Integrated Global Observing Strategy - Putting The Vision Of Digital Earth Into Actions by International Communities

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ABSTRACT: A number of critical development challenges ahead are disussed. To address environment and sustainability issues, information and decision support tools are essential. Translating the vision of the Digital Earth into actions and the implementation of the Integrated Global Observing Strategy(IGOS) provide an important international framework for scientific and technical cooperation in addressing information needs for sustainable development in the new millennium.
Key Words: Environment and Sustainability, Information and Decision Support Tools, Digital Earth, IGOS

1. Critical Development Challenges Ahead

The waning of the second millennium presents greater development challenges to various stakeholders in effectively dealing with global environmental changes, such as those related to desertification, land degradation, loss of biodiversity and climate change and related global warming. For more than a decade, in particular since the adoption of Agenda 21 at the UNCED in 1992, a large number of international or multilateral environmental agreements have been adopted and at least some 200 multilateral environmental agreements are already in force. These include in particular the UN Convention to Combat Desertification, Convention on Biological Diversity and the UN Framework Convention on Climate Change. However, policies and institutional frameworks , technologies, methodological approaches and procedures are still to be sought for systematic implementation of the Conventions and related environmental agreements and for monitoring of progress at various levels. The problems are linked to several domains - scientific, technical, institutional and political, but most fundamental is perhaps to take stock and assess how the Earth's environment has been continuously altered by humans and what responses can be introduced to reduce the vulnerability and enhance the resilience of various ecosystems.

One of the over-riding trends in the beginning of the third millennium will be characterized by continuous threatening of the global ecosystem, as a result of imbalances in development. Currently, more than 110 countries are affected by desertification, which costs the world US$42 billion a year in loss of productivity. With a projected world population of 7,824 million in 2025(at the medium population growth rate) by the United Nations, the social cost of environmental degradation would be even more worrisome. In fact, only the desertification alone, it has already prompted millions of poor farmers to move to urban centres, seeking livelihoods that have put a huge strain on services that are already over-stretched. Ecological degradation in dry areas already affects an estimated one-quarter of the world's land area and some 250 million people on all continents. The continent loses 24 billions tons of topsoil annually and this process has accelerated over the last two decades. Around 30 million more people could be forced out of their homes in the next ten years if nothing is done to stop the root causes of desertification. The effects of desertification will further threat the often-fragile equilibrium of the ecosystems.

Climate changes and variation affect all countries. Natural climate variability, especially the extreme events such as droughts and floods often cause catastrophic consequences for nations and their populations. The past year saw an extraordinary rise in the number, scale, and human and financial cost of natural disasters, which claimed the lives of more than 50,000 people world-wide. Forest fires raged in Indonesia, Brazil and the Russian far east; El Nino caused historic levels of flooding in Latin America; unprecedented floods devastated large parts of Bangladesh and China, and hurricanes 'George' and 'Mitch' caused massive destruction in the Caribbean region and Central America. According to a United Nations release (2 July 1999), the estimated economic losses exceeded US $93 billion, compared with US $30 billion in 1997. In addition, possible human-induced climate change has the potential of extreme cost in financial, human and ecological terms. Apparently, it will not be an easy task to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, and within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

The problem is that the required level of stabilization cannot be determined without further research and systematic observation to improve understanding of the effects of anthropogenic emissions of greenhouse gases on the climate, and on the impacts of such effects with regard to, for example, ecosystems, sea level rise, agricultural production and economic development.

The Kyoto Protocol, adopted in 1997, commits the signatories to reduce overall emissions of greenhouse gases (including carbon dioxide, nitrous oxides, methane and others), by 5% below 1990 levels in the five-year "commitment period" from 2008 to 2012. The Kyoto Protocol also makes provision for three "mechanisms": emission trade, clean development, and joint implementation. The concept, methodology and procedures needed for implementing the Conventions and the Kyoto Protocol remain an issue to be resolved. In particular, reporting issues, such as how a reporting entity is defined, which reporting formats and units to be used, and how to relate to national emissions inventories and other corporate environmental reporting schemes remain unresolved.

