AGRO-CLIMATIC PLANNING AND INFORMATION BANK (APIB) FOR UTTARAKHAND STATE, INDIA

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ABSTRACT:

Agriculture reform is the need of the hour to bring better productivity through utilization of new technology. APIB has designed a database structure to contain information on both spatial and non- spatial elements namely mapping, GPS survey, soil survey, GIS and Image Processing analysis, fertilizers use, plant protection, seeds/seedlings, package of practices, agricultural implements, climatological data, credit/insurance schemes available, infrastructure for processing and marketing, demographic details, etc. The strength of APIB is a powerful state-of-the-art image analysis and GIS facilities to assess the natural resources endowments to any agro-climatic and would present them in the spatial and temporal domain. The Natural Resources databank are generated for the following themes at 1:10,000 scale. All the database are generated at 1:10,000 scale level, except in case of very steep and steep hilly areas under forest where the level of mapping will be reduced to 1:50,000 scale. Maps showing spatial variation of agro-meteorological parameters are generated by GIS aided geo-statistical interpolation of ground meteorological station collected point agro-meteorological data. These maps are utilized for preparation of agro-climatic and agro-ecological micro zonation and sub zonation suggesting agricultural management; estimation of erosional soil loss etc. Action plans for land resources development include plans for Management of agricultural land, Management of wasteland and Allied agricultural activities. The land resources data integrated with climatic variability, location specific agronomic packages of practices in vogue and management scenarios helps in optimum crop management practices and predicting productivity of the area.

1. INTRODUCTION

India, with a geographical area of 329mha is bestowed with the bounties of natural resources, namely minerals, soils, water, flora and fauna, and marine resources. Over exploitation of available natural resources for meeting the increasing demand for food, fuel and fibre of ever-growing population has led to degradation of land by way of soil erosion by water and wind, salinization and alkalinisation, water logging, shifting cultivation, etc. An estimated 175mha of land are subject to some kind of degradation. Soil erosion by water and wind alone accounts for an estimated 150 m ha. In addition, water logging, soil salinization and alkalinisation, and shifting cultivation have affected an estimated 6mha, 7.16mha and 4.36mha of land, respectively. Degradation of land by deforestation, forest fire, frequent floods and drought, further compounds the problem. For optimal utilization of available natural resources and for taking up any preventive or curative measures, timely and reliable information on natural resources with respect their nature, extent and spatial distribution; and nature, magnitude and temporal behaviour of various type degraded lands, is a pre-requisite. Hitherto, such information has been generated through conventional approach using topographical sheets or aerial photographs. Synoptic view of a fairly large area provided by multi-spectral measurements made from satellite platforms at regular intervals enable generating information on natural resources, degraded lands and environment in a timely and cost-effective manner.

Agriculture constitutes the backbone of the Indian economy. With rapidly rising population, already a billion plus, threatening to make India the most populated country in the world in next few decades, one has to look towards advanced technologies to help in meeting the needs of this burgeoning population for food, fibre and fuel. There is also need for utilization of our natural resources in a sustainable manner. Remote sensing and Geomatics technologies have demonstrated the potential for assisting in the management of these precious resources. At the international level, ever since the launch of Landsat 1, the first civilian remote sensing satellite in July 1972, the indispensable role of satellite remote sensing in agriculture sector has been fully appreciated. In fact, the choice of spectral bands in most of the civilian remote sensing satellites launched by various countries, including India, to- date