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Agenda item 6
Implementation of the recommendations of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III)

Final Report of the Action Team on the Management of Natural Resources

The present document contains the final report submitted by the Action Team on the Management of Natural Resources (recommendation no. 2 of UNISPACE III) for consideration by the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space at its forty-first session. The final report will be issued in all languages of the United Nations as document A/AC.105/L.250 prior to the forty-seventh session of the Committee, to be held in Vienna from 2 to 11 June 2004.

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IMPROVE THE MANAGEMENT OF EARTH'S NATURAL RESOURCES

UNISPACE III - Follow-up on the Recommendation 2

Chair: India

February 2004

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Chapter 1

Background and Rationale

1. Natural resources, the unique endowment of planet Earth, are in the crisis today. The resources of many developing countries are under severe strain over the past few decades. The rate of degradation and depletion of resources has accelerated tremendously in view of the ever-increasing demographic pressure. Deforestation, desertification, soil erosion and salinisation have degraded the environment, threatening the food security and economic development of many countries. Over exploitation of resources to meet the burgeoning requirements is leading to crowded crop lands, falling water tables, declining biodiversity, overfishing and increased pollution. As against the estimated minimal need of 0.5 ha per capita, over all arable land of 1500 M ha in the world presently available for agricultural activities amounts to only 0.3 ha per capita. This will further dwindle to 0.15 ha by 2100. It is appalling to learn that about 75% of major marine fish stocks are either depleted from overfishing or are being fished at their biological limit. About 50% world's forest cover has shrunk due to logging. About 58 per cent of coral reefs are potentially threatened due to destructive fishing practices, tourist pressures and pollution. About 65% of cropped land experienced significant degrees of soil degradation (World Resources, 2000-2001). These issues cut across geographical barriers and transcend national boundaries. Stretching the finite resources of the world to meet the basic requirements of explosive population growth that is conservatively expected to touch 11 billion by 2075, without impairing ecological and environmental conditions is the biggest challenge facing the world today.

2. With the above backdrop, UNISPACE III set forth the agenda for universalizing space application towards the benefit of humanity and placed focus on using Earth Observations (EO) by respective governments, international agencies & NGOs in their resolve to address the management of natural resources. In order to examine the status of UNISPACE III recommendations, with the backdrop of globalisation, WTO regime as well as the Millennium Development Goals and World Summit on Sustainable Development (WSSD), the action team, constituted by UN OSSA on improving the management of Earth's natural resources, has brought into focus the several issues, listed out the operational practices and derived the recommendations accordingly.

3. The concept of sustainable development, which most of the government and non-government agencies have recently started practicing, is based on an ecosystem approach that keeps the economic growth in harmony with ecological foundations; arrests the trends of natural resources degradation and involves the stakeholders in the decision making. The sustainable development has thus become a knowledge intensive model of growth involving the public-private & stakeholders partnerships. The recommendations of WSSD have

emphasized strongly the need for employing an ecosystem approach and, as several case studies have proven, the use of remote sensing (RS) and geographic information system (GIS) can help nations achieve this. Besides providing to policy support and bringing out the suitable interventions & implementation strategies, the role of RS & GIS was also identified as directly benefiting the livelihoods of poor fishermen and farmers in these studies. On 'green governance' and towards implementing international protocols & conventions, the role of RS & GIS has been worth replicating. The recommendations of action team, consistent with the recent findings, suggest certain steps to promote the use of EO applications, especially in developing countries, to achieve a balanced approach towards natural resources and a sustainable future.

Chapter 2

Post UNISPACE III Scenario – Managing Earth's Natural Resources, Some Milestones and Conceptual Framework

4. The recommendations of the Third United Nations Conference on Peaceful Uses and Exploration of Outer Space or UNISPACE III held in Vienna in July 1999 called for using space applications for protecting the Earth's environment and managing its resources towards human security, development and welfare. UNISPACE III recommended the capacity building in the utilization of space technology for social and economical developments in developing countries. Emphasis was placed on enhancing the awareness among decision-makers to use space technology applications for improving the common economic and social welfare of humanity.

5. The manifestation of UNISPACE III at the regional level was reflected in terms of the Second Ministerial Conference on Space Applications for Sustainable Development in Asia and the Pacific, held during November 1999 at New Delhi. The Ministerial Conference launched the second phase of Regional Space Applications Programme for Sustainable Development phase –II, called RESAP-II and also known as Delhi Declaration. Towards implementing RESAP III, the Conference identified the following goals as the essential elements of the Minimum Common Programme (MCP):

- Environmental and natural resource management
- Food security and agriculture systems
- Capacity-building
- Human resources development and education
- Poverty alleviation
- Natural disaster reduction
- Health care and hygiene
- Sustainable development planning

6. Following the Conference, the MCP containing the common denominator projects (CDPs) was formulated. Under CDPs, there were twelve projects identified having the direct relevance to natural resources management **(Appendix I)**. While these projects have led to the enhanced awareness and capacity building in the region, the real focus of such activities has been the regional cooperative mechanism to pursue natural resources management using Earth Observations (EO).

7. While UNISPACE III provided global consensus on the use of space technology for public good, the RESAP-II brought into the focus the regional cooperative mechanisms to use space technology towards improving the qualities of life and sustainable development in Asia and the Pacific regions. United Nations Millennium Declaration heralded a new chapter in the global effort to reduce poverty and eliminate hunger. The adoption of Millennium Development Goals (MDGs), a partnership effort between developed countries and the developing countries, provides unprecedented collective opportunity. In fact, MDGs are a set of numerical targets with an explicit time dimension to which the international community has committed themselves to resolve collectively - the issue of eliminating poverty in all its forms. The goals set forth towards natural resources development aspects of MDGs are at **Appendix II**.

2.1 Ecosystem, Natural Resources and Stakeholders: A New Paradigm

8. Arresting environmental degradation, poverty, and depletion of the natural resources base, by harmonizing the economic development with environmental ethics and social ethos is at the core of sustainable development. The Principles of the 1992 Rio Declaration were a collective vision of the world community in this direction. Following the UNISPACE III, the major global joint initiative was the 2002 Johannesburg World Summit on Sustainable Development (WSSD), which spelt out the roles of Government & Institutions, NGOs and the Stakeholders i.e. the people themselves in the sustainable development processes. WSSD essentially gave the blue print for the natural resources management with the stakeholders primarily holding the responsibility – an essential element in the success of any meaningful programme strategy. WSSD recognized that managing the natural resources with ecosystem approach is the pathway to sustainable development. Thus, building the natural resources through multi-stake holders participation has to be routed through ecosystem approach (World Resources 2001, www.unep.org/wssd/html, www.johannesburgsummit.com). The approach:

- recognizes the "system" in ecosystems, respecting their natural boundaries and managing them holistically;
- calls for assessing regularly the condition of ecosystems and study the processes that underlie their capacity to sustain the livelihoods and weighting of the trade-offs among environmental, political, social and economic goals;
- needs appropriate policies, interventions towards mid-course corrections, more effective institutions and governance to implement them.

9. The WSSD recommendations have brought into the focus the roles of the stakeholders in the sustainable development, and their rights and responsibilities in development processes. The Johannesburg declaration went on to refer to: 'the three components of sustainable development-economic development, social development and environmental protection - as interdependent and mutually reinforcing pillars. The recommendations of the draft Johannesburg Declaration for sustainable development (www.johannesburg.com), included statements on conservation and management of resources by:

- combating deforestation and conservation of bio -diversity,
- combating desertification and drought,
- protection of the quality and supply of fresh water,
- protection of the oceans and coastal areas,
- rational use and development of their living resources
- protection of the atmosphere from pollution
- the management of natural disasters

2.2 Conceptual Framework towards Natural Resources Management – Post WSSD Scenario

10. Ecosystem approach recognizes these dynamic limits of sustainability and also takes into the account the ecological footprints - beyond the geographical boundaries. WSSD focuses on ecosystem approach and emphasizes the direct involvement of stakeholders in all the processes of natural resources management. While WSSD sets in a new paradigm wherein the stakeholders are themselves now the custodian of natural resources, governments and institutions will now play the role of enabler and facilitator. Bringing ecology and the stakeholders face to face is a process wherein national policies and programme are to be harmonized with global level protocols/conventions as well as policies/funding support. On the other hand, 'Green' Governance followed by social

mobilization like creation of self-help groups, watershed community etc, supported by subsidy and entitlements need to be set in taking into account the empowerment and livelihood support for the stakeholders (Fig 2.1).