The Earth's biological systems meet humans' critical needs for food, fibre, fuelwood and medicines and provide essential services such as water purification, carbon storage and the maintenance of biodiversity. Growing stresses on the ecosystem level are undermining their capacity to provide goods and services to meet human needs. However, there is to date no adequate knowledge base to understand the full extent of the problem, including in particular the major eco-system types such as croplands, grasslands, forests, fresh water, and coastal and marine zones. In addition, there is a lack of basic knowledge about the number of species living on Earth: estimates of the total species numbers vary between 5 and 30 million and a mere 1.6 million species have been described to date. With continued population growth and increased demand on land, food and other natural resources, millions of species may go extinct before they can be identified and their important functionality determined. Knowledge about the functions of biodiversity, synergies and complementarities, interactions within agro-ecosystems, ecological processes within soils and interactions with the atmosphere and water, is rudimentary. As in climate change, there are considerable uncertainties about the functioning and dynamics of ecosystems, hence on-going scientific debates on the actual causes, trends and consequences of continued decline.

In particular, much research work remains to be done to improve and expand our knowledge of agricultural biodiversity and its functions. To that end, historical data, complementary methodology and the indigenous knowledge of local people need to be used in combination with the strengths of modern science and technology to identify and properly explain the structure and functions of agro-biodiversity at different scales. There is a clear need for assessment methodologies and indicators relating to agricultural biodiversity at the levels of landscape, ecosystem, population, species, and even genes to be developed and operationalized.

In the course of the implementation of Agenda 21 and post-UNCED environmental conventions and agreements, it has been increasingly recognized that the lack of pertinent data and information, as well as adequate tools for decision making have been a key impediment which needs to be addressed by all concerned. Hence, there is a critical need to develop systematic mechanisms for operational monitoring of global progress associated with measures towards reducing greenhouse gas emission and enhancing carbon sinks, monitoring loss and preservation of biodiversity; mapping and assessing desertification and land degradation. In short, to understand global changes as a background noise to sustainability, it is fundamental to ensure that timely, accurate, reliable, up-to-date information products and decision-support tools of various types are made available to different users to facilitate scientific studies, guide early warning and support policy formulation and decision making at various levels

2. Integrated Global Observing Strategy

2.1. A vision - Digital Earth

Through space observation systems, intensive *in-situ* measurements and sampling in strategically selected locations, and a wide range of modelling techniques, the understanding by scientific communities worldwide of the Earth system, inparticular, how the climate systems and the major global cycles function, such as carbon and water cycles, has made dramatic progress in the past decade. To further study sustainability and its background noise - environment, global changes and associated driving forces, more concerted and integrated efforts will be required for systematic observation of the earth system: its atmosphere, lithosphere and biosphere. Such an effort is also essential for constant investigation of interactions between humans and various components of the earth system and for understanding of the impacts of anthropologic activities on the Earth environment. Traditional means of collecting data and information about the earth's environment are under a serious challenge; hence there will be a shift in the way of perception of the earth's system.

Advances of information, digital communication and networking technology, along with space-based observation technology, including satellite remote sensing and geographic information systems, coupled with a wide range of modelling and decision support tools can provide new opportunities for 'rediscovering' the Earth system through a digital perspective. Currently, there are some 50 Earth observation satellites in operation collecting a wide variety data about the earth's environment and some 300 communication satellites providing an increasingly effective global communication network. The number of such satellites could double in the next decade. Through electronic networking of ground receiving stations worldwide, the satellite systems provide global digital coverage and data flow in various spatial and temporal domains for scientific communities, operational users and decision makers. No doubt, socializing information technology, including the digital Earth observation data will change the way of living and revolutionalize planning and decision making process at all levels.

