to a minimum. By preventing long-term maintenance costs and by dealing with potential problems from the initial stages of a project, Celant is able to offer professional, long-term solutions to its clients worldwide.

> **Celant** E-mail: encelant@tin.it For further information see Annex B

# tel ecommunications *in Action*

sources to map water quality in remote areas. Existing maps are digitized and combined with a database of statistical information on sanitation facilities, sources of fresh drinking water and other relevant information. The software tools incorporated in RAISON (which stands for Regional Analysis by Intelligent Systems ON Microcomputers) can then generate digital maps giving information on overall water quality and highlighting where there are issues to be addressed.<sup>17</sup>

A common problem facing environmental managers is the lack of adequate knowledge about the distribution of the species. The Centre for International Forestry Research has developed DOMAIN, new Windows software for generating maps of the potential distribution of plants and animals. DOMAIN takes known distribution points for species and uses map layers of environmental factors, such as climate, soil and land use, to construct an environmental habitat envelope or "domain" for those points. The envelope is then compared with environmental data for the

### **CORPORATE VIEW**

### Wide-area data communications

I N MANY REGIONS of the world, terrestrial data networks can provide only patchy, unreliable coverage, and this can have frustrating consequences for telecommunication users. For instance, electrical power distribution facilities often extend over vast rural areas, and to pinpoint a location where repairs are needed can require workers to drive for miles until they find the failure point. This is a time-consuming, unproductive and costly process.

Big LEO (low Earth orbit) satellite systems can be an answer, but they are mainly designed to focus on voice services and are expensive. On the other hand, non-voice, non-geostationary, mobile satellite service systems (Little LEOs) are designed specifically to address situations that require minimal data, at low cost and with a high level of reliability. And because of their VHF/UHF (very high/ultra high frequency) specification, they can focus on short data message applications.

The Leo One system is a two-way seamless wireless network offering worldwide coverage. It is designed to complement and extend existing national networks of local, long-distance, private and terrestrial wireless services via interconnection with a global system of gateways. It is suited particularly for situations that require wide-area, low-cost data communications. For example, the system's control and monitoring functions make it possible to send data to and receive data from remote or unmanned facilities, such as government weather stations, a waste-water treatment plant, or the powerhouse of a hydroelectric dam. Even a van crossing the desert, a lonely trawler far out at sea, a hiker high in the mountains, livestock or wildlife on the move, or an irrigation station 60 kilometres from a ranch house, are within the system's range.

The Leo One system will target five main applications in a wide variety of industries:

- tracking and fleet management: trucks, trailers, other commercial vehicles, intermodal containers, maritime vessels, aircraft and heavy equipment;
- monitoring and remote control: utility meters, oil and gas wells, pipelines, environmental systems and irrigation systems;
- emergency services: monitoring, locating and dispatching in emergency situations;
- transaction processing: mobile data processing for point-of-sale credit card validation and similar uses in both industrial and retail operations;
- two-way messaging: electronic mail and paging services for both businesses and individuals.

Leo One E-mail: erik@leoone.com Website: http://www.leoone.com For further information see Annex B

# telecommunications & *Environment*

region under study and a map produced of ranges that are similar to the species' primary domain. This can be a useful way of generating maps for planning and inventory. In line with the Centre's policy on data and information sharing, the DOMAIN package is distributed free of charge, and can be downloaded direct from the Internet at <http://www.cgiar.org/cifor/research/intro\_d.html>.<sup>18</sup>

### Preventing and dealing with environmental emergencies

Costly natural disasters are one of the forces behind the growth of GIS for risk assessment applications. Government and other agencies need to be able to respond rapidly to natural disasters and environmental crises, and geographic information can help them to make the right decisions in time. For example, new communication technologies are being utilized in Brazil to monitor the huge forest fires and make intelligent decisions in combating them, as discussed below. Using GIS-produced models, strategic plans are being developed and will be disseminated in a variety of ways to reach government officials and others concerned. The programme that Brazil is now launching serves as a useful working model for other countries and regions.

### Emergency response to forest fires in the Amazon<sup>19</sup>

Forest fires have long been a problem in the Brazilian Amazon, either resulting from natural processes or in connection with agricultural practices. In the last few years the risk of these events spreading across wide areas has greatly increased as a result of the effects of El Niño. The areas of highest risk are concentrated in the "Arc of Deforestation", which represents the southern/eastern interface between the Amazon basin and human interference. In response to this, and in reaction to the huge fire which swept the state of Roraima in early 1998, the World Bank launched a project, called PROARCO (a programme for the prevention and control of forest fires), to provide a coordinated and rapid response to future fire events, by mobilizing government agencies and operational capacity, including state and municipal fire brigades, the military and responsible federal agencies.

An integrated information system is essential to the project as a few hours may mean the difference between a controllable fire and a catastrophe. The system, designed for PROARCO, builds on the capacity and expertise of a number of agencies, notably the Instituto Nacional de Pesquisa Espacial (INPE) and the Instituto Brasileiro de Meió Ambiente (IBAMA). The system, which is designed to produce useful output on a four-hour turnaround, combines data from a number of sources, including high-resolution satellite data (available daily) used to identify fire hotspots, meteorological data, information on basic vegetation coverage, topographic data and a risk assessment model.

These data sources are combined by INPE in a GIS (SPRING, a system written in Brazil by INPE) at a base mapping scale of 1:1,000,000. The outputs from the system include Web pages of hotspots plus an assessment



The PROARCO project uses an integrated information system to provide a coordinated response to forest fires.