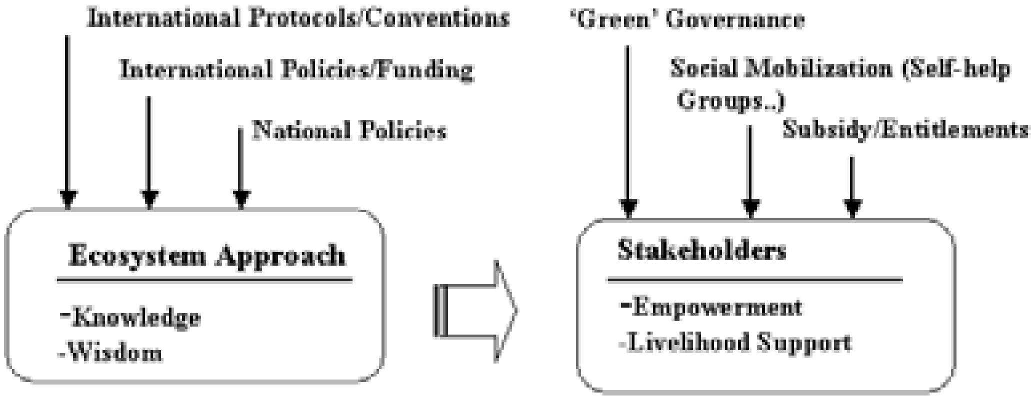


Fig 2.1 New paradigms of natural resources management in post WSSD era.

11. The sustainable development of natural resources management, however, cannot be separated from the fundamental issues like poverty alleviation and food security that the stakeholders in the developing countries are confronting with. While the environment and poverty nexus is well understood, it is important that poverty alleviation coupled with empowerment and livelihood supports of stakeholders are to be harmonized with the issues related to natural resources development. The pathways achieving sustainability, putting such paradigms into the operational domain, however is knowledge based and calls for better contextual information unfolding the linkages among natural resources endowment, opportunities for livelihood and empowerment.

2.3 Natural Resources Management – EO Perspective

12. By virtue of capturing the variability, vulnerability and dynamism of the diverse ecosystems, Earth Observations can provide critical inputs to the decision-making behind natural resources management. The strength of EO and GIS lies in unfolding the various linkages and the underlying factors that exist between the state of natural resources & ecosystems and the empowerment & livelihood status of the stakeholders. While EO maps out, monitors and quantifies the co-existence among all these, GIS establishes its dynamic linkages with the stakeholders, through modeling and simulation. The EO and GIS, therefore, provide the valuable scientific insights into the factors contributing to the status of stakeholders' vis-à-vis mismanagement of natural resources and ecosystems (Fig 2.2).

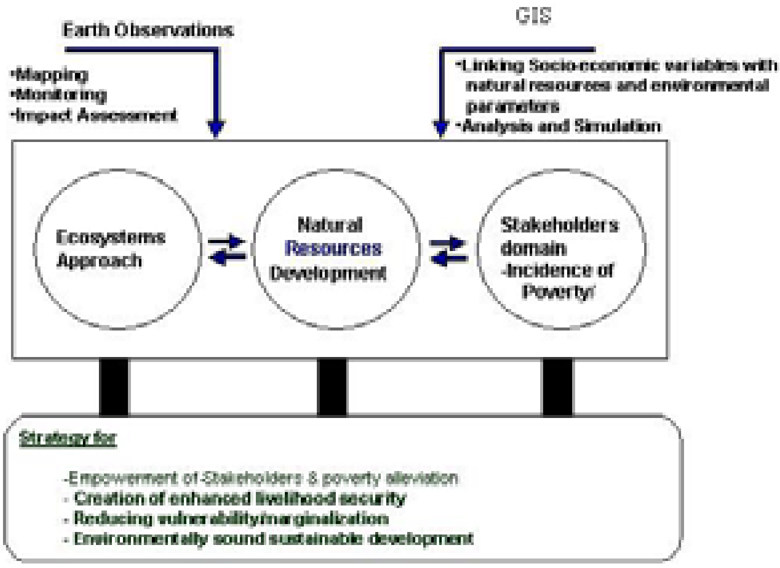


Fig. 2.2 Role of EO & GIS towards management of natural resources in the framework of new paradigms.

13. While UNISPACE III has duly focused on their roles towards natural resources management, it is important to examine their perspectives taking into account the new opportunities and the concepts, set forth as the result of MDGs and WSSD recommendations that have been emerging worldwide.

Chapter 3

Post UNISPACE III Era – Accomplishments in the Spirit of Newer Paradigms

14. The post UNISPACE III era has seen considerable progress in terms of using EO inputs towards natural resources management worldwide. Among some of the notable accomplishments where EO inputs are directly used for operational applications towards natural resources management especially in the developing countries include setting up of natural resources management department by Malaysian government and India's effort towards launching Natural Resources Census (Box 3.1) – a national effort to identify information needs for the development of natural resources, etc. In the emerging situation, the trend indicates that EO inputs have become critical as far as management of natural resources is concerned. However, it is important to promote the necessary capacity building and enabling environments to accelerate the operational use of EO especially in developing countries where natural resources.

Box 3.1

EO based Natural Resources Census

Inventory and Monitoring of Natural Resources of the nation – mainly addressing the need for a regular census activity of the nation's Natural Resources and generation of a "State of the Country's Environment Report" provide dynamically appropriate information support for the development of natural resources. India has launched a major EO based Natural Resources Census (NRC) mission in 2001 to assess "NR Hot-Spots" that are a cause for concern and lead to identification of environmentally sensitive areas require urgent conservation/management action. The environmental hotspots are being monitored and characterized based on multi-spectral and multi-temporal high resolution data. The NR Census is being implemented through specific National Natural Resources Management System (NNRMS) with participation

15. As the focus is placed on the management of natural resources based on ecosystem approach and through the stakeholders' participation, it is therefore important to examine the progress made during the post UNISPACE III era taking into account WSSD perspective of natural resources management, and then bring out the recommendations accordingly. The EO and GIS provide the valuable scientific insights into the factors contributing to the role of stakeholders' vis-à-vis management of natural resources and ecosystems. Towards this, their roles have been examined in the following areas:

⇒ **To evolve the suitable policies and plans that resulted in efficient management of the natural resources;**

⇒ **To provide contextual and vital information support which helped in bringing out effective interventions/implementation strategy that led to the immediate success as well as improved the state of natural resources;**

⇒ **To enable certain key services that help directly to support the livelihoods of the stakeholders.**

16. In these areas, a list of the operational applications especially highlighting the use of EO & GIS inputs in the developing countries is depicted in Box 3.2.

Box 3.2

Operationally demonstrated RS & GIS applications natural resources management in developing countries

Planning and Policy Making:

Ecosystems mapping: to target environmentally fragile areas and the incidence of poverty – to create rural employment through afforestation, creation of rural infrastructure and land reclamation programmes;

Land use mapping: for agricultural intensification/ diversification by identifying the suitable areas based on multi-date RS data analysis;

Land Capability/Crop Suitability Classification: Based on land use & soil quality indicators extracted from RS data – such classifications are necessary for cropping systems to raise the income from agricultural enterprise;

State-of-the-art agricultural informatics– based on *in season* crop monitoring and conditions assessment, pre-harvest acreage estimation and production forecasting

Watershed development: Adequate information on land, water, drainage etc to enable ridge-to-valley based treatments in dry land areas to ensure enhanced agricultural productivity and reduced environmental degradation.

Surface and Groundwater Inventory: Mapping of surface and sub-surface features, river-basin characterization, Identification of irrigated/non-irrigated areas etc.

Forest and Biodiversity: Mapping the forest types, conditions, bio-mass and broad level species composition

Coastal zone: Mapping, characterization and identifications of the zones for conservation, preservation and development.

Information Support for the Interventions/ Implementation of Policies:

Floods, Drought and Forest Fires: Impact mapping and targeting the affected/ vulnerable populations for relief & rehabilitation, damage assessment;

Mapping of 'Hotspots': Identification of the vulnerable areas with severe land degradation vis-à-vis incidence of poverty, crop damage due to pest infection, diseases, the hard rock terrains having severe drinking water problems etc

Dis-aggregated poverty mapping: for better targeting of the poor and their entitlements, poverty alleviation through development of natural resources

Information Support for the Livelihoods:

Potential Fishing Zones: Identification of the potential areas for fishing, weather information etc

Farmer's based Information: Crop suitability, crop related information for insurance, subsidy.

3.1 Inputs to Policy Making

17. For developing countries, natural resource endowments are the most significant component of national wealth. The timely information on the natural resources as well as the economic and social status of the dependent stakeholders is an important input to work out the policies, and make the necessary investments to harmonize the poverty alleviation strategies within the framework of sustainable development goals. Towards integrating the ecosystem approach at policy and planning level, it is necessary to look at the natural resources and their link to poverty alleviation. The indicators related to the land resources viz., land use patterns, cropping systems, soil health and the anthropogenic pressure on land are amenable to remote sensing, while the census and survey data on the dependent population/stakeholders could be integrated to the land indicators using GIS technique. The appraisal on the resources and their stakeholders could lead to evolve the suitable natural resources management policy (Fig 3.1).