Information access by Internet, computing technology and rapid development in sensors and automation technologies will facilitate the emergence of geo-agents for humans and intelligent software agents, which will enable tools for interaction and action at a distance. With smart computing chips attaching to objects of interest, and sensors on satellites operating at various altitudes, aircrafts, ships, mobile platforms, data on environmental, physical and biological events will be simultaneously collected, recorded, measured and tracked. Intelligent agent technologies that characterize a shift of paradigm from algorithms to interactive systems with problem-solving engines are capable of knowledge discovery and learning. They will become an indispensable part of the digital Earth environment and will be widely applied to such diverse fields as collaboration, and model discovery and information access.

The digital Earth is bound to create both vertical and horizontal impact on society. Horizontally, pertinent data and decision support tools will be timely accessible by scientific communities for studying global issues, such as monitoring both terrestrial and ocean primary productivity, carbon and water cycles and climate changes. Vertically, the value-added information will become user-friendly and more easily accessible by all interested stakeholders, including planners and decision-makers at various levels, local communities and even individuals for monitoring physical, chemical and biological conditions. Local farmers, for example, by modernizing response farming and precision farming, will improve their tactical decision making based on the quantitative observation of local environmental factors, such as physical parameters of soil, nutrients, water stress and crop diseases. Real time monitoring and modelling of crops will enable decisions by farmers on optimum farming practices relating to irrigation, pesticides and harvesting, using centrally stored reference data, automatically collected weather data and rainfall estimation from satellite images, in combination with some key data of social and economic constraints. Precision farming will contribute to sustainable agriculture development by trade-off between productivity and pollution and efficient use of resources.

The three key technologies - remote sensing, satellite based positioning systems, and geographical information systems - are an important part of the digital Earth infrastructure and will become essential tools for detecting and measuring variables of landuse and land cover, soil, crop and rangeland, forests and trees and fisheries resources, and for monitoring and predicting environmental changes and sustainability. By "implanting" smart sensors in strategically selected vulnerable locations/objects, and collecting and communicating data through various platforms from large satellite systems to mini-, micro- or nano-satellites operating at an altitude from a few dozens kilometers to 36,000 kilometers, it will enable a real-time detection for early warning of natural disasters such as land slides and forest fires, monitoring spreads of hazardous materials, or perhaps reporting the loss of those critical biodiversities which have been put under close surveillance. The information can be disseminated through a worldwide digital earth network ready for on-line processing, analysis and utilization.

2.2. Missions An Integrated Global Observing Strategy

Operationalization of the digital Earth concept will be a long-term, continuous and stimulating process. An Integrated Global Observing Strategy (IGOS) that has been currently developed by the concerned international communities is such an international mission that would contribute to the implementation of the digital Earth concept. The objective of IGOS is to unite the major satellite and surface-based systems for global environmental observations of the atmosphere, oceans and land. As a strategic planning process, IGOS links research, long-term monitoring and operational programmes, as well as data producers and users, in a framework that delivers maximum benefit and effectiveness in addressing information needs in decision making for sustainable development.

The strategy of IGOS covers all forms of data collection concerning the physical, chemical and biological environments of the earth, as well as data on the human environment, on human pressures on the natural environment, and on environmental impacts on human well-being. It emphasizes the user-driven approach, leading to value-added information products that increase scientific understanding and guide early warning, policy-formulation and decision-making for sustainable development and environmental protection.

The major thrusts of IGOS, as stated, will include: strengthening space-based/*in situ* linkages to improve the balance between satellite remote sensing and ground- or ocean-based observing programmes; encouraging the transition from research to operational environmental observations within appropriate institutional structures; improving data policies and facilitating data access and exchange; stimulating better archiving of data to build bench mark databases and the long-term time series necessary to monitor environmental change; and increasing attention to programme harmonization, quality assurance and calibration/ validation so that data can be used more effectively by various users, particularly those from developing countries.

As it proceeds, IGOS encourages modular approaches in identifying and planning specific components, elements or programmes. In a coordinated and integrated manner, the IGOS Partners will plan the effective combining of space and ground observations and the effective utilization systems for monitoring and managing the climate variables, terrestrial surface and oceans. Currently, the IGOS partners adopt a theme approach in the implementation of its strategy, with an intention to assure some systematicality and coherence in priority issues of global concern. In its rolling planning process, oceans, terrestrial, disaster management, carbon cycle, climate variability and change have been identified as potential theme areas, which could have the potential to progress rapidly through joint planning and implementation.