SR Telecom

### CASE STUDY

### Monitoring forests

### **OBJECTIVES**

 To build an independent global monitoring system to track forest resources, changes and activities, especially in developing countries.
 To provide information that will allow societies to identify and head off destructive development before it results in widespread forest destruction.

BACKGROUND Global Forest Watch is initially being set up as part of the World Resources Institute's Forest Frontiers Initiative which promotes stewardship in and around the world's last major frontier forests by influencing investment, policy and public opinion.

**DESCRIPTION** Action is necessary because 80 per cent of the forest that originally covered the Earth has been cleared, fragmented or otherwise degraded. The remaining forest - largely in the Amazon basin, central Africa, Canada and the Russian Federation - is threatened by logging, mining and other large-scale developments. The exact magnitude of these threats is not known because current global forest monitoring efforts are limited to tracking forest loss rather than changes in forest use and condition. Such "post-mortem" data are often of limited value as they are usually available only when it is too late to take any action.

The World Resources Institute (WRI) is working in cooperation with 25 non-governmental organizations on Global Forest Watch. This independent, decentralized global monitoring network is using geographic information systems (GIS) and other techniques to collect and disseminate forest development monitoring data.

Monitoring centres or "nodes" are being established in areas most at risk. These nodes are collecting standardized data that can be used to build up a broad picture and maintain a set of interlinked websites to share, communicate and evaluate the data collected.

Informative maps will be produced containing spatial information about particular forests. Fused with the geographic information will be administrative data such as bidding practices for leasing of land as well as laws and regulations regarding specific forest areas.

**COSTS** Core support for monitoring activities comes from a trust fund administered by the Global Forest Watch service unit. Software and hardware companies, such as the Environmental Systems Research Institute (ESRI), and major data providers, such as NASA (National Aeronautics and Space Administration), are being asked to provide materials and training at low or no cost to those nodes most in need. In most countries, nodes will be supported by matching funds from the service unit and money raised by their own fundraising activities.

Costs for the software and hardware to equip each node are likely to be between US\$100,000 and US\$250,000, depending on the particular needs of the location, the skills already available, and the existing information and communication technology infrastructure.

**RESULTS** To date, WRI has begun Global Forest Watch initiatives in Cameroon, Canada, Gabon and Indonesia. These four pilot countries are representative of the range of conditions that will be met as the project is extended to other regions. Chile and the Russian Federation are scheduled to participate soon.

Previous projects of the Forest Frontiers Initiative using similar methodology indicate the sort of

results that may be obtained. In one example, satellite data, sophisticated computer mapping and data collected on the ground were used to investigate the environmental implications of the increasing logging activity in Myanmar. Satellite data showed that forest clearing in Kachin State more than tripled between 1978-1989 and 1989-1996, and that logging was responsible for almost half the deforestation. A convergence of evidence suggested that a combination of logging and shifting cultivation was opening up large areas of intact forest along Myanmar's borders, with potentially quite damaging environmental consequences that could include soil erosion, reduced soil fertility and agricultural productivity, sedimentation of river channels, siltation of dams, catastrophic floods, and acute water shortages during the dry season. This information will help the international community to take action to improve the situation in Myanmar.

Information about this project is made available on the Forest Frontiers Initiative website <http://www.wri.org/wri/ffi>. Interactive forest maps, similar to those that Global Forest Watch will produce, graphically illustrate areas of forest loss, and "Realaudio" is used for discussion of the threats to frontier forests in southeast Asia. An animation shows shrinkage of forests in Asia from original to current frontier forest cover.

### CONTACT

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of associated risk, which are updated automatically, maps, which are faxed to the states and municipalities, and input transmitted to the GIS held in the IBAMA situation room. The latter, which is based on the ARC/INFO GIS software, combines fire data with data on protected areas, socio-economic data and forest-burning licences, not only to assist in guiding the deployment of fire brigades but also to monitor compliance with legal procedures. Deployment itself is carried out following a teleconference between the agencies.

### A global early warning centre

The new Center for Applied Biodiversity Science, housed in the Conservation International building in the United States<sup>20</sup> but with a worldwide remit, will gather world leaders in science, technology, economics, conservation and other disciplines to develop action plans to quickly counter imminent global threats. Working closely with partnership organizations worldwide, it will tackle in the field some of the most pressing threats to biologically rich natural habitats and will serve as an early warning system by forecasting impending biodiversity crises. The centre will tackle complex, emerging issues such as predatory logging. This threat has rapidly escalated in the past decade with international logging conglomerates targeting tropical developing nations for huge tracts of pristine forests. In most cases, massive environmental degradation occurs as a result of these logging activities, with little economic return for the developing countries involved.



Source: World Bank, World Development Indicators, 1998



### Meeting communication needs for the environment

Like all modern organizations, environmental agencies can use telecom applications to make their internal and external communications more efficient. Conservation International (CI), an international biodiversity conservation organization based in Washington DC in the United States, has used advanced communication technologies since it was set up in 1987. In the late 1980s, fax technology was a breakthrough for international development organizations since it enabled extremely rapid document delivery to remote areas via regular telephone lines. Unfortunately, while less expensive than voice communications, the cost of faxing between different countries remained quite high. When e-mail became available, therefore, CI adopted it for both internal and international correspondence. CI has offices throughout the developing world, and a rapid and inexpensive communication infrastructure has been fundamental to enabling it to manage widely dispersed projects effectively, improve overall productivity and develop a rapid response to critical conservation issues.