Box 3.3

Remote Sensing based forest land use policy

Graduated from the pilot project, the biennially forest cover mapping is carried out using satellite data by the Forest Survey of India (FSD) on 1:250,000 scale; and the relevant inputs required for forest management are generated at 1:50,000 scale. The advent of high resolution data has enhanced the capability to prepare forest type and large-scale stock maps. RS data is used for providing information on potential, extent and composition of various ecosystems. The rates of afforestation and deforestation are assessed using multi-temporal satellite data. Taking into account that the conservation of forest ecosystem requires an understanding of the biophysical processes, their spatial interlinkages and monitoring of the human interventions, FSI has institutionalized remote sensing technique and has been using the information to address the dynamics of forest policy as well as the participation of the stake holders in the overall forest management.

Brazilian Space Agency (INPE) has been providing details on deforestation of the Brazilian Amazon tropical forests, as well as has been analyzing the sociological causes of deforestation, the types of farmers responsible, and the implications of government controls on deforestation. These inputs are being used to evolve the Amazon conservation policy.

Satellite radar data was used in a cooperative project between ESA and the Ministry of Science and Technology of China to discriminate forest from non-forest zones in Guangdong Province. RS data from space-borne sensors had been used for forest mapping, monitoring and biomass estimation in China since the 1980s. In particular satellite data had been used extensively in the Three Norths forest shelter project in which over $460 million had been spent in efforts to improve the ecological environment and promote economic development. The data were applied to various technical assessments such as the survival rate of afforestation, the extent of rebuilt pasture area, the degree of soil improvement and the rate of reduction of desertification.

18. Quite a few developing counties are using operationally EO inputs towards development of their land use policies – especially in the areas of forest policy. Box 3.3 highlights 3 examples from Brazil, China and India.

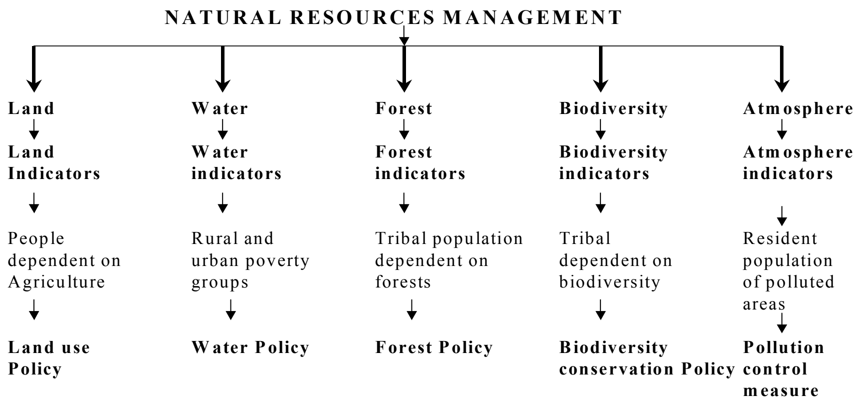


Fig 3.1: List of indicators facilitating natural resources management policy.

3.2 Information Support for 'Green' governance

19. Unplanned industrial, agricultural and urban developments have often been found in the conflict with each other and also not in tune with the environment. The solution lies in integration of environmental concern in decision-making through the responsive governance, by putting the functioning of judiciary and executive in tandem on this issue. 'Green' governance takes into account the ecological integrity of the decision-making based on the benchmark survey of natural resources, in the spatial and time domain. This is where the RS inputs provide valuable means to implement "green" code as a part of the governance. Integrating RS inputs towards 'green' governance is an innovative trend in some of the development countries (Box 3.4). The integration of RS & GIS as part of decision-making apparatus may enable environmental ethics to be the part of the development. It will serve the purpose of protecting the ecosystems from further degradation taking into account ecological footprints of natural and man-made habitats.

Box 3.4

Remote sensing – as an instrument to judiciary

In the recent times, remote sensing has become an instrument for judiciary to arrest the forest encroachment and enforce environment sensitive legislations.

Forest department of Maharastra State Government, India has found an innovative solution to tackle perennial encroachment problems using multi-date RS images. Forest encroachment in Shirpur-Sangvi Ranges, Dhule, Maharastra and Rajiv Gandhi National Park near Mumbai was delineated using Indian remote sensing satellite data. Maharastra forest department could win the court cases quoting the evidence of encroachment generated from remote sensing data.

Similarly, under the Enforcement of Environmental (Protection) Act (1986), the Coastal Regulation Zone prohibits any construction within 150 m from High Tide Line (HTL) to preserve the mangroves. Taking the cognizance of RS based study, Ministry of Environment and Forests, Govt of India directed on February 14, 2001 to demolish all the constructions made by a private company M/s Eversmile Construction Pvt. Ltd. within 150 m from HTL along the Mahul creek (Maharastra).

Source: K Kasturirangan, 4th Tata Memorial Lecture on August 31, 2001, Space – An

3.3 Towards implementing international Protocols/Conventions

20. Use of RS & GIS inputs to promote the environmental conservation is already in place in several countries. Further, satellite derived products can be used to assess country reports, to quantify above ground biomass stocks and change therein, to update obsolete forest inventory data and to monitor forest disturbances and recovery (www.esa.int). In support of UN Convention to Combat Desertification, more than 30 years of satellite data enable detection and continuous monitoring of the effects related to desertification. Today these satellites deliver key information for threat assessments and contribute to drought early warning systems operated by the UN and other agencies (CEOS Report, 2002).

21. At country level, a joint initiative taken up by Government of India on bio-diversity characterization at landscape level reflects the concern towards implementation of Gene to Ecosystem concept in biodiversity conservation and prospecting. To start with, this

initiative is focused in the North East India- a bowl of plant diversity and ecological hotspot. Such initiatives are in line with implementing the Agenda-21 of Rio declaration. Besides implementing Bio-diversity convention treaty, it helps in formulating the policy framework to ensure environmentally sound sustainable development (Kasturirangan 2001).

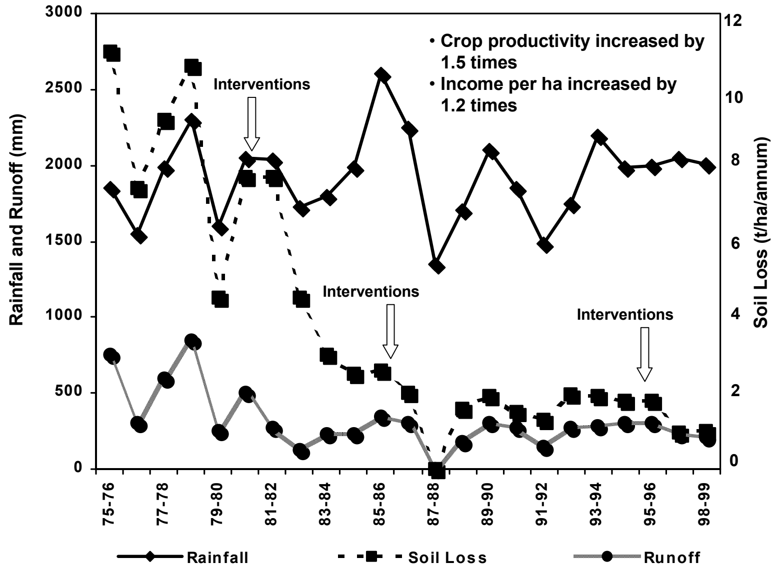
3.4 Towards evolving interventions/implementation strategy

22. Use of RS & GIS can make lot of difference in developing as well as implementing targeted interventions in the developing countries. Some of the developing countries have started using operationally RS & GIS in implementing the targeted interventions. In dry land areas, which are characterized by the increasingly higher incidence of poverty and natural resources degradation. Some developing countries have already come to use and rely on RS & GIS operationally. Watershed management is one such example – where the applications of RS & GIS are well integrated. International funding agencies such as the World Bank, Asian Development Bank, and UN agencies such as the UNDP, have started recognizing RS & GIS techniques as vital for most of the watershed development programme in the dry land areas of developing countries. It is therefore important to promote the operational applications of RS & GIS in developing the targeted interventions – addressing poverty and natural resources under the diverse ecological, social and contextual conditions of the developing countries.

Box 3.5

RS & GIS based interventions to increase stakeholders' income and halt the land degradation

The watershed of Fakot, India was characterized by massive land degradation and marginal income from the farming to the stakeholders. Using RS & GIS techniques, the interventions in terms of watershed development plans were worked out and implemented. The results showing the phenomenal improvements in terms of controlling soil erosion and run-off are shown in the figure. The success of such interventions led to launching a major National mission – called National Watershed Development Programme for Rainfed Areas (NWDPRA) and Drought Prone Areas Programme (DPAP) covering 7.46 Mha- through people's participation/employment generation.