IGOS represents the convergence of several processes and inter-governmental mechanisms that recognize the importance of systematic observation of the Earth environment and the value of synergizing various space observation and in-situ programmes. The major partners of IGOS include: the Committee on Earth Observation Satellites (CEOS), the World Climate Research Programme (WCRP) and the International Geosphere-Biosphere Programme (IGBP), the International Group of Funding Agencies for Global Change Research (IGFA), the Food and Agriculture Organization of the United Nations (FAO), the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO-IOC) and UNESCO itself, the International Council for Science (ICSU), the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), which jointly sponsor the development and implementation of the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS) to organise global-scale operational observations of the climate, oceans and terrestrial surface.

3. Putting Vision Into Actions - Fao's Involvement in Igos

3.1. Remote Sensing and GIS as Decision Support Tools in FAO

The importance of information and decision support tools for sustainable management in agriculture, forest and fisheries has long been recognized by FAO, which introduced remote sensing in renewable natural resources management in the early 1970s. In response to UNCED decisions, the Environment and Natural Resources Service (SDRN) was created within the Sustainable Development Department (http://www.fao.org/sd) through the merging of several environmentally related programmes, including the FAO Remote Sensing Centre. The Service supports a wide range of normative and field programmes concerned with the development of environmental databases and decision-support tools, environmental analysis and natural resources management. Remote sensing and GIS have also become important tools for addressing issues relating to environmental agreements, such as Conventions on biological diversity, desertification and climate change.

In the field of environmental monitoring, since 1988 FAO has been operating the Africa Real Time

Environmental Monitoring Information System (ARTEMIS). ARTEMIS supports the operational monitoring of seasonal growing conditions and vegetation development over Africa, based on hourly Meteosat and daily NOAA-AVHRR data. Specifically, the information is provided for use in global early warning for food security, crop forecasting, desert locust control, animal health and transboundary livestock diseases monitoring and water resources management and forestry applications.

To assist in addressing land cover information required for land dynamics study, the AFRICOVER project was initiated in 1995. The project aims to establish a digital land-cover database for selected sub-regions in Africa. It produces land-cover maps on the scale 1:250,000 mainly, using the same geographic references and projection system in Africa, with updated information on drainage, toponymy, roads and land-cover features, etc. The project has developed a harmonized land-cover classification system with mapping guidelines and standards, including four modules on classification, legend, field data and translation. In addition, a Regional Environmental Information Management Project (REIMP) in Central Africa has been implemented by FAO in cooperation with the World Bank since 1996. This project aims at improving and strengthening of planning and management of natural resources in the countries of the Congo Basin.

In support of coastal area ecosystems management, an Integrated Coastal Assessment and Monitoring System (ICAMS) was developed to monitor water quality and coastal resources distribution and usage parameters by using multiple earth observation data such as satellite data from SeaWIFS and future ENVISAT sensors and *in situ* measurements. Such a system will provide data of appropriate spatial and temporal scale to address information needs in coastal management, such as the origins, causes and implications of changes of coastal water quality on associated resources.

The Forest Resources Assessment (FRA) project of FAO initiated in 1990 has demonstrated that with the help of remote sensing, information on changes in forest and land use could be obtained on a global basis in a cost-effective, timely and statistically sound manner. To address information needs of the international community for studies on global changes, FAO has decided to continue to implement FRA on a regular basis in order to build consistent and reliable time-series observations of forest and land use. FAO is currently executing the global forest resource assessment for the year 2000 (FRA 2000) which relies on the use of remote sensing for many of its components, ranging from coarse resolution global coverage for land cover mapping to high and very high resolution multi-date satellite imagery for surveying global and regional forest/land cover changes.

