REMOTE SENSING AND GIS FOR SUSTAINABLE DEVELOPMENT IN HARYANA STATE, INDIA

K E MOTHI KUMAR*
T B V M RAO**
JITENDRA PRASAD***

*Haryana State Remote Sensing Application Centre (HARSAC)
CCS H A U Campus, Hisar 125 004. **INDIA**
Fax No: +1662 – 25958,
E mail : info@harsac.com

**Haryana State Remote Sensing Application Centre (HARSAC)
CCS H A U Campus, Hisar 125 004. **INDIA**
Fax No: +1662 – 25958,
E mail : info@harsac.com

***Haryana State Remote Sensing Application Centre (HARSAC)
CCS H A U Campus, Hisar 125 004. **INDIA**
Fax No: +1662 – 25958,
E mail : info@harsac.com

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ABSTRACT

Sustainable development aims at maintaining the equilibrium between the human needs and economic developments within the parameters of environmental conservation through efficient use of natural resources to ensure trade off between desired production - consumption levels. The well-known Brundtland Commission defined sustainability as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In essence, the sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and instrumental changes, all are in harmony". The sustainable development of natural resources is based on maintaining the fragile ecosystem balance between the productivity functions and conservation practices through monitoring and identification of problem areas, agricultural practices, crop rotation, use of bio-fertilizers, energy efficient farming methods and reclamation of underutilized lands. Sustainable development requires a holistic approach towards natural resources after taking into account the precarious environmental conditions.

HARSAC had under taken a project namely Integrated Mission For Sustainable Development (IMSD)**,** a project funded by the Department of Space, ISRO, Govt. India. The objective of the study was to generate site-specific action plans by integrating the natural resources information generated from satellite data in conjunction with collateral and socio economic information. HARSAC carried out this study with the active cooperation from respective District Administration in the state.

The main objectives of the project is as follows: -

- To generate thematic maps of various natural resources on 1:50, 000 scale.

- To integrate these natural resource data to draw site-specific action plans for Sustainable Development that deals with:

    - Land Resource Development (Agriculture, Fodder & Fuel wood etc.)
    - Water Resource Developmental Plans

Under this study HARSAC has mapped various natural resources such as Landuse / landcover, Physiography and soils, Landforms, Ground Water quality etc. on 1:50, 000 scale using the latest satellite data. The maps were integrated to derive site specific Action Plans such as sites for Agro forestry, Agro horticulture, Horticulture, Horticulture / Agro horticulture, Agro forestry / Agro horticulture, Dune Stabilization /Forest Plantations, Silvipasture, Horizontal Drainage system, Vertical Drainage system, Bio drainage, Fish/Prawn culture, Soil Conservation measurers, Fodder and Fuel Wood plantations etc.

The paper discusses the methodology adopted in formulating the action plan packages.

1. INTRODUCTION

Sustainable Development aims at maintaining the equilibrium between the human needs and economic developments within the parameters of environmental conservation through efficient use of natural resources to ensure trade off between desired production - consumption levels. The well known Brundtland Commission defined sustainability as a "*development that meets the needs of the present without comprising the ability of future generations to meet their own needs. In essence, the sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and instrumental changes, all are in harmony".*

The Sustainable Development of natural resources is based on maintaining the fragile ecosystem balance between the productivity functions and conservation practices through monitoring and identification of problem areas, agricultural practices, crop rotation, use of bio-fertilizers, energy efficient farming methods and reclamation of underutilized lands. Sustainable Development requires a holistic approach towards natural resources after taking into account the precarious environmental conditions. The advent of Remote Sensing and Geographical Information Systems (GIS) has opened new vistas in inventorying and monitoring of natural resources. Because of the unique characteristics of satellite data such as repetitive coverage, spectral, spatial resolution, ability to provide the near real time cost and time effectiveness, the remote sensing techniques has emerged advantageous over the conventional surveys (HARSAC, 1992).

2. BACKGROUND OF IMSD PROJECT

The Integrated Mission for Sustainable Development (IMSD) study was initially conceived in 1988 by the Department of Space (DOS), and launched as a technology demonstration study in response to the then Prime Minister of India late Rajiv Gandhi's specific poser to the scientific community of India to find a permanent solution to the occurring drought situations in India. A data base on various natural resources such as land use/land cover, surface and ground water, soils etc were generated from the remote sensing data of Indian Remote sensing satellite (IRS). Additional information such as information related to drainage, slope, meteorological and hydrological conditions, were collected from the available resources. The information on natural resources, physical parameters, socio economic conditions were integrated to prepare the action plan maps. The action plan maps suggests location of specific activities related to land and water management. After successful completion of the pilot study the Dept. of Space has initiated a national project on Integrated Mission for Sustainable Development (IMSD) on mission mode (NRSA, 1995).