(Source: Vision 2020, Natural Resources Management Research, Division of Natural Resources Management, Indian Council of Agricultural Research (ICAR), Govt of India, New Delhi, 2000)

3.5 Supporting the livelihoods of stakeholders directly

23. There are some operational practices wherein RS has directly been put to use to protect lives and support the livelihoods. Use of weather satellite based ocean state forecasting that helps the fishermen to avoid fishing in the turbulent sea has contributed immensely to save their lives. The Sea Surface Temperature (SST) charts derived from NOAA-AVHRR thermal data is being used to locate Potential Fishery Zones (PFZs). The features extracted from SST images are generally associated with areas of fish concentrations based on thermal fronts, meandering pattern, gyres, eddies, upwelling zones, etc. The feedback received from fishermen demonstrates the potentials of SST to strengthen the livelihood opportunities directly **(Box 3.5).**

24. Satellite based agro-meteorology is yet another area of operational applications contributing directly to support the livelihood systems of the farmers. Use of satellite

meteorology based weather forecasts, if it is interpreted at local level, provides important inputs to the farmers' advisory services – with regard to optimizing their agricultural operations. There are farmers' based information systems – wherein satellite meteorology inputs are well integrated. With the improvements in weather predictions techniques as well as state of satellite meteorology, such services are likely to become popular.

Box 3.6

Fishermen "Remote Sensing" Scientists – Chile and India

A university in Chile had taught "illiterate" fishermen to read SST maps. They were also trained about the strategies for using SST to locate fish. The fishermen turned experts and could use less fuel finding fish, and had less uncertainty about their upcoming week at sea. They could optimize the fishing operations – keeping sustainability into account. They are happier, more secure, even more prosperous, by becoming "remote sensing" experts (Source: David Hastings, STAS/ICSD, UNESCAP through E mail – hastingsd@unescap.un.org).

Veerampattinam, Pondichery, India is a coastal village with 98% families involved in fishing. The fishermen cooperative society has been running, a self-managed - the village information hub, where they themselves download the satellite images http://www.nemo.navy.mil/LIBRARY/Metoc/Indian+Ocean/Bay+of+Bangal/MODELS/SWAPS/Sig+Wav+Ht+and+Dir+Series/index.html). They process the information and based on wave height information extracted from the satellite imageries, they make a advance forecast about the sea conditions, and passed on to nearest information centre to breadcast this to the local fishermen. This has been a very popular service among the fisher folks and they have been conducting all fishing operations purely based on this information. " It saves lives" – said one respondent when asked about the usefulness.

(Source: www.mssrf.res.in/informationvillage)

3.6 Cost Effectiveness

25. As inputs to policy, planning and targeted interventions, which contributes more in terms of social and environmental gains than the benefits in terms of money, the cost benefit analysis of RS & GIS, like many other societal projects, is not an exact science and lacks consistency. In today's context, when management of natural resources is more urgent than ever before, RS and GIS data can be a vital tool in the management of natural resources, which goes much beyond the costs associated with its acquisition. Yet another aspect worth highlighting is the catalytic role that EO inputs play in the successful implementation of natural resources development projects. The cost of EO inputs may be of less than 5 percent to the total cost of the development project, but the nature of such inputs are critical and catalytic, besides having the advantage of opportunity cost.

26. Subsequent to the Millennium Summit and WSSD, nations have mobilized political will and a visible willingness to pursue sustainable development – with a focus on poverty alleviation and natural resources management based on an ecosystem approach. To assist nations in achieving this goal, we must better advocate the role of RS & GIS in developing successful policy frameworks, implementing them and improving the livelihoods for poor fishermen, farmers and all the people directly.

Box 3.7

Restoring the ecological degradation and benefiting the poor – a success story

Lack of proper drainage associated with shallow ground water table led to massive water logging and soil salinity and alkalinity, in Indo-Gangatic plains of Uttar Pradesh (UP), India. The irrigated land used to be highly productive and the dependent stakeholders were financially well off. The degradation of ecosystems slowly drove the stakeholder to poverty trap.

In order to restore the degraded ecology by reclaiming wastelands and improving agricultural productivity, World Bank funded 'U.P. Sodic Land Reclamation Project' was undertaken and executed by the U.P. Bhumi Sudhar Nigam supported by Remote Sensing Applications Centre (SAC)-UP, Lucknow in providing satellite based information. The starting point was wastelands maps. 10 districts having maximum area of sodic soils were selected from these maps. Further, based on ground water quality reported from ground observations, villages were selected for reclamation. For actual execution and identification of plots within the villages, using high resolution data, three categories of sodic lands namely, 'C' barren sodic lands, 'B' single cropped sodic lands and 'A' double cropped sodic lands were mapped on cadastral scale (1:4000) for about 900 villages. The success of the land reclamation was monitored using satellite data.

Benefits:
Cost of Phase I of the Project: Rs.400 crores (88.8 Million US $)
Cost of RS mapping, monitoring, GIS and infrastructure: 2% of the project cost
Overall Economic Rate of Return (ERR) exceeding initial expectations: 23%
Incremental productivity Gains from C and B lands: Rs. 70.47 (15.6 Million US $) crores/annum

With an average family income of Rs.6200/ (US $ 138)- per annum, total increase in income from the project: Rs.99crores (US S$ 22 Million).

(Source: A N Singh, 2003, Director, UP Remote Sensing Applications Centre, Lucknow, India)

Chapter 4

Emerging Trends, Issues and Recommendations

27. Recognizing the genuine advantage that EO has in terms of addressing the various dimensions of natural resources management, UNISPACE III and RESAP II have already laid the foundations to sensitize the global opinion. However, there is no uniform prescription for using EO operationally towards natural resources management; initial conditions do matter - with the context, the institutional mechanisms and political leadership. There are a number of operational and policy related issues that, some times, are more important than the introduction of technology *per se*.

28. As far as EO is concerned, the technology trend that is of significance to natural resources management is continuing improvements in imaging sensors and consequently the value-added products that can be derived from EO – leading to the large-scale mapping and the appropriate decision support, which is likely to facilitate, enhanced sustainable development support. It is expected that the gaps, that exist presently, between some of the very specific down-the-line information needs and potentials of EO would get addressed.

29. In fact, the progress made by earth observation satellites in last ten years - from Rio to Johannesburg earth summit is summarized in Box 4.1. Taking into account the planned earth observation missions worldwide – both in public and private domains, as well as the developments taking place in GIS & modeling, the quality of services will continue to provide better services.

Box 4.1

"100+" – Progress in satellite earth observation since Rio Earth Summit 1992

⇒ **Mapping the Earth's Surface: 100+ times more accurate than 10 years ago**

⇒ **Measuring the sinking of cities: 1/100+ of a metre accuracy in surface subsidence**

⇒ **Predicting El Nino:100+ days early warning**

⇒ **Storms and floods:100+ hours advance risk warning**

⇒ **Earth check-up:100+ new satellite sensors for sustainable deve.**

(Source: www.esa.int)

30. On the other hand, world has changed considerably, with as many as seven countries (China, France, India, Israel, Japan, the Russian Federation and the United States) possessing the capability to build their own EO satellites. There is also a regional capability by agencies such as the European Space Agency (ESA). Many private commercial operators such as Space Imaging, DigitalGlobe (until recently Earthwatch), OrbView, and Radarsat International have entered into EO business market in the recent years. With more and more players entering the field, and with many private operators looking for commercial return from EO, the time is not far off when earth observation will also become a market commodity, as has happened in communications.

4.1 Issues

31. On analyzing the 'best practices' and success stories wherein EO inputs have played operational role towards natural resources management, the lessons learnt include the following:

- A large cross-section of population in the developing countries depends on the natural resources for their livelihoods and marketable surplus. Their dependence on natural resources, unless harmonized by suitable policies, interventions/implementation strategies etc, will lead to ecological degradation.
- Mismanagement of natural resources is reflected in terms of having seen the co-existence of human and ecological poverty in the developing countries.
- The WSSD has provided the framework for managing the natural resources based on the ecosystem approach through the community participation & empowerment, and 'green governance' – in terms of legislation and enforcement of the environmental ethics.
- Putting the management of natural resources to benefit the poor, breaking environment-poverty nexus as well as implementing WSSD framework, into the operational framework, is information intensive and knowledge based.

4.2 Trends and Strategies

32. Over the past decade renewed interest in practical applications of EO has coincided with and been fueled by significant improvements in the availability of remote sensing data and in their spectral and spatial resolution. In addition, advances in complementary spatial data technologies such as GIS and the Global Positioning System have permitted more varied uses of the data. During the same period, the institutions that produce remote sensing data have also become more diversified. In the United States, for example, satellite remote sensing was until recently dominated largely by federal agencies and their private sector contractors. However, private firms are increasingly playing a more prominent role, even a leadership role, in providing satellite remote sensing data, through either public-private partnerships or the establishment of commercial entities that serve both government and private sector Earth observation needs. In addition, a large number of private sector value-adding firms have been established to work with end users of the data. These changes, some technological, some institutional, and some financial, have implications for new and continuing uses of remote sensing data (Transforming Remote Sensing Data into Information and Applications, National Academy Press, Washington, D.C., 2001).

33. The increasing role of public-private partnerships in EO sector is more visible in developed and some of the developing countries. The perennial issues such as capacity building and setting up the cooperative frameworks are still relevant in most of the developing countries. Addressing these issues continues to hold the key for EO applications towards natural resources management.