FAO considers forest fire management and related activities an integral part of the conservation and sustainable management of forests, which is at the core of the forestry programme of the Organization. Activities related to the use of fire as a tool as well as those related to fire prediction, prevention and control have received long-standing attention in FAOs programmes. FAO has consistently provided information and technical assistance to its Member States and to the international community in the area of forest fire prevention, control and management within the framework of the regular and field programmes. The proposed FAO Strategic Framework includes provision for a database on forest fires and technical assistance in forest fire management, and the focussing of attention on policy, legal and institutional issues related to forest fire management.

FAO has a long history of involvement with climate related activities such as agroclimatological studies. Currently, the main activities on agroclimatic databases and agrometeorology, using data both from satellite and *in situ* observations include: (i) management of the climatic database for about 25,000 stations worldwide (FAOCLIM); (ii) production of digital maps (at various levels) based on the climatic database; (iii) compilation of a database of African sub-national crop statistics; (iv) real-time monitoring of food crop conditions and yield forecasting, in particular for African countries; (v) fulfilment of specific requests which require the analysis of climatic data to be integrated with socio-economic variables. Together with ARTEMIS, AGROMET is providing essential value-added analysis and related information products for FAOs operational GIEWS on Food and Agriculture.

Collection, storage and maintaining of various geophysical data and global digital databases as well as value-added information processing for environmental analysis and sustainable agricultural development are a priority area of FAO. It has so far developed a soil map of the world and agro-ecological zones map of the developing countries; the continental shelf and fishing (statistics) areas of the oceans; coastal lowlands in the developing countries. Several pilot GIS databases have also been developed to carry out the evaluation of marine resources, integrated terrain unit and waterbasins study in Africa. A number of GIS analysis and applications projects have also been implemented. These mainly include: estimation of available arable lands for the major FAO study Agriculture Towards 2010; Africa, South and Central America inland aquaculture site suitability analysis for fish farming potential; soil suitability analysis studies for various crops in Africa; potential food self-sufficiency at high and low input levels; dominant land resources types map for Africa; nutrition profiles map; fish distribution maps for the Mediterranean; World Food Summit support maps. Currently, remote sensing and GIS technology are also being used for Food Insecurity and Vulnerability and Poverty Mapping in FAO, in cooperation with several other agencies.

In addition to global and regional projects, FAO is currently executing or providing technical backstopping to some 60 field projects with a major component on remote sensing, GIS and information management systems in more than 50 developing countries covering Africa, Asia, Latin America and the Caribbean, and Central and Eastern Europe. FAO has recently also been actively involved in developing and field testing several new remote sensing methodologies, including the use of radar data, through pilot projects in a number of countries.

3.2. Fao's involvement in IGOS

As a biggest user of the Earth Observation technologies in the United Nations system, FAO considers IGOS a strategic tool for enhancing its capability in addressing information needs in sustainable agricultural development, including the implementation of Agenda 21 and environmental conventions. FAO is a founder member of the Global Terrestrial Observing System (GTOS), which plays a pivotal role in IGOS. The central mission of GTOS is to provide policy makers, resource managers and researchers with a decision support tool and access to the data needed to detect, quantify, locate, understand and warn of changes, especially reductions, in the capacity of terrestrial ecosystems to support sustainable development. GTOS focuses on five issues of global concern: changes in land quality; availability of freshwater resources; loss of biodiversity; pollution, toxicity and climate change. This programme aims to provide guidance in data analysis and to promote integration of bio-physical and socio-economic geo-referenced data; interaction between monitoring networks, research programmes and policy makers; data exchange and application; and quality assurance and harmonization of measurement methods.

FAO hosts the GTOS Secretariat at its Headquarters. Under the guidance of the GTOS Steering Committee, the Secretariat is currently developing a Global Terrestrial Observing Network (GT-Net), the TEMS meta-database, and a project on Net Primary Productivity (NPP) with an objective of estimating and mapping of the global net primary productivity of terrestrial ecosystems, and activities in Eastern Europe and Southern Africa. GTOS is anticipated to provide with participating agencies, member states, and scientific communities with value-added services, including a strong framework to link terrestrial databases, sites and networks; improved access to terrestrial data and information; filling gaps in key observations; stronger links between science and policy; faster response to emerging issues and various decision support tools for a range of user communities. Currently, the GTOS Secretariat plans for joint regional workshops with the Global Climate Observing System (GCOS) for formulation of regional activities to address various technical and operational issues. Closer cooperation is also envisaged with other parties in the framework of priorities identified for IGOS, including in particular the theme on the terrestrial carbon initiative(TCI) - initially global mapping and monitoring of carbon sources and sinks.