3. STUDY AREA

The Haryana state came into existence on 1st November 1966. It is small state located in the North West part of the country with a geographical area of about 4,42,1000 ha and forms only 1.35 % of the total area of India. Haryana state is located in between 27° 39' N to 30° 55' N latitude and 74° 27' to 77° 36 E longitude. The state shares a common border with the states of Delhi, Rajasthan, Punjab, Himachal Pradesh and Utter Pradesh. The state has 19 districts and over 100 community development (CD) blocks (Master Plan, Govt. of Haryana, 1998). Haryana state is blessed with unique resources of land, water and other mineral resources. The state is predominantly an agricultural state and its economy mainly depends upon its agriculture. With less than two percent of the area of the country, it contributes more than 60 % of wheat and 40 % of rice to the central food grains reserves. The cropping intensity of 176 per cent with 94 per cent of cropped area under irrigation is highest in the country. Such a production level of food grains has been achieved by green revolution for which, besides the introduction of high yielding crop varieties, use of fertilizers, agrochemical and increased irrigation facilities. Thus Haryana state has created a record in agricultural growth, while on the other hand the natural environment has been adversely affected by "green revolution". This is mainly because of the fact that over exploitation of ground water facilities, fertilizers, introduction of canal irrigation facilities etc. compounded the **Ecological Backlashes** such as water logging, salinity, depletion of ground water resources etc. The state covers about 3.3% cultivated area and contributes about 5.6% to the total food grain production in the country. The per capita availability of the land has been decreasing progressively over the years and is likely to decrease further due to the population pressure, urbanization and the industrial expansion of the arable lands. In Haryana state HARSAC has under taken the responsibility execution of IMSD project in two phases. Under phase I entire Bhiwani district has been covered while in phase II the following blocks / district was selected under IMSD.

Block Name	**District**
Mahendragarh Block	Mahendragarh
Khol Block	Rewari
Hisar I & II Blocks	Hisar
Karnal & Nilokheri Blocks	Karnal
Nathusari chopta Block	Sirsa and
Gurgaon District	

4. OBJECTIVES

The objective of the present study is to generate site-specific action plans by integrating the natural resources data (derived from satellite data) in conjunction with collateral and socioeconomic information. To fulfill the above goal following objectives are envisaged:

1. To generate thematic maps of various natural resources on 1:50, 000 scale.
2. To integrate these natural resource data to draw site-specific action plans for Sustainable Development that deals with:

    - Land Resource Development (Agriculture, Fodder & Fuel wood etc.)
    - Water Resource Developmental Plans

5. DATA BASE AND METHODOLOGY

The primary source of data used in the present investigation was IRS 1B and IRS LISS - III FCC. Other conventional data such as meteorological, ground water depth, canal irrigation, socioeconomic profile etc. were also used and integrated with the satellite data.

5.1 Satellite Data

The following satellite data were used for visual interpretation to generate various thematic maps in the present study. IRS 1B LISS II Geocoded FCC 2,3 and 4 bands of the following seasons/years were selected for the study.

- 3 rd Oct. 1992 for Kharif season
- 6 th Mar. 1993 for Rabi season
- 17 th Feb.1999 (LISS–III)

5.2 Ancillary Data

- District Census Handbooks
- Statistical Abstract of Haryana state
- District Gazetteers etc.

5.3 Conventional Data

The various meteorological and hydrological soil and land resources data were collected from various Central and State Government agencies and utilized for the study.

5. METHODOLOGY

The IRS LISS-II & LISS - III paper prints (FCC) on 1:50,000 scale were interpreted visually for preparation of maps for the following themes.

- Land use / Land cover
- Hydro-geomorphology
- Soils

Based upon the standard image characteristics such as tone, texture, pattern, shape, size, location and association etc. the visual interpretation of the imagery was carried out and maps were prepared for the above-mentioned themes. The interpreted thematic details for all the themes were checked during the ground truth verification. Based upon the field visit, the boundaries were finalized. To identify the village names, coordinates position and different reference points have been marked on the images based on the 1:50,000 scale toposheet of Survey of India. The soil and land use maps prepared on 1:50,000 scale were overlaid and were interpreted for land irrigability and for land resource evaluation purposes. Based upon the study of soils, land use, ground water quality and availability, canal water supply, geomorphic units, rainfall and site conditions as observed on the ground, suitability of a large number of ground points were assessed for recommending alternate farming systems such as agro-forestry, agro-horticulture, fodder and fuel wood plantation including more efficient water management practices and methods for surface water harvesting. This has formed the basis for preparation of site / area specific action plan for the study areas on 1:50, 000 scale (Mothi Kumar et. al., 1996, 1997).