4.2.1 A Suggested Framework for Capacity Building

34. Promoting EO towards natural resources management especially in the framework suggested by WSSD, which has direct relevance to UNISPACE III, calls for building the awareness and specialized type of the capacity building efforts.

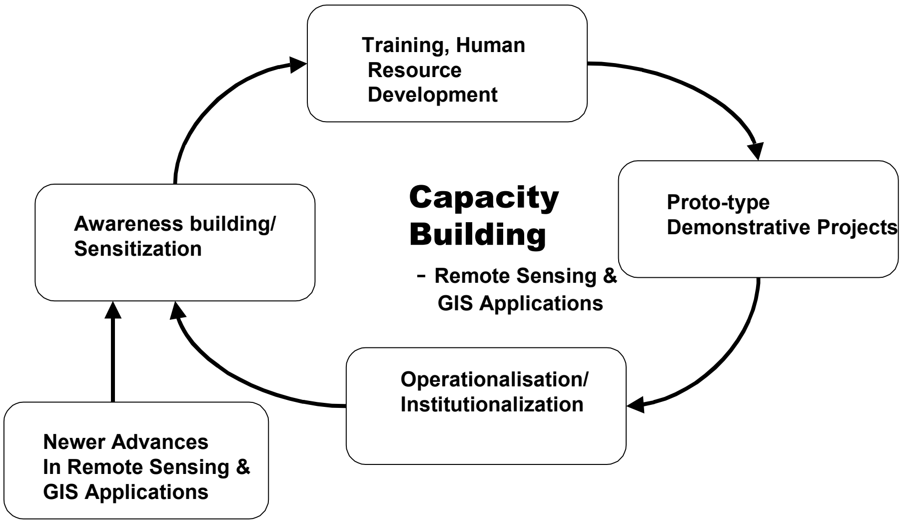


Figure 4.1: The cycle of capacity building – integrating EO inputs for decision making towards natural resources management

35. Capacity building efforts involve end-to-end initiatives (Fig 4.1): As depicted in the figure, the cycle of capacity building continues further with the latest advances in EO technologies and their subsequent integration into the ongoing natural resources developmental efforts.

36. EO applications in natural resources sector cut across several disciplines viz., database technologies, modeling frameworks, networking solutions and development of a decision support system. The inter-disciplinary nature of EO especially RS & GIS applications calls for focused and specialized training taking into account the new paradigms emanating from WSSD recommendations.

37. Specialized training modules covering the aspects viz., institutional strengthening, stakeholder's enrichment and involvement, integration with their traditional mechanisms etc are necessary. Considering the developments taking place in EO technologies and applications, at the faster rate with high-resolution imaging and advances in GIS and database technologies, it is equally important to train the trainers also. Specialized training focused on training the trainers will enable the quality cycle to move from strength to strength, as the technologies make advances with time.

38. The contextual EO applications are basically field-oriented approach with problem solving environments. It is in this context that proto-type demonstrative pilot projects, with the active end user participation, are important to integrate EO inputs into the existing practices of natural resources management. Ideally, demonstrative pilot projects could be integrated with training and HRD segments itself. The demonstrative projects should be carried out with down-the-line user involvement. This is equally important in view of transferring the know how from laboratory/ RS & GIS agencies to field level functionaries.

39. There is large spread of Centers of Excellence/ Learning Centers in the areas of EO with immense expertise in development of suitable algorithms, appropriate decision support tools etc, which are of very high value to other developing / least developing countries as well. In case an appropriate institutional mechanism is established taking the advantage of UN OOSA platform, it facilitates the diffusion of EO technologies to several other countries addressing the issues related to natural resources management. Issue based institutional partnerships within the framework of international cooperation provide good

opportunity for capacity building as well as building the institutional infrastructure in terms of skill and expertise which are crucial for EO applications.

40. Developing the operational framework, wherein EO based inputs and services are fully integrated, is of crucial importance. As the process of operationalisation involves well-knit diverse institutional networks at various levels, it is important – to start with, to have an active interface with user departments. The strategy lies in delivering the services hitherto generated by user agencies, with significant improvement and operational reliance in terms of time and the quality of the content –enhanced through the value addition by using EO inputs. Taking into account the fact that value addition to natural resources informatics involves a very large cross-section of the functionaries starting from the pool of village level stakeholders onwards, it is important that EO inputs strengthen their hands and minds.

41. Institutionalization is the final stage of operationalising RS & GIS inputs into the mainstream of natural resources management. The line departments are institutionally strengthened in terms of skill and well-knit operational networks/interfaces so that the services emanating from RS & GIS are fully internalized. In summary, capacity building initiatives aim at carrying out end-to-end activities encompassing training & HRD, demonstrative projects, institutional partnerships and the process of institutionalization.

4.2.2 Role of UN OOSA

42. Countries should consider the use of EO on an operational basis for the management of natural resources. However, it is essential to understand the exact needs for information at all the levels in order for it to be useful. Countries must also see the involvement and participation of stakeholders in order for EO inputs to be effectively used. A way of bringing together all the stakeholders is through a pilot or demonstration project. The results of such a project are more likely to be accepted if a "bottom up" approach is followed, in some cases reaching down to the grass-roots level. The involvement of non-governmental organizations helps in interfacing with that level. Owing to the diverse backgrounds of those involved in the project, specialised training workshops and user sensitization programmes are necessary to develop a common understanding of the terminology to be used. The list of training institutions, with the support directly or indirectly from UN agencies is listed below:

- *United Nations Regional Centres for Space Science and Technology Education*
  http://www.oosa.unvienna.org/SAP/centres/centres.htm
- *European Space Agency*
  http://www.esa.int/export/esaCP/ESANNA094UC_index_0.html
  http://www.estec.esa.nl/outreach/
  http://www.esa.int/hr/educational/fellow.htm
- *European Earth Observation Web Site for Secondary Schools*
  http://www.eduspace.eurisy.org/
- *Indian Space Research Organisation (ISRO)*
  http://www.isro.org/training_facilities.htm
- *International Institute for Geo-Information Science and Earth Observation (ITC)*
  http://www.itc.nl/home.html
- *ISPRS Educational Task Force*
  http://www.ltid.inpe.br/dsr/tania/RSdir/

43. UN OOSA can play a catalytic role in promoting and advocating the operational use of EO in building the natural resources base– especially in the framework suggested by

WSSD. UN OOSA provides the platform to develop cooperative frameworks between the developed and developing countries, on bilateral as well as multi-lateral basis, to promote EO applications for natural resources development. One such example, highlighting the cooperation between Japan, Indonesia and Thailand, is summarized at **Appendix III**.

44. UN OOSA is an ideal platform to promote such concepts – by advocacy of the enabling policies among the member countries, enabling to conduct proof of the concept experiments and establishing international cooperative frameworks to pursue such agenda.

45. UN OOSA may bring out a detailed report highlighting the 'best practices' of EO applications towards natural resources management in tune with WSSSD recommendation.

4.3 Recommendations

46. Several developing countries have already used EO data operationally and in doing so, proven the viability of an ecosystem approach towards natural resources management and policy. As they have recently demonstrated, these countries can obtain economic growth and maintain ecological harmony at the same time with the aid of EO data. Striking this balance helps build a sustainable future, supports "Green" governance and assists countries with the implementation of international protocols and conventions. With this in mind, this Action Team offers the following recommendations:

- Member States of COPUOS should be encouraged to submit written summaries of these instances where EO has proven to be an important tool in the management of natural resources, so that others may learn from their experiences.
- Governments and non-governmental organization (NGOs) should consider these and other recent case studies and best efforts in sustainable development, then assess what might work for them, given their situations and circumstances.
- Countries and NGOs should consider the many EO training centers and capacity – building opportunities that exist to develop greater skills in using and applying EO data.
- Countries and NGOs may want to take advantage of the wealth of EO data, interpretations and analyses that exist and are available, although at differing costs.
- OOSA could assist in promoting and advocating the operational use of EO and its role in managing natural resources.
- OOSA should maintain examples of best practices and successful uses of EO in natural resources management, and then provide them to Governments and NGOs seeking assistance. A compendium highlighting briefly some of the success stories, especially in the developing countries, is listed out in **Appendix IV**.
- OOSA could organize specialized training courses, taking advantage of regional centers for space science and technology established under OOSA's Programme for Space Applications.

Appendix I

Common Denominator Projects related to Natural Resources Management of RESAP II- A Brief Summary

(i) Development and applications of a multi-purpose environmental and natural resources information base for food security and sustainable development

Short title: Asia Cover

This is a joint Technical Cooperation Project conducted with the Food and Agriculture Organization. Its primary objective is poverty alleviation, through increased food security and sustainable agriculture output. The focus is on improved regional cooperation in using spatial information and techniques.

The planned outputs are:
(a) multi-purpose data base for environmental monitoring, natural resource management, and sustainable agricultural development
(b) decision support tools for sustainable agriculture and rural development, based on integrated analysis of geophysical, environmental, social and economic information
(c) improved national capacity in integrating environmental considerations into development planning at local, national, regional and global levels (d) increasing national capacity to understand and participate effectively in relevant international agreements and conventions.