**CORPORATE VIEW** 

### Learning from the rainforests

GUNNER's mobile satellite communication networks are taking important discoveries made on scientific expeditions in remote corners of the world directly into the classrooms of students in Bermuda, Mexico, the United Kingdom and the United States. Project Jason, one of the most innovative and important of these expeditions, is using satellites and related space technology to carry out valuable research on tropical rainforests. The programme, which has been designed to stimulate student interest in science and technology and provide professional development for teachers, is breaking new ground in distance learning techniques.

Advanced telecommunication technology is allowing millions of students at primary interactive network sites to see the expedition unfold before them. They are able to interact with scientists in the field and control video cameras to feed them live information. Simultaneous broadcasts involving video, audio and data signals are downlinked to the sites in less than half a second. Before taking part in a live broadcast, students and teachers spend time in and out of the classroom preparing for the "telepresence" experience. Teachers are supplied with a multi-disciplinary curriculum ensuring that students are fully briefed on the scientific principles they will come across during the live broadcasts.

The Jason Foundation for Education offers teachers comprehensive professional development programmes including courses delivered via the Internet. Collaboration is essential in scientific research. On-line systems provide the ideal forum for this by enabling students and teachers to access news, join discussion groups and exchange and share information. Students are encouraged to post the results of their local field investigations on-line, communicate electronically with students around the world, and compare and contrast research findings. Graphics, video, sound clips and interactive exercises on current and past scientific projects, as well as photoscrapbooks on recent expeditions, journal entries and on-line chats with scientists, are all available on the website.

Exciting technological advances in satellite communications have opened up the world. Distance learning has meant that students are taken out of the classroom into real experiences and situations without leaving their desks. Teaching and learning methods have been revolutionized as interactive programmes allow wider discussion, access to an enormous and varied range of information and practical hands-on participation. Other innovative programmes in the pipeline include the use of photographs of the Earth's surface to identify and calculate the rate of deforestation, and the role of geographical information systems in analysing the distribution of medicinal plants.

### Gunner

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### CASE STUDY

### Helping the biosphere reserves network

### **OBJECTIVE**

■ To help the international biosphere reserve network conduct research, share information and provide examples of sustainable development, effectively and efficiently, regardless of location.

**BACKGROUND** Each biosphere reserve represents one of the Earth's major ecosystems. It is managed in a series of zones, from the most highly protected core zone, through a multi-use buffer zone to the transition area at the edge of the reserve, in order to conserve the ecosystem and its biodiversity. While traditional parks often attempt to form small protected areas in a world increasingly dominated by severe human impacts, biosphere reserves are designed to bring people and nature together to demonstrate how to both use and preserve nature.

**DESCRIPTION** In 1996 Conservation International (CI) and the UNESCO Man and the Biosphere programme began collaborating on a project to improve technical capacity and communication links for 25 biosphere reserves in Africa, Asia and Latin America.

The project provides each reserve with a computer, software, an Internet connection and training in conservation-related applications. Training takes place in two- to three-week regional workshops and is followed by ongoing technical support and information sharing via the Internet.

The Internet is an especially effective tool for international conservation and development. Like the fax, it can help people in different time zones communicate easily and quickly and, like e-mail, it has the advantage that it does not usually require expensive (and sometimes difficult) international telephone calls.

Satellite technology is often used for remote sensing in these projects, and these data are formatted and analysed on the ground for sharing over the network. Cl's primary focus here is information management.

### COSTS

Equipment budget (per site)	Price (US\$)
Computer: Intel Pentium II 300 Mhz,	
64-megabyte RAM, 4-gigabyte hard disk,	
CD-ROM, video	2,000
Colour inkjet printer	400
Modem	250
Digitizing tablet 18 x 24 inches	600
Uninterruptable power supply 350w	250
Internet connection (6 months)	300
Office software	500
GIS software	700
Total	5,000

### Two-week training workshop budget

	Quantity	US\$/Unit	Total
Trainers – CI Washington (2)			
Travel	2	1,500	3,000
Expenses	2	800	1,600
Local counterpart trainer			
Travel	1	500	500
Expenses	1	800	800
Salary	1	1,500	1,500
Participants (2 per reserve)			
Travel	12	1,000	12,000
Expenses	12	800	9,600
Training site fees	1	1,000	1,000
Workshop preparation and f	ollow-up		
Copying & printing	1	3,000	3,000
Telephone, fax, mail	1	1,000	1,000
Information purchase	1	1,000	1,000
<b>Fotal</b>			35,000

### RESULTS

The CI-UNESCO project is using the Internet to reinforce the biosphere reserve network in the following ways:

■ facilitating the exchange of information on protected area management methods and data;

enabling collaborative research between scientists and managers in different geographic regions;

providing a conduit for accessing experts and information databases from different scientific disciplines;

■ allowing simpler communications with development assistance agencies which provide funding for conservation initiatives.

Cl staff are also using the Internet to facilitate discussions between reserve managers, scientists and other interested parties. This assistance includes a special Internet mailing list and the development of an on-line library of relevant information (primarily case studies and techniques for computer-assisted planning) available on Cl and UNESCO's Internet servers.

### CONTACT

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A CI project that is benefiting from advances in communication technologies is the Rapid Assessment Program (RAP). Formed in 1990, RAP aims to identify, through rapid biological field assessments, what species actually exist in the planet's most biologically important regions. The core of the Rapid Assessment Program is a team of the world's premier field biologists who identify and evaluate species' distribution and natural communities.