TCI is aimed to have a better understanding of the regional and global cycles of carbon, the distribution of sinks and sources, their seasonal and annual dynamics and the interactions of the various ecosystems and between the ecosystems and the atmosphere. The study requires further research and large scale observations where space borne and in situ measurements have to be analyzed in an integrated manner. Main variables to be observed include status and dynamics of land cover, canopy structure of vegetation, plant nutrition status and biogeo chemistry, Leaf Area Index, Net Primary Productivity, atmospheric CO_2 concentration, meteorological and other data. Some of the required data sets can be obtained at regional and global scale from existing satellite instruments, such as NOAA AVHRR and SPOT VEGETATION, with improvements to be expected from forthcoming satellites with higher spatial resolution and more and sharper spectral bands such as the Moderate Resolution Imaging Spectroradiometer (MODIS) which is expected to be launched shortly (spatial resolution between 250 m and 1000 m, 36 spectral bands between 0.415 and 14,235 μm and 1-2 days global coverage). MODIS will be the prime sensor of NASA's Earth Observing System (EOS) and will deliver global data sets on land cover, vegetation indices, surface temperature, fires, snow and ice cover, spectral albedo and other variables important for global carbon cycling modelling.

Other relevant data sets are already available with international organizations, associations, institutions and research communities. Digital and analogue data sets produced by FAO include the Soil Map of the World; national and regional land cover maps and digital data (for instance AFRICOVER) using a standardized Land Cover Classification System (LCCS); a meta data base on land cover and natural resources data base for parts of East and Southeast Asia; a set of forest cover change data based on approximately 120 statistically distributed Landsat scenes of the tropical belt between the late seventies and today (three observation cycles); time series of vegetation index and rainfall estimate data from ARTEMIS; agro-meteorological data; yield statistics for agricultural and forestry products and other environmental, natural resources and socio-economic data sets.

Net Primary Productivity (NPP) is considered as one of the key variables for the modelling of carbon sequestration and release--an important aspect of the TCI . NPP is defined as the difference between the total carbon uptake from the air through photosynthesis and the carbon loss due to respiration by living plants (measured in kg/m2/yr). The NPP distribution is a direct indicator on the productivity of croplands, forests and grasslands and thus an important information base required for improving management strategies for sustainable development of natural resources.

In situ measurements of NPP are time-consuming and expensive and not suitable for regional/global estimates. The NPP-project will therefore adopt a hierarchical approach and use models combining both in situ measurements as well as satellite derived data. Regarding the application of remote sensing data, experience exists with the analysis of NOAA AVHRR data for global land cover classification and global Leaf Area Index (LAI) mapping, both key variables for NPP. In this context, FAO is also receiving SPOT VEGETATION data on a 10-day basis. A major improvement is, however, expected with the forthcoming launch of MODIS (Moderate Resolution Imaging Spectroradiometer) aboard the Terra (EOS AM-1) satellite. NASA has identified 45 sites representing 12 countries for initial validation studies. Countries participating in this activity include China, Costa Rica, Czech Republic, Hungary, Israel South Korea, Poland, South Africa, Ukraine, United Kingdom, United States and Venezuela.

Besides being a key parameter for terrestrial cycling modelling, the NPP project has as primary objective the distribution of global standard NPP products to regional networks for distribution and to translate these standard products to regionally specific crop, range and forest yield maps for sustainable land resources management. More information can be found under http://www.ilternet.edu/gtnet/demoproject/.