Note: Preliminary work on this project has already started, with the assistance of experts supported by the Czech Republic. The first phase will continue for the next two years, with support from FAO and ESCAP, and participation by Cambodia, Lao People's Democratic Republic, Myanmar, Thailand and Viet Nam.

(ii) Promoting regional cooperation for integrated coastal zone management

Short title: Coastal zone

The overall technical goal of the project is to develop national and regional capacities for effective use of spatial information, Geographic Information Systems (GIS) and decision support tools for integrated coastal zone planning and management. The underlying purpose is to ensure protection of the coastal environment and achieve sustainable development of its resources.

The planned outputs are:
(a) Enhanced national capacities and regional cooperation towards the application of space technology and other decision support tools for sustainable coastal zone management.
(b) Agreed methodologies for integrating space technology, GIS and conventional techniques for data acquisition and analysis in support of decision-making
(c) Updated coastal resource information databases.

(iii) Enhancing capacities for urban and rural development planning

Short title: Urban & rural planning

The overarching goal of the project is poverty alleviation through enhanced capacities to integrate space technology applications in planning sustainable urban and rural development. The focus is on policy makers and planners.

Planned outputs are:

(a) Methodologies for operational land use mapping and planning using space technology and other decision support tools (remote sensing and GIS)
(b) Spatial databases for management and planning at various scales
(c) Sustainable networking among participating countries for data exchange and knowledge transfer in the field of urban and rural development planning
(d) An expanded pool of experts trained in the operational use of space technology applications and decision support tools for urban and rural development planning, especially in the fields of urban slums and encroachment of nature reserves.

(iv) Disaggregated Poverty Mapping

Short title: Poverty mapping

The project is aimed at poverty alleviation. Its thrust is in generating updated and accurate information on agriculture resources, food production and vulnerability situations, by applying analytical methods based on remotely sensed data and Geographic Information Systems, combined with socio-economic statistics at small scale.

Planned outputs of this project are:

(a) Pilot study on poverty mapping with input from remotely sensed data, such as NDVI time series and land cover classification
(b) Seminar and roving seminar or workshop on the methodology of poverty mapping to transfer and present the methodology to countries in the region
(c) Development of national poverty maps
(d) Regional poverty database.

(v) Integrated land and water management

Short title: Land and water

This project aims to alleviate poverty by improving the sustainable productivity of agricultural systems through the use of space-based information. The specific objectives are:

(a) To transfer knowledge about integrated land and water management in arid areas
(b) To transfer knowledge about techniques for identifying areas at risk from soil erosion in the moist tropics.

(vi) Crop monitoring and agricultural production forecasting

Short title: Rice crop

This project contributes to poverty alleviation by increasing food security and improving agricultural productivity and profitability. The core methods to be employed are crop yield estimation through application of remotely sensed satellite and agro-meteorological data. Its specific planned outputs are:

(a) Database of major crop areas
(b) Published methodology of crop monitoring and forecasting, using machine-based integration of satellite and ground-based observations, climate and weather details, administrative boundaries and agricultural/ecological units.

(vii) Potential off-shore fishing delineation and inland aquaculture development

Short title: Fishery & aquaculture

The project intends to alleviate poverty and address emerging social issues through providing opportunities for new or more successful small-scale enterprises in fishing and aquaculture.

For fisheries enhancement, the approach is to harness new capabilities in detecting from space, on a synoptic basis, areas likely to sustain above-average catches of particular species, while also supplying the means to more effectively monitor, and hence protect, the marine environment.

The aquaculture component involves employing Geographic Information Systems, remotely sensed satellite data, biological/environmental analysis and socio-economic statistics to identify areas most suitable for developing the industry. The same inputs will also be used to assess the scale of operations that is sustainable in terms of the environmental sensitivity and prior resource use.

Expected outputs are:

(a) Fishery potential maps
(b) Methodology for identifying sites suitable for aquaculture
(c) Guidelines for use of new technology while maintaining sustainability of fisheries
(d) A regional network for disseminating information on fish catch potential.

(viii) Mapping for groundwater potential and identification of recharge zones

Short title: Groundwater

As emphasized by World Water Day 2001, about 20% of the world's population, or around one billion people, lack access to adequate clean drinking water. This deficiency, and related under-availability for water for irrigation and sanitation, perpetuates poverty and increases health risk and unnecessary loss of life.

This project aims to increase national capacity in the application of space-based technologies and decision support tools for the following purposes:

(a) Identification of potential ground water aquifers, especially in drought-prone area
(b) Identification of potential areas for ground water recharge and run-off.

(ix) Environmental monitoring and analysis for health and hygiene

Short title: Environment & health

This project is designed to exploit space technology and Geographic Information Systems for mapping disease vectors and other environmental health risks.

The intended outputs are health hazard maps and medical databases.

(x) Applications of meteorological satellite data and information products for sustainable development

Short title: Metsat applications

The increasing sophistication of instruments carried by meteorological satellites combined with falling investment in "conventional" measurement networks means that national meteorological services have become reliant on satellite observations both for basic weather forecasts and for specialized functions such as severe weather warnings. Data from these satellites are generally made available at no cost to national weather services, which are developing an increasing variety of non-traditional applications including drought monitoring, crop yield estimation and fisheries management.

This project is aimed at helping weather services in developing countries of the region to access and use weather satellite information more widely and effectively. There are three main aspects in the project:

(a) Repair or upgrading of existing satellite ground station equipment
(b) Installation of improved Internet links to enable countries without suitable ground stations to access satellite information processed by larger meteorological services
(c) Sharing regional best practice in applications of meteorological satellite information for sustainable development needs.

(xi) Precision farming

Short title: Precision farming

"Precision farming" is the knowledge-based agricultural system that harnesses the power of satellite navigation and remote sensing in order to increase productivity while safeguarding the environment. This project proposes a pilot project to demonstrate, document and disseminate precision farming methods.

The expected outcomes are:
(a) Guidelines and methodology on precision farming
(b) Network of experts and institutions for continued exchange of information and experience.

(xii) Cropping system studies towards enhanced food productivity

Short title: Cropping system

Poverty alleviation is the principal objective of this project, which aims at evolving optimum cropping systems to ensure sustainable crop production and enhanced food security.

Elements of the proposed project are:

(a) Pilot projects on intensive application of remotely-sensed data and Geographic Information Systems to farming of different crops in several different locations, possibly within the same water basin.
(b) Development of guidelines on the use of these techniques for determining cropping strategies (including decisions about optimum type of crop).

Appendix II

Millennium Development Goals, Targets and Indicators – Related to Sustainable Development of Natural Resources

Goals	Targets	Indicators
Ensure environmental sustainability	Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources	Proportion of land area covered by forest
		Land area protected to maintain biological diversity
		GDP per unit of energy use (as proxy for energy efficiency)
		Carbon dioxide emissions (per capita) [Plus two figures of global atmospheric pollution: ozone depletion and the accumulation of global warming gases]
	Halve by 2015 the proportion of people without sustainable access to safe drinking water	Proportion of population with sustainable access to an improved water source.
	By 2020 to have achieved a significant improvement in the lives of at least 100 million slum dwellers	Proportion of people with access to improved sanitation.
		Proportion of people with access to secure tenure *[Urban/rural disaggregation of several of the above indicators may be relevant for monitoring improvement in the lives of slum dwellers*]

Source: United Nations, Road map towards the implementation of the United Nations Millennium Declaration, Report of the Secretary General to the Fifty-sixth session of the General Assembly, A/56/326/, 6 September 2001, New York

Appendix III

Asia Pacific Region Pilot Project in Earth Observation

In Asia Pacific Region, the Remote Sensing Cooperation between Japan and Thailand and the one between Japan and Indonesia has been successfully conducted.

From 1992 to October 1998, NASDA Japanese Earth Resource Satellite-1 (JERS-1) obtained valuable Earth observation data using its Optical Sensor and Synthetic Aperture Radar.

Japan and Thailand, and Japan and Indonesia established the excellent frame work sharing the benefits of precious data from JERS-1 of NASDA for capacity building.

(1)Project Purposes

For the capacity building in Asia Pacific area and for the wider use of earth observation data by this satellite,
1) to help develop groups of experts in satellite data applications within the administrations of Indonesia and Thailand, especially experts in mapping using satellite data;
2) to help these expert groups to create maps of land use and other factors, for the operational use of each government.

(2)Project Details

From March 1999 to March 2002, In Indonesia, the National Institute of Aeronautics and Space (LAPAN) and the Centre for Soil and Agro climate Research (CSAR) are participating in a pilot project to:

1) Map rice crop areas
2) Monitor rice crop growth development
3) Estimate rice yields
4) Detect and identify rice diseases

As the cooperation with Thailand from Nov. 1997 to Nov. 2002, The Geo-Informatics and Space Technology Development Agency of Thailand (GISTDA) coordinates the participating Thai government agencies:

i) Department of Fisheries (DOF), Land Development Department (LDD) and Office of Agricultural Economics (OAE) of Ministry of Agriculture and Cooperatives;
ii) Department of Town and Country Planning, Ministry of Interior.