RAP and its aquatic counterpart, called AquaRap, are using satellite telephones to rapidly communicate the results of their scientific expeditions for publication on CI's website. Digital photographs and field reports are transferred using satellite telephones to transmit the data only hours after they have been collected. CI-Washington then posts the information directly on the Web. Using this technique, satellite communication technology permits very rapid conversion of raw data to information that can be used to strengthen the decision-making process.<sup>21</sup>

Radio also has a part to play in communications in the environmental field. For example, a radio network in Madagascar provides a vital communication link between the SAVEM (Sustainable Approaches to Viable Environmental Management) headquarters in Antananarivo and its project office in Maroantsetra. Before the network was available, messages were passed by sending written documents on thrice-weekly Air Madagascar flights or by telegram which took six days to arrive, significantly hampering time-efficient project operations.<sup>22</sup>

### Using the Internet to spread the word

Environmental organizations can use the Internet to keep their existing supporters informed about what they are doing, and to reach new supporters. For example, WWF-World Wide Fund For Nature, the conservation organization, has a lively and constantly updated site at <http://www.panda.org>. WWF's 1998 *Living Planet Report*, which seeks to present a quantitative picture of the state of the world's natural environment and the human pressures upon it, is available in a format that is quick to download as well as in two interactive versions, one of which uses cutting-edge Macromedia Flash technology. For the organization, the Internet is a more cost-effective way to reach an interested public than mailing printed copies of its reports could ever be.

Making information available to environment professionals is another useful function performed by the Internet. Websites range from the International Institute for Sustainable Development's Linkages <a href="http://www.iisd.ca">http://www.iisd.ca</a>, designed to be an electronic clearing house for information on past and forthcoming international meetings related to environment and sustainable development, to The African Water Page <a href="http://www.sn.apc.org/afwater/index.html">http://www.sn.apc.org/afwater/index.html</a> which was set up by one enthusiastic individual so that water sector professionals in Africa could exchange information and views.

The Internet is also a good source of updates on information and communication technologies for environmental organizations, which can even download specialized software. For example, ICONS is a database management system designed by IUCN–The Conservation Union to meet the needs of nongovernmental, rural and indigenous groups and individuals working in



The WWF site at <http://www.panda.org> keeps supporters informed about WWF activities and tells them how they can help.



developing countries. It can be downloaded free of charge by such users from the website at <http://www.iucn.org/icons/index.html>. The system consists of integrated modules for managing information on organizations, projects, source materials, laws, species and other commonly needed information, and includes desktop GIS capability. LEAP, the Long-range Energy Alternatives Planning system, is a user-friendly software tool for energy and/or environment planning and greenhouse gas mitigation analysis. Developed by the Stockholm Environment Institute–Boston, it can be downloaded, together with training notes, at <http://www.seib.org/leapbro.html>.

### Communication and education for lasting results

Many of the projects described in this section are of major national or regional proportions, some are even global in extent, and many deal with monitoring environmental systems and resources or maintaining an inventory of them. Much of the damage to the environment, however, takes place at a local level

### **CORPORATE VIEW**

### Advanced communications

**I**NTERSAT is a data network engineering company uniquely positioned to provide advanced communication solutions through the development of its Global Data Network (GDN) technology to a diverse international client base.

GDN software and hardware technology have been designed to:

- capture mission-critical or important data at a source anywhere in the world;
- use a wide variety of incoming core communication media;
- modify or add value to the data based on the customer's requirements;
- use a wide variety of network routes to send or transmit data;
- deliver the data to their destination.

Core communication media such as satellite, microwave, cell, radio and the Internet can be used. INTERSAT specializes in satellite and Internet communication. In data acquisition cases where there is no suitable communication infrastructure, it designs and develops microwave and satellite systems to comply with clients' specific needs.

Its engineering teams have an extensive background in real-time industrial control and telecommunications for large-scale manufacturing and processing operations over wide area networks. In these critical, and often harsh, data communication environments, security, timeliness, reliability and integrity of data are paramount. An example of a feature designed to ensure timeliness and integrity is an innovative device which allows an interrupted transmission to be resumed from the point at which it was broken off without starting again from the beginning.

The GDN technology has produced a number of products and services to address specific client applications. When natural gas clients asked for remote asset monitoring and control from around the world, the company produced the Site Hawk series of services for alarm monitoring, polling and exception reporting. Site Hawk allowed the client's employees to send and receive data where there is neither electrical power nor terrestrial communications.

When clients asked for G3 faxing across geostationary satellites and the Internet, the company developed the Interfax product line.

Products and services are not dependent upon the availability of a particular communication medium. The company works with the communication medium which makes the most business sense for the client's communication needs whether that be landline, cell, satellite or microwave. Targeting its remote monitoring and control (SCADA) services at the natural resource, utility, environmental, transportation and telemedicine markets, the company has a key role to play in developing systems in emerging economies. It has the research and development capabilities to design and build devices and systems to meet all client needs.

### Interprovincial Satellite Services (INTERSAT)

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# telecommunications *in Action*

and in rural or remote areas where central administrative influence is minimal. Without realizing the impact of their actions, individuals or groups, such as farmers, may follow traditional practices (e.g. slash and burn) that have longterm negative environmental impacts. Others, fishermen for example, may use modern technological methods (such as explosives or powerful chemicals) which cause irreversible damage to such delicate species as corals and their rich microbiological environment. Still others may accept technological advances in their daily lives (such as plastic bags and plastic water bottles) but have never been provided with adequate means for disposing of the resulting wastes which then pollute the land and the sea, causing problems for animals and fish.