7. DATA ANALYSIS AND INTEGRATION

The main objective of the IMSD study is to generate the action plan for the area which is optimally suitable to the terrain and to the productive potential of the local resources so that the level of production is sustained without decline of overtime. The recommended activities of the action plan should be taken in to consideration of contemporary technology and the resources, climatic and terrain parameters (HARSAC, 1999, Fig. 1). To generate the action plan map, the following steps were involved: -

1. Study of individual thematic maps,
2. Study of theme maps in combinations

3. Development of decision rules for action plan
4. Development of Action daft plan
5. Finalization of Action Plan and
6. Expert evaluation of Action plan

7.1 Study of Individual Theme Maps

In this step, the individual thematic maps were studied in order to make the spatial assessment of the relative variations of the resource potentials and a wide range of terrain conditions. This analysis helps in understanding the peculiar nature of the study area viz., the waterlogged conditions, wastelands, land degradation etc. in a quick look.

7.2 Study of Theme maps in Combinations

The second step, the natural and logical association of various parameters of one theme visa-a-visa those of the other are studied. This analysis helps in better understanding of the cause and effect in respect of not only problems / limitations and also at the same time understands the potentials of the study area.

7.3 Development of Decision Rules for Action Plan

During this step, a number of spot observations were prepared, covering the entire area that consists of various land forms, soils, nature of ground water, depth to the ground water table, rainfall conditions, climatic zones, present land use etc. At each spot, the land characteristics/parameters as mapped in the respective theme maps along with the present land use along with the existing irrigation facilities and cropping pattern were recorded. Further while making the alternate recommendations for land use practice futuristic considerations such as exploitation of ground water (if not presently exploited), and possibility of adopting more efficient irrigation system and water management and other site improvements through soil and water conservation methods were kept in mind. The availability of improved varieties of crops, trees, shrubs and grasses and advantages of interdependency of agriculture, live stocks and other practices such as integrated farming systems etc. were taken in to consideration.

7.4 Development of Draft Action Plan

Based upon the decision rules, short deliberations were made on the optimum utility of the present land use pattern especially keeping in view of the sustainable production and quality of the ecosystem. Later various development activities like forestry, horticulture, agro forestry, agro horticulture, sites for structure for surface water harvesting, ground water quality exploitation and recharge etc. have been considered and based on the results of experimental research, the suitability of these activities for specific land units have been examined. The detailed action plan map showing areas recommended for various activities and location of structure is prepared on 1:50,000 scale. Thus a tentative scheme of integration was evolved taking into the consideration of the basic research carried out by premier research institutions such as CAZRI, ICAR and Agricultural Universities. The contemporary technologies in the area of research development and management were also taken into consideration. Additionally the useful discussions carried out with the district development authorities and a series of packages/measures were suggested to be adopted for the eco-development. These recommendations were subjected to ecological/environmental scrutiny to decide whether they are environment friendly and ecologically sound. The study resulted in the following packages were shown in the form of an action plan map on 1:50,000 scale.

7.5 Finalization of Action Plan

The prepared draft action plan on 1:50,000 scale showing site specific action plan items were discussed with the line department officials, district administration officials, local research stations etc. for feedback. These feedbacks were critically evaluated keeping the concept of sustainability

in mind, and suggestions were made wherever needed. The prepared action plan map was evaluated on ground, for improving the accuracy. Then the action plan was finalized after incorporating the field observations.

Based upon the decision rules a number of site-specific action plan items were suggested for the sustainable development in the respective study areas. The action plan items includes sites for Agro forestry, Agro horticulture, Agro horticulture / Horticulture, Horticulture, Horticulture / Agro horticulture, Agro forestry / Agro horticulture, Dune Stabilization /Forest Plantations, Silvipasture, Agro forestry / rabi crop, Horizontal Drainage system, Vertical Drainage system, Bio drainage, Fish/Prawn culture, rabi crop, Silvipasture / rabi crop, Soil Conservation measurers, Fodder and Fuel Wood plantations etc.