This project has the following aims:
-Mapping of urban land use
-Constructing a Digital Elevation Model (DEM) database Mapping for agricultural classification
-Crop yield estimation
-Mapping of coastal land use for fisheries and regional land cover

JERS-1 ended its mission in October 1998, all the data obtained was retained in an archive for the use of the pilot projects. Today, project participants in the Indonesian and Thai administrations continue their analysis of the accumulated data, using new techniques and applications.

(3)Future Possibilities

NASDA has launched the Advanced Earth Observing Satellite (ADEOS-II) in 2002. NASDA is also preparing the Advanced Land Observing Satellite (ALOS), which is scheduled to be launched in 2004.

The data obtained from these satellites have the potential to be used for the continuation or expansion of these pilot projects and thus to encourage active use of satellite data by the administrations of Asia-Pacific countries.

-Sharing the responsibilities by both Space-faring countries and developing countries

Both countries had the tremendous efforts as;

Space-faring country: Data provision, Training

Developing countries: Application-oriented investment

-Step-by-step approach

Regional cooperation is important as the first step with limited resource. Step-by-step approach is very important. To realize the ideal Global level cooperation, we should start from cooperation with neighbor countries as our resource is always limited.

-Regional Cooperation

We can benefit a lot from these regional cooperation from the point of regional economical and social factors. Thus it is easier for us to feel incentives when we work together in regional level.

(Source : Mr Toshihiko Oida, Director, NASDA Bonn Office, H 1201 Bonn-Center, Bundeskanzlerplatz 2-10, 53113, Bonn, Germany; oida.toshihiko@nasda.go.jp)

Appendix IV

A Glimpse of Success Stories from Different Parts of the Globe

I. People and Pixels: Socializing EO Products

The Johannesburg declaration emphasizes the three pillars of sustainability: environmental, economic and social. While EO can determine the 'what' and 'where' of changes that have occurred to land surface characteristics brought about by humans, the social sciences aim to determine 'why'. That is, '…to socialize the pixels is to take remote sensing imagery beyond its use in the applied sciences and towards its application in addressing the concerns of the social sciences' (Geoghegan et al 1998).

Two approaches suggested are 'mining' and 'modelling'. 'Mining' the pixel refers to seeking social meaning in the imagery, while 'modelling' aims to extract further social information from the imagery. These studies demonstrate the difficulties in relating the physical nature of the terrain surface with the social activities of humans, because of the lack of consistency of the physical and social data in terms of time of acquisition, as well as the resolution of the data. Wood at al (1998), studying deforestation in the Amazon, used Landsat MSS data to determine the impact of deforestation and a sub-set of the Brazil population and agricultural census for 1980 and 1991. Significant relationships were determined between the levels of deforestation and such variables as population relationship between land cover and the in- and out-migration of the population in the villages. Andersen et al (1999) have appropriate indicators for a particular application. The application of remote sensing and as a tool for assessing sustainable development must be related to the social indicators that can be measured with the technology. While remote sensing will not be the only tools for assessing these indicators, they should make an important contribution to this multi-disciplinary process, provided they satisfy scientific criteria, such as being subject to strict calibration and validation. A great deal has yet to learnt about these processes and how the full potential of remote sensing can be achieved in the direction of people to pixel.density, rural migration density and ranch density. INPE (1998), in providing details of deforestation of the **Brazilian** Amazon tropical forests, has also commented on the sociological causes of deforestation, the types of farmers responsible, and the implications of government controls on deforestation. Entwisle et al (1998) classified Landsat TM and SPOT data for studying land-use/land-cover change in **Thailand**. Social data was derived by longitudinal and multi-level surveys of households and villages over a period of 10 years from 1984-1994. The purpose of the study was to determine the

II. Natural Resources Accounting: A Case Study from China

Recent satellite-based studies indicate that land use change in the People's Republic of China (PRC) is occurring at unprecedented rates. A recent analysis of time-series Landsat images by Seto (2000) showed that between 1988 and 1996, urban land areas in the greater Pearl River Delta (PRD) region in the southern PRC increased by over 300%, while natural and agricultural land declined by approximately 6% and 10%, respectively. In order to assess quantitatively how these contemporary land use changes have affected the region's terrestrial carbon cycle, Dye et al (2002) combined remote-sensing based modeling with reported environmental and ecological data to investigate the effects on two components of the terrestrial carbon cycle: net primary production (NPP) and ecosystem carbon storage. The results indicate that land use change during the 9-year study period reduced the annual total NPP of the region by 1.6 Mt C (-7.5%). This reduction in NPP is a consequence of the conversion of biologically productive land areas (natural and agricultural) to urban uses. Vegetation removal and soil disturbance reduced the size of the terrestrial carbon pool by nearly 12 Mt C (-6.1%), of which 81% was from phytomass. This result suggests a sustained reduction in the potential size of the terrestrial carbon pool in the PRD region.

III. Evaluating the Management Strategy of Preserving Natural Water Bodies: A Case Study from Kenya

Management plans in the natural resources realm aim to achieve and maintain the delicate balance between resource preservation and utilization. However, as much as resource management planning has proliferated in the past decades, it has also left a legacy of shelved plans whose implementation leave verification questions. Such questions are commonly answered through evaluation. Evaluation systems employ feedback correcting mechanisms to ensure that project inputs, work schedules, target outputs, and other related actions are proceeding according to plan.

A management plan was prepared for Lake Naivasha riparian area in 1996. One of the objectives was to check inappropriate land use and maintain a sustainable papyrus fringe. Respective options included re –establishment of the papyrus fringe around the lake, maintaining a minimum of 50 m buffer zone on the land-side of the papyrus edge; and discouraging reclaiming of flooded land, intensive agriculture, and permanent structures below the 1906 lake level (1893.3 m contour). In order to verify the adequacy and implementation progress of these options a 1995 satellite image was used to derive the 1997 land cover, papyrus swamp distribution, plus a land use map for the riparian area. In a GIS, the 50-m buffer and land cover within were established. A digital elevation model was used with the land cover and land use map to verify the appropriateness of the activities below the 1893.3-m contour. Arial photographs of 1967 were used to derive the 1967 papyrus distribution as reference for possible papyrus re-establishment. Results showed that the papyrus swamp was hardly protected as per 1996 proposed measures. Within the 50 m buffer, agricultural fields covered 35% and scrubland 55%. Both land-cover types are of high threat to the papyrus area. Activities below the 1893 .3 m contour included intensive agriculture, and buildings covering 80 % of the area against the 1996 proposal. These land use types provide minimal chance to papyrus regeneration. 1673 ha was identified as possible restoration area for papyrus taking the 1967-swamp area as reference (Jane Bemigisha, 2002).

IV. Watershed Development: A Case Study from India

Watershed management is perceived by many as the most viable approach for increasing agricultural production in rainfed marginal areas on a sustainable basis. According to the Ministry of Agriculture, Government of India in the next 20 years, intends to treat 88.50 million hectares. Unfortunately, monitoring and evaluation has not got its share of attention and therefore it is often very difficult to quantify or qualify the changes which have happened not only to natural resources but also to the livelihoods of people due to these programmes and in the long run to justify the need for these schemes. There is often not enough room for mid-term adjustments in ongoing programmes due to lack of a proper monitoring system. The need therefore arises to identify a quick and cost-effective technique for monitoring the impacts of such schemes on a "before project"–"after project" temporal scale as well as during project implementation. Accurate, reliable and timely information on the current scenario of natural resources as well as their degradation and depletion are essential for integrated natural resources management and monitoring. In India, Satellite remote sensing and GIS are being used operationally as effective tools for such impact studies. India's experience strongly suggests the use of these techniques in conjunction with participatory techniques for a holistic picture of changes in the fields of natural resources and livelihoods of the people that have taken place due to project interventions.

V. Sustainable management of natural resources for improving livelihoods through watersheds in the semi-arid tropics (SAT): ICRISAT Approach

The natural resource base of the semi-arid tropics (SAT), covering 11.1 million km2, is the lifeline of rural livelihoods for 800 million people with agriculture as the major source of livelihood. The SAT rainfed areas with dry agro-ecosystems are characterized by unpredictable weather, limited, erratic with long intervals of dry spells and intense rainfall causing runoff and severe soil erosion. The overexploitation and reduced recharging of groundwater, along with low rainwater use efficiency are seriously threatening scarce water resources in the SAT. The poverty of Asia's poor is both a cause and a consequence of accelerating soil degradation and declining agricultural productivity. Over exploitation of natural resources is causing environmental degradation and land degradation in particular in the SAT. The extent of land degradation is severe in Asia and Africa. Asia's degradation is specifically attributed to deforestation with overgrazing and agricultural activities contributing as major factors. Low agricultural yields and high population pressure have forced small farmers to cultivate fragile marginal lands and clear forests, causing soil erosion and land degradation. The challenge therefore, is to develop sustainable and environment-friendly options to manage natural resources in this fragile ecosystem to increase the productivity and incomes of millions of poor farmers who are dependent on the natural resources for their survival. The way forward to address this gigantic task is to harness new scientific tools to manage fragile ecosystems through precision farming. Systems productivity can be sustainably increased by using science-based and farmer-centered natural resource management options. An appropriate manageable land unit for this approach is a watershed.