The people responsible are often acting under survival pressure to provide food or monetary earnings (in response to non-local demand) and, in their current situation, have no choices. The primary decisions for change must come from the highest levels of government where enforceable environmental protection policies must be adopted. However, there is frequently

### **CORPORATE VIEW**

### Private sector finance

THE PRIVATE sector will be responsible for funding new information infrastructure systems in emerging economies. Targeted at the education, business, governance, health, agriculture and environment sectors, the new systems will be developed jointly by the users and service providers. Investment companies, banks and international lenders will join the World Bank Group and other international financial institutions to work with the users and providers of these services to package the appropriate financing arrangements. International Investment World works with developing countries to finance projects in a number of ways, including loans and discount promissory notes. It also assists in putting together larger financial packages with other institutions.

Developing countries realize that inaction means that they will fall further behind, and possibly lose the opportunity to join the global information economy. Investment in cost-effective information infrastructure is critical for each sector, and innovative financing techniques and structures are needed to attract capital to implement these new services in emerging markets.

Lenders and equity investors such as the International Finance Corporation, the private sector arm of the World Bank, and private financial companies such as International Investment World, will assist in feasibility studies for larger projects, including infrastructure development. Acting as a catalyst to attract finance from other sources, the International Finance Corporation syndicates finance from lenders and investors in the private sector. However, the ability to access capital is dependent on business fundamentals and market conditions.

Project finance may create a stand-alone entity which would be funded through equity contributions by the sponsors and by non-recourse or limited-recourse debt. Build-lease-transfer and build-own-transfer transactions have been extensively used in the telecommunication sector. Vendor and supplier financing for equipment and software is an integral part of a financing plan although it covers only imported equipment and products.

High-yield debt is used for early-stage telecom ventures where institutional investors require high fixed returns and sometimes equity participation. Wireless projects are using this method where there is a proven demand and likely future cash flows for service providers. Non-traditional equity investments offer convertible debt, straight or convertible preferred stock, warrants and equity-derivative instruments.

The private sector, with the international financial institutions, will provide funding for information and communication technology infrastructure while new technology and services such as the Internet, cellular technology and video will be privately financed and operated.

> International Investment World E-mail: papadakis@swissonline.ch For further information see Annex B

### telecommunications & Environment

inadequate communication between government and its more remote citizens. Telecommunication infrastructures can provide the necessary means, not only for governments to communicate policies, but also to educate their citizens to adopt sustainable practices which are often more productive than their traditional ways. Distance education, health instruction and training in farming methods using telecommunications are dealt with in other sections of *Telecommunications in Action*.

### **COSTS AND FINANCING**

The costs of developing and implementing an environmental project utilizing GIS in a developing country will vary according to the nature and specifics of the project, what currently exists, and to the needs, skills, and existing information and communication technology infrastructure. Some of the key determinants of cost will be:

- 1. Data availability: what spatial data already exist at a defined accuracy and precision?
- 2. Data model/data standards: do these already exist in a systematic way?
- 3. Number of agencies involved.
- 4. Does a local area network exist? Can it link to the Internet?
- 5. Who has had formal GIS training? Who has had training in managing databases?
- 6. What is the ultimate purpose of the GIS solution?
- 7. Where will the data store be managed effectively?

These will be the major drivers of the costs of the project. The other elements are the hardware, which is declining in price, the software to be licensed and adapted, and the professional services or technical assistance. Dramatic increases in power, reductions in cost, and greater ease of use have changed the costings for GIS. In 1981 the GIS software ARC/INFO ran on a mainframe computer and required eight hours to get useful data. In 1999 the data are instant. Just three to four years ago, a US\$16,000 workstation was required, and now it is slower than a US\$2,000 personal computer which does the same job. Then only trained personnel could use the system; now anyone can point and click. Software costs and training of technical personnel are similarly declining as the GIS systems have evolved and become more accessible. Much of the key content is now available on the Web at little or no cost, including access to the technical experts and information through a wealth of websites. And as data sets are made public domain, much of the time and energy normally spent on creating such data sets will be saved. Large initial expenditures for GIS technology are not necessary: the model suggested is to advance gradually in a modular system. A well-designed GIS is likely to be more costeffective in the long run.

In Nepal, for example, the Information Technology Laboratory, Asia Technical Department of the World Bank, carried out a feasibility study on the development and implementation of a comprehensive GIS. The cost of the entire system was about US\$20,000 – this covered technician labour, GIS software (ESRI's ARC/INFO, digitizer, plotter), an IBM personal computer and other hardware. Satellite data and aerial photographs were used to



Digital geological data for Tasmania were incorporated into this map which is part of a national geoscience mapping project.

### telecommunications in Action

examine environmental aspects of the local area. The contribution of the GIS as a monitoring and planning tool was considered well worth the investment in order to be able to understand land use types and land capabilities.<sup>23</sup>



### Sources of finance

GIS programmes for government agencies are generally funded from national budgets with whatever project financing may be required. World Bank or other regional development banks provide loans. Vendors help arrange export credits and guarantees from their national export-import banks or export promotion programmes. Cost sharing among agencies or between government and the private sector, both local and multinational enterprises operating in the country, will reduce the financial impact on individual agencies. International agencies and organizations mandated with environmental protection may assist or advise on financing.