FAO and its partners on TCI, including GTOS sponsors and the Canadian Space Agency as focal point of CEOS have recently jointly drafted a preliminary workplan. This workplan envisages to demonstrate by the year 2004 the capability to map the carbon sinks and sources at global scale by combining space borne and in situ measurements using appropriate models which are sensitive to natural and human-induced environmental changes. This would be followed by the development of an operational system, which would produce such estimates at seasonal, annual, inter-annual and decadal intervals. Ultimately, the terrestrial carbon cycle will have to be linked with oceanographic carbon cycles and human-induced carbon emissions to obtain an overall carbon cycling model that allows a quantitative assessment of the impact of the different ecosystems and components.

TCI would be implemented by combining operational activities with parallel research efforts. Better quantitative assessment of the carbon sequestration and release potential of different land cover types will facilitate the emission trade mechanism anticipated in the Kyoto protocol. Better knowledge of the impact of human activities affecting the carbon cycle (e.g. deforestation, agricultural practices, biomass burning and fuel consumption) will enable the formulation of policies to minimize negative impacts on the ecology and to ensure sustainable management of natural resources. Not the least, some of the information layers needed and produced for global carbon cycle modelling, such as land cover and its changes and NPP will have their value on its own as important variables for other applications, such as assessment of food security, early warning of agricultural draughts, land degradation and erosion harzards, deforestation and large fires.

4. Way Ahead - Moving Towards A Digital Fao

Currently, FAO is developing a Strategic Framework of the Organization. One of the five corporate strategies proposed for the period of 2000-2015 clearly emphasizes " improving data availability and information exchange, monitoring, assessing and analyzing the global state of food and nutrition, agriculture, fisheries and forestry, and promoting a central place for food security and international agenda". A comprehensive, current and reliable set of data, to be disseminated to all Members and accessible to the international community and the public at large" has been identified as a key priority in this strategic process.

Accordingly, efforts are being made to develop an environmental geo-spatial information infrastructure within FAO to facilitate services in the use of remote sensing, GIS and agrometeorology, including the activities of GTOS, as decision support tools for the Organization and its Members in monitoring of environment and impact assessment, crop modelling, and inventorying and management of natural resources and disaster management at various levels for food security and sustainable agriculture.

Increasingly involved in information and communication technologies applications, FAO is progressively moving towards the digital age. By developing a World Agricultural Information Centre (WAICENT) and various corporate digital spatial databases, a wide range of social, economic and environmental data and information collected by FAO are readily accessible on Internet. Through worldwide networking, FAO aims to expand the outreach of its services to help its Members to design and implement national policies and strategies in the operational use of new and emerging space technology and applications for sustainable agricultural development. A digital FAO will, no doubt, improve the accessibility of data and information for decision making by various stakeholders, including non-governmental organizations and the private sector, and greatly facilitate awareness creation among various end-users. In the long run, FAO will contribute in its own way as both a provider as well as a major user of information to the process of a digital Earth.

5. Concluding Remarks

Sustainability is a multivariable issue involving physical, chemical, biological, socio-economic as well as political dimensions with humans as the major driving force. Sustainable development requires wide participation from and consultation with various stakeholders. The use of spatial information and appropriate decision support tools has become essential in raising awareness, providing scenarios, reaching consensus and making decisions on a wide range of sustainability issues. Similarly, such information and tools are also indispensable for evaluating the progress, assessing the trends and monitoring the impact of responses to environmental pressures by human beings.

The emerging of the digital Earth concept is bound to create a strong impact on social and economic dimensions, as well as science and technology domain, contributing to human's effort on sustainability. The development and implementation of IGOS, through synergizing space-based observations and *in-situ* measurements of Earth resources and environment, will facilitate the integrated use of remote sensing, geographical information systems, satellite based positioning systems. IGOS is a fine example for the implementation of the digital earth concept.

International partnership is the only way to the operationalization of IGOS, hence the digital Earth concept. Close cooperation on research and development, education and training on Earth observation and related information technology will be the key to the success in developing global information networks and redressing current imbalances between North and South in the access to databases, information and decision support tools for managing the Earth resources and environment and ensuring sustainability.

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