Approach towards the problem

A watershed is a delineated area from which the runoff drains through a particular point in the drainage system. Watershed management is the integration of technologies within the natural boundaries of a drainage area to optimally develop land, water and plant resources. Within a watershed, natural resources are managed and handled effectively, collectively, and simultaneously by the people themselves, thereby sustaining rural livelihoods where focus is on the scope and priorities for development of rural people. Appropriate benchmark watersheds in the semi-arid tropics could serve as learning sites for stakeholders. More mileage could be covered by empowering the primary stakeholders to manage natural resources sustainably. Moreover, they can also be used as onfarm laboratories for scientists, development workers and policy makers in developing and evaluating management options for the sustainable development and use of natural resources.

Integrated Watershed Management Model for Efficient Use of Natural Resources

International Crop Research Institute for Semi-arid Tropics (ICRISAT) started on-station watersheds research from 1976. Based on the impressive successes of on-station watersheds, exchange of technologies between ICRISAT and farmer fields was initiated to enhance the productivity for rainfed systems and also to help the rural poor of the SAT by increased productivities. The whole process was based on "demonstration" of the technology package and possible benefits from the package under farmers' conditions.

- The integrated watershed model for efficient development and management of natural resources in the SAT has emerged from the lessons learnt from long watershed-based research of ICRISAT and partners. The important components of the new integrated watershed management model are:
- Farmer-participatory approach through cooperation and not through contractual mode Stakeholders are involved at all the levels in watershed activities from inception – planning, implementation, sharing benefits, and managing the process.
- Use of EO tools for management of watersheds EO, GIS, digital terrain modeling and crop simulation modeling are utilized for implementing and executing the watershed activities.
- Water budgeting approach Using GIS linked water balance simulation studies upon monthly rainfall and soils information, the generated outputs could be efficiently used to prioritize the regions and strategies for efficient management of rainwater budgeting.

A results indicate that a balance between attending to needs and priorities of rural livelihoods and enhancing positive directions of change by building effective and sustainable partnerships. The new integrated watershed development model encompasses conservation and efficient use of natural resources (William Dar and S P Wani, 2002). It is worth noting that in the holistic watershed development program of ICRISAT in SAT, EO inputs play a critical role.

VI. Remote sensing activities for lake water quality in Italy

Remote sensing applications to lake monitoring started in early 80's with the launch of the second generation satellites for earth observation whose sensor resolutions show a 20–30 meter footprint at ground and some 6–7 spectral bands in the optical range. Since then several experiments were carried out in different lake districts and ecoregions in the world indicating that remote sensing could be helpful in mapping some parameters of limnological interest like the secchi disc depth, the surface temperature, the suspended matter and the chlorophyll a concentrations linked to the eutrophicating process. Other subject of interest is the proved mapping capacity of spaceborne sensors providing information on spatial distribution of environmental emergencies in lakes such as infesting macrophytes and algal blooms. In Italy, lake water qualities are monitored regularly using remote sensing data (G. Crema, 2002).

VII. EO Applications towards Coastal Ecosystems – Trends

Coastal zone is under pressure on account of globalisation. It is necessary to protect coastal ecosystem to ensure sustainable development. This requires information on coastal wetlands, landforms, water quality, hazards on a periodically. Remote sensing data are being used extensively in most of the countries to provide information on these aspects. EO inputs are particularly used to generate thematic maps on wetlands, land use, landforms, mangroves, corals, shoreline on the various scales such as 1:250,000, 1:50,000 and 1:25,000. The classification accuracy have been achieved to the extent of 90 per cent confidence level. This information has been used for the assessment of condition of wetlands, corals and mangroves, water quality, exploration of living resources and identification of areas under erosion and deposition. Satellite-derived derived information are integrated with the other collateral information through GIS to select sites for aquaculture, zoning of coastal zone for regulatory purpose and assess possible impact of climate.

VIII. Forest Fire Monitoring: Case Studies from China and Russia

Forest fire in the boreal zone is recognized as a rather complex phenomenon, which influences a wide variety of aspects of human life, directly at local scales or indirectly on broad or even global scale. The description of spatial burned scar extent, understanding of vegetation succession pattern and post-fire development of biomass regrowth are usually achieved using satellite remote sensing data, which represents effective and affordable observation tool. In hardly accessible areas and in areas with lack of forest fire records, the satellite data is practically the only tool.

There are several case studies on time and space description of burned areas polygons in Far East region of Asia consisting of part of Russia and China, wherein the forest vegetation succession after fire and its connection with biophysical variables (LAI, FAPAR and ANNP) has been established. NOAA-AVHRR data archive (1984-2001) is used as the main data source. The designed burned scar mapping algorithm is based on complementary effect of multi-channel threshold fire detection scheme and detection of abrupt change of NDVI in 18 years time series. As a result the burned areas are obtained for each year (1984-2001). Vegetation succession is studied using NDVI time series for burned and unburned areas and NDVI development patterns after fire event are depicted. Biomass burning is simulated with terrestrial ecosystem model Sim-CYCLE and time series of biophysical variables after fire are obtained. These studies provide valuable inputs to the planners and decision makers in order to control forest fires (J. Kuèera et al 2002)

IX. EO Support to protect agro-ecosystems in Kazakhstan

Kazakhstan is a major crop exporter in Central Asia. Dependable agricultural production significantly affects food security within the country, as well as that of other countries in the region. Locust infestation is an annual occurrence, but the scale and intensity of the problem in recent years has reached a crisis level. In a United Nations Food and Agricultural Organization (FAO) report, the 1999 locust plague caused severe localized damage to crops in Kazakhstan despite best efforts to control the disaster. The Department of Space, Government of India together with RADARSAT International, the

Canadian International Development Agency (CIDA), and the Space Research Institute of Kazakhstan have developed a model to identify areas of locust risk within west Kazakhstan.

Ideal breeding parameters were determined for the model based on conditions specified by the locust experts and entered into the locust Life Cycle Builder. The locust Life Cycle Builder is a forecasting tool designed to predict the various stages of locust development by evaluating daily weather data. Using initial locust observations the model predicts the following aspects:

- Breeding Suitability
- Egg Development
- Hopper Development
- Sustained Flight Suitability

The final output from the model is a locust risk map. RADARSAT data is being used as inputs to soil moisture variations, a key parameter to generate the risk map. The selection criteria used to identify areas of very high-risk habitat was to determine all areas currently fallow and consisting of sandy and sandy loam soil types and Aeolian plain geomorphology. Furthermore, those areas with little or no vegetation were considered for this category. Although locusts require vegetation in close proximity to their place of hatching, this was not considered here. For the high-risk category, soil moisture values of 10 to 15 per cent is being used and temperature conditions ranging from 35 –40 degrees. For the medium Risk habitat only the soil moisture and temperature conditions differed. The study strengthens the plans of Kazakhstan Government to control locust.

X. Impact of Urbanization on Natural Resources: A Case Study from Turkey

The JRC (Joint Research Centre) supports the integration of scientific and technical methods and results into the European Union policies. The "Urban and regional development sector" of the IES (Institute for Environment and Sustainability) is carrying out the MOLAND (Monitoring Land Use Changes) project, to define and validate a methodology in support to European policies with territorial and environmental impacts. A temporal analysis of the change of the land-use in urban and suburban agglomerations related to the connection of cities (corridors) is one of the objectives of this project.

The use of very high-resolution satellite imagery for the reference year 2000, Russian satellite photographs for the year 1988 and aerial photographs for 1968 and 1945 solved the MOLAND-Project. Georeferencation and Orthorectification were done in PhoTopoL software. The land-use-classes have been predefined by the JRC as MOLAND level 4 classifications, which is built up on CORINE. Vectorisation was done in TopoL-GIS by using topological structure and interpretation into a database attached to lines and areas. Interpretation was done in combination with ancillary data like maps, plans and local knowledge. For the reference year was created a transportation network dataset with line-features, a land-use dataset with areas and in addition a layer with 3 d-objects like bridges or tunnels. Theses datasets have been "down-dated" to the years 1988, 1968 and finally to 1945. Theses data have been used for temporal analyses, trend-estimations and scenarios. In combination with ancillary data (socio-economic statistics), deeper analyses in order to detect key-events for the urban grow have been done. The growth is amazing and was compensated mainly by the loss of agricultural land. Related with other similar analysed cities, more common strategies for planning the future is being developed (M. O. Altan 2002).

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