For example, the Global Environment Facility (GEF), created in 1991, provides grants and funding to developing countries to help combat the following problems: threats to biodiversity, climate change, pollution of international waters and depletion of the ozone layer. GEF projects are implemented by the United Nations Development Programme, the United Nations Environment Programme and the World Bank. As at the end of 1996, the GEF had allocated some US\$1.33 billion to 220 ongoing and planned projects in 85 countries. This funding has been supplemented by some US\$3.3 billion in co-financing from international agencies, donor nations and the private sector.24

As part of the ITU's global project Telecom-Environment, a number of pilot projects are being encouraged. These are intended essentially to assist the developing countries concerned in seeking, from interested partners of BDT (public and private sector), the necessary means and resources to implement pilot projects for environmental protection. Such assistance may be financial, technical or both.25

Decentralization of environmental management will help contain costs. It is essential that environmental protection and natural resource management be dealt with at the local level. Local governments, closer to the stakeholders, are likely to incur lower costs in gathering information about environmental concerns. This information can be relayed to the municipal and state governments where intelligent policy decisions can be made, for example on emissions standards or zoning restrictions. This decentralization of environmental management in developing countries can also shorten the time it takes to effect policy change.<sup>26</sup>

### **PLAN OF ACTION** Determining needs and priorities

The following guidelines could be used by developing countries as a simple tool to evaluate their needs and the potential benefits of telecom applications for the environment. It comprises reasonable objectives for a multi-disciplinary task force and a list of open questions to help identify and prioritize areas of potential use of information and communication technologies to improve environmental protection and management.

Declining water resources in Nevada, USA, are shown in a hydrogeologic map (top) and a map of groundwater levels.



The mandate of the multi-disciplinary task force could be:

- to identify environmental problems and specific areas of environmental protection and management which could potentially benefit from the use of such technologies;
- to assign each area a degree of priority;
- to make an inventory of all relevant resources (physical, human and financial, in environmental protection and management, information and communication infrastructure and technologies) and their geographical distribution;
- to identify constraints, potential obstacles, socio-cultural factors and legal considerations to be taken into account before introducing new information and communication technologies;
- to coordinate a cost-benefit study of various technological alternatives;
- to make a certain number of recommendations based on the findings of this study.

### **CORPORATE VIEW**

### Global satellite communications

A STHE WORLD'S first global satellite communication service provider, INTELSAT provides interconnection services between domestic terrestrial networks allowing an efficient flow of communication traffic anywhere in the world. Established in 1964, the organization is a not-forprofit cooperative based in Washington DC in the United States, with regional customer service centres in London, United Kingdom, Mumbai, India, and Singapore.

Today, INTELSAT operates a fleet of 19 high-powered satellites which provide international and domestic voice, data and video transmission services to over 140 customers in member countries and over 400 non-member organizations. Its satellites carry multiple applications including telephony, fax, video conferencing, Internet, multimedia traffic, news, entertainment, special-events broadcasting, satellite news gathering, telemedicine and distance education. The organization serves a broad range of customers from large public network and multinational corporations and national telecommunication companies to disaster relief and health care agencies and international organizations.

The organization works in partnership with its members to improve and expand telecommunications and develop economical solutions. As an example, it began a trial with Telefónica de Peru in 1998 which used its service called DAMA (demand assignment multiple access) to link a low-capacity wireless local network to the low-capacity satellite DAMA channel to connect a few remotely located payphones to a public network. The service can also be used by alternative network providers to avoid routing calls via expensive intermediate or transit countries, thereby saving call routing charges. In 1996 Togo Telecom routed almost a million call minutes via transit countries. The subsequent use of the new links has achieved large savings.

The growth of wireless technologies and satellite solutions such as very small aperture terminals (VSATs) is contributing to the changing face of telecommunication services in rural areas. Recent field trials have successfully demonstrated that a combination of INTELSAT products and conventional wireless systems can deliver communication services to remote areas. A rural telephone project with more than 2,000 units has been implemented in South Africa by Telkom SA, while in Venezuela, Direct-to-Phone International has formed a joint venture, ALTAIR, with Compañía Anónima Nacional Teléfono de Venezuela to install several hundred units.

The organization also offers customer support initiatives to its members to enhance their use of its global satellite system. These initiatives are in the areas of human resource development and technical, operational and financial assistance. In cooperation with its partners, the organization has also established a telecommunication maintenance training centre in Lomé, Togo, for technicians and engineers.

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# telecommunications *in Action*

### Assessment of needs

The task force could use the following questions for assessing needs:

- Is there a comprehensive long-term plan for environmental protection and management, and is it adequate in terms of taking into consideration the new information and communication technologies?
- 2. What are the most pressing environmental protection, remediation and management problems that need to be addressed in the country, by region and by type?
- 3. What is the geographical distribution (and quality) of resources for environmental protection and management?
- 4. What is the geographical distribution (and quality) of information and communication networks and technologies? Information is required on:
  - the present and projected telecommunication infrastructure and equipment of various types;
  - computers and peripherals in the environmental protection and management sector (type, capacity); availability of parts and maintenance

**CORPORATE VIEW** 

### Transmitting data via satellite

T ELECOMMUNICATION needs in developing and emerging economies today require a mixture of multi-technology systems and networks to bring benefits to a wide range of audiences.

Globecomm Systems has provided a network in Thailand to allow cooperation between doctors in Bangkok and 15 other hospitals. The network includes data connections via satellite for transmitting all forms of medical diagnostic data, as well as on-demand video conferencing by satellite to allow doctors to confer and consult.

Direct-to-home broadcast systems for television programming have been widely used in Europe and the United States. Now they are being implemented in other regions of the world. In Egypt, Globecomm Systems designed and implemented a major Earth station facility for the new Nilesat Direct Broadcasting Satellite system covering the Middle East. In Thailand, it provided a major Earth station system for Shinawatra for access to the Thai com 3 satellite system.