8. BENEFITS OF THE ACTION PLAN MAPS

The possible benefits of these recommendations and action plan can be enumerated as:

- ✓ Increase in the production of food grains, pulses and oil seeds
- ✓ Increase in the fodder production as to support the live stock system leading to higher production of milk /meat eggs etc.
- ✓ Save land form degradation and bring more areas under cultivation
- ✓ Increase production of vegetables and fruits
- ✓ Improve the economic and nutrition standards of the people
- ✓ Improve the environmental conditions all over the study area

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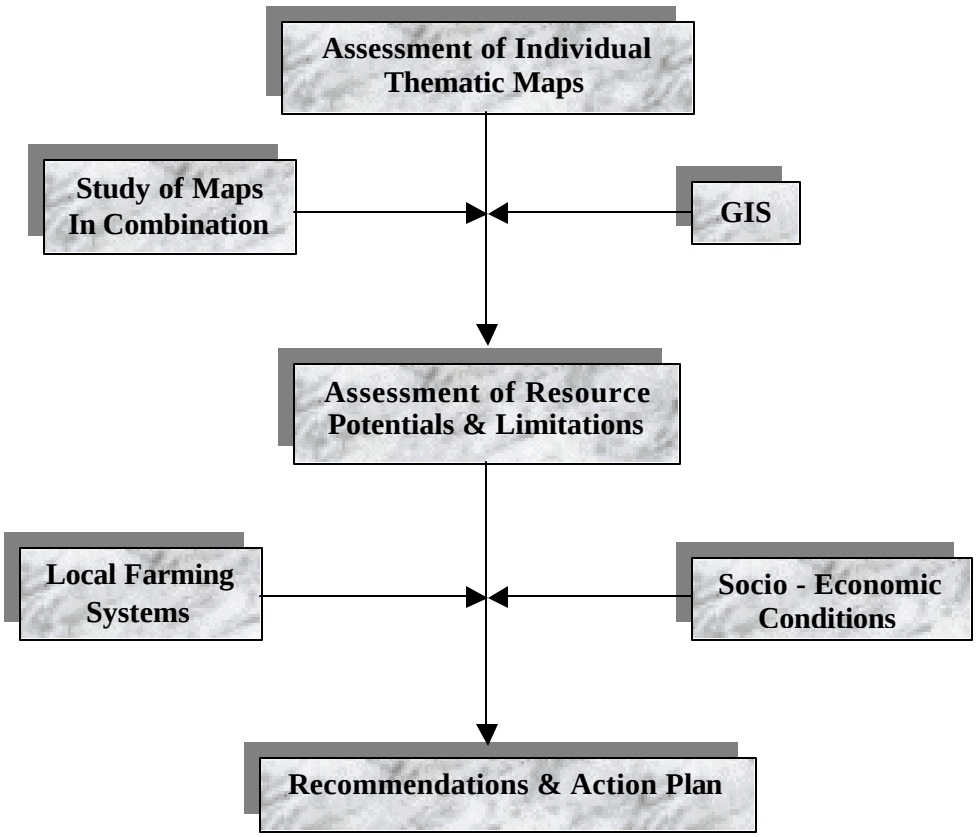

Fig. 1. Scheme of Data Integration

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Table 1. DECISION RULES FOR NATHUSARI CHOPTA

LU/LC	HGM	Soils/Phsiography	DPW (mts)	GWQ ECe	Action Plan Suggested
Degraded	FAP	Chadiwal-Kukurtana Series	I	III	Fodder & Fuel wood
Sandy	FAP	Rupawas series	I	I	Horticulture
Degraded	FAP	do	II	do	Silvi pasture
Degraded	FAP	do	III	III	Fodder & Fuel
Only rabi	DC	do	IV	do	Agro Forestry
Only kharif	FAP	Chadiwal-Kukurtana	IV	do	Agro Forestry
Fallow	DC	Rupawas series III	III		Agro Forestry
Rabi	FAP	Chadiwal-Kukurtana	II	II	Agro Horticulture
Kharif	DC	Rupawas series	I	II	Double crop
Kharif	DC	Kukrutana-Rupawas	II	II	Double crop
Kharif	EP	Chadiwal-Kukurtana	II	IV	Horticulture
Sandy Plantations	SD	Rampuria series	II	II	Forest
Fallow	DC	Rupawas series II	I		Horticulture
Fallow	DC	do	II	III	AGF/AGH
Degraded	FAP	.Chadiwal-Kukurtana	I	II	AGH/AGF
Fallow	SD	Rupawas series		I IV	Forest Plantations
Fallow	DC	do	I	I	Horticulture
Kharif	DC	do	I	I	Double crop
Sandy	SD	Rupawas series	II	II	Agro forestry
Fallow	DC	do	do	do	Horticulture

Note:

LU/LC : Landuse / Land cover, **HGM** : Hydro Geomorphology,
DPW : Depth to Ground Water level and **GWQ** : Ground Water Quality