The company designs multi-technology networks to maximize the benefits of satellite and wireless technologies. It has developed such solutions for Hyundai in the Republic of Korea and for a major corporate network in Africa. These solutions include satellite distribution technology for voice, data and video. In one case, it provides a back-up network for restoring circuits normally carried by fibre-optic links. Another solution broadcasts corporate training materials while a similar network integrates cellular wireless and satellite infrastructure to provide cell sites with cheaper alternative routes by satellite.

Globecomm Systems is a supplier to the Inmarsat system, the first global mobile satellite system, which has been a major contributor to improving access to telecommunications in remote areas. It is a partner with WorldSpace in the development and implementation of the world's first digital satellite radio broadcast system, designed to support services in Africa, the Americas and Asia. Three satellites, coupled with transmit uplink Earth stations, will provide broadcast radio channels for direct reception by low-cost radios. Since the system is completely digital, each radio also provides a data port for use for Internet "push" applications, such as distance learning. Such a system could provide education and training at low cost.

NetSet Express, a subsidiary of Globecomm Systems, provides Internet access by satellite to developing and emerging economies, currently in the Caribbean and eastern Europe, and in due course in Africa, Asia, the Middle East and South America. The services include direct links from Internet service providers in these regions to the United States, as well as a broadcast signal.

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### telecommunications & Environment

technicians; training programmes for users; modems and connectivity;

- the present and projected electrification coverage.
- 5. What specific geographical, climatic, cultural and political factors need to be taken into consideration in integrating information and communication technologies into environmental protection and management?
- 6. What are the current uses of information and communication technologies in environmental protection and management?
- 7. Has there been any evaluation of the use of information and communication technologies for environmental protection and management, and what were the benefits produced and problems encountered?
- 8. What are the present sources of financing for environmental protection and management (national and foreign), and what is the allocation of these resources?
- 9. Are financial resources sufficient to cover the present plan for the environment? Would they be sufficient to integrate information and communication technologies into environmental protection and management? Are there any strategies to generate new sources of financing?
- 10. Is there a concerted development strategy by different related sectors to share costs and resources at national and community levels?

# Framework for designing a working model for geographic information processing

It is useful to understand how GIS applications actually process data. Geographic information can be referenced by exact points of latitude and longitude, or more generally by addresses, census information or even earthquakes. A process called "geocoding" links the more general features to explicit geographic points. "Environmental researchers might use data on watershed boundaries, pesticide loading figures, air quality readings or locations of chemical factories. A GIS program typically deals with these various attributes in layers, mixing and matching the information to reveal associations, for example the relationship between household income and proximity to a toxic release site."<sup>28</sup>

Before data can be used in a GIS, they must be digitized, or converted into the proper digital format. Different systems may require different conversions. Fortunately, there has been an increase in the number of ready-to-use data sources. This is of particular benefit to developing countries, where the technological expertise necessary to format data may be limited. Once the data are made compatible with the GIS, they must be made to fit the same scale. For example, if postal code data are available at 1:10,000 and census boundaries at 1:50,000, one set of data must be adjusted so that the two can be analysed together.

When files become too large, it may be necessary to store the information in a database management system. The most useful type is the relational database, in which data are stored conceptually as a collection of tables with common fields linking them together.

Once the geographic information is stored, queries can be performed to provide complex analyses. At this point, it is possible to identify patterns and

### IMPLEMENTATION – FRAMEWORK WORKING MODELS<sup>27</sup>



This GIS map is part of a forest planning analysis carried out using ARC/INFO software.



trends in the data. Questions such as "How will traffic be affected by a new road at this location", "What is the total number of residents within 10 kilometres of this polluted site?" or "Where is land zoned for industrial use?" may be considered.

Overlay analyses allow for the spatial integration of data. For example, with overlays it becomes possible to relate land ownership to land use. These analyses are part of the process of visualization, which is basically a map or a graph. These displays can be integrated with reports, three-dimensional views, photographs or any other media.

### Model for national natural resource management

The national natural resource management model outlines the components, roles and relationships in an integrated GIS application and decision analysis framework. The GIS fits the key pieces of the puzzle together – maps, spread-sheets, database and models. Maps will indicate types of GIS spatial data with special symbols:

- points water and oil wells;
- lines rivers and streams;
- polygons lakes, hydrogeologic zones;
- three-dimensional surfaces elevations.

Some examples of the roles of the four GIS technology components, both tabular and spatial, might be as follows:

- Spreadsheets are a tabular component of the GIS technology and can be used to indicate:
  - target level calculations;
  - concentration data analysis;
  - simple transport algorithms.
- Database components are tabular and can show, for example:
  - physical and chemical data;
  - geologic and hydrologic information;
  - sources, receptors and pathways.
- Maps are spatial and can be used to show:
  - geographic features and relationships;
  - a site in its regional context;
  - results of data analysis.
- Models are both numeric and spatial, and could be used to show:

sophisticated transport or weather simulations.

In developing such a national model for natural resource management, GIS provides a tool to:

- identify and protect valuable natural resources;
- mitigate conflict between development activities and natural resource protection;
- predict and act upon natural and man-made disasters, such as drought, floods, oil spills;
- communicate and visualize synthesized information and results.

Decision makers are able to see important regional information in an integrated, rather than separate, visual model that covers land use, census,

### Some features of a GIS



A GIS makes it possible to integrate many different sorts of data.



Spatial data (maps) and tabular data (database components) are used interactively in a GIS.



Maps show geographic features and make clear the relationships between them.



GIS maps use special symbols to indicate different types of spatial data.

# telecommunications *in Action*

topography, soils data, river networks, regulated facilities and political boundaries. This information will help them make land use decisions, take corrective action, create groundwater protection plan maps and establish a national database of standard input values.

The benefits of this model are that it provides both place-based and sourcebased information, as well as empirical data, interpretive and assessment information. The place-based information provides data on local, regional and national ambient conditions. Data on facility emissions are an example of source-based information. Indicators of ecological and human health provide key assessment information. Interpretive information would include data to allow the evaluation of whether or not environmental progress was being made.

When this information is communicated to all the stakeholders and decision makers in government and the responsible parties, the process for arriving at solutions is facilitated. The Internet can be the vehicle for providing the access to this information for all these players and the public.

### **CORPORATE VIEW**

### Remote monitoring and control

M ODERN technology has enabled even the most remote parts of the world to take advantage of the information and communication opportunities available today. INTELSAT is an international cooperative consisting of more than 140 member countries which owns a global communication satellite network bringing television, telephone and data distribution services to billions of people on every continent. To upgrade the management and control system of its satellite attitude monitoring network, the organization approached Newpoint Technologies, which supplies management and control systems, to provide a complete turnkey project based on four new satellite Earth stations supplied by Globecomm Systems.

Newpoint's software package, Satnet Manager, will provide remote monitoring and control of the four stations which are located in Argentina, Italy, South Africa and the United States. INTELSAT needed fast and reliable systems to meet customer expectations. Newpoint's well-established Satnet Manager software, which is already being used in over 40 installations worldwide, provided the solution.

One of Time Warner's associated companies, a market leader in the production and distribution of television programming services, chose a Newpoint Compass system when installing a new control system which needed to operate efficiently for at least ten years. While the initial requirement was for a control system to manage the company's satellite Earth station equipment, the system, which comes on a single compact disc, provides user-friendly monitoring control with configurations possible within five minutes. With this system in place, the company can monitor equipment which is being used in live feeds without causing disruption, making it possible to identify which equipment is being used and whether or not a service is functioning correctly.

The friendly interface offered by the system means that operators are able to add a new service to the satellite by filling in a table which lists the service name as well as the devices or equipment assigned to it. All the devices and alarms are then automatically organized and reports formatted accordingly. By using this system, it is possible to eliminate nuisance alarms from off-line equipment, allowing operators to concentrate their attentions on the live revenue-generating traffic. Other advantages of the system are the ability to incorporate intelligent audio monitoring as well as a scanning facility through the complete range of video services to display monitors.

> Newpoint Technologies E-mail: pmh@newpointtech.com Website: http://www.newpointtech.com For further information see Annex B

### BENEFITS

Using telecommunications, especially GIS, for environmental protection and management can benefit developing countries in a number of ways. Such countries face many decisions in environmental management. At the same time they have limited resources of time, finance and people. They are faced with a dynamic environment with rapid changes, especially as economic development proceeds. And there are complex interdependencies that they may not have addressed previously. Environmental problems affect the health and well-being of very many people, and damage prospects for economic development. Information and communication technologies have a vital role to play in combating such problems. Some of the direct benefits include:

- fewer environmental disasters, so that lives are not lost, people's homes and livelihoods are not damaged, and roads, utilities and crops are not destroyed;
- more time to put into action emergency responses, so mitigating destruction and suffering;
- the preservation and more sustainable use of valuable and diminishing natural resources;
- the typical benefits of using automation, including cost savings;
- better data management, more efficient storage and updating;
- faster information access, more reliable decisions;
- operational efficiencies.

ESRI estimates that GIS typically provides benefits and impacts that can be quantified and measured in various ways:

- better decisions: 50 per cent;
- reduced costs: 31 per cent;
- expanded capability: 6 per cent;
- increased confidence: 13 per cent.

ESRI also estimates that there can be savings of up to 80 per cent when using GIS rather than other traditional means.<sup>29</sup>

Some further benefits of using information and communication technologies for environmental protection and management include:

- reduced expenses for environment-related illnesses;
- improved effectiveness of environmental workers and specialists: broader reach, more time spent doing productive work due to reduced travel;
- improved overall environmental management;
- improved availability and reduced cost of training for workers in the field;
- increased support for environmental personnel working in remote and isolated areas, resulting in increased job satisfaction;
- improved teaching and learning possibilities and opportunities.

Using information and communication technologies for environmental protection and management can also yield many socio-economic benefits from among national development objectives such as the following:

- a cleaner, safer and more healthy environment for everyone;
- education of important segments of the population;
- employment opportunities for indigenous workers and technicians;
- dissemination of advanced technological knowledge;
- improving the image of a country (important, for example, for attracting investment).



Improving environmental protection and management brings lasting benefits to all sections of the population.

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<http://nsdi.usgs.gov/nsdi/pages/what\_is\_gis.html> is the United States Geological Survey's GIS tutorial.

<http://www.esri.com/base/gis/index.html> is ESRI's basic information about GIS.

<http://www.esri.com/library/gis/index.html> is an ESRI GIS site with application examples.

<http://www.gap.uidaho.edu/gap> is for a developing country.

Environmental Systems Research Institute (ESRI) Corporate Headquarters 380 New York Street Redlands, CA 92373-8100, USA Tel: +1 909 793 2853 Fax: +1 909 793 5953 E-mail: info@esri.com <http://: www.esri.com> Contact: Sara Moola, Environmental Industry Manager at smoola@esri.com ESRI is a consulting firm in GIS applications with experience in developing countries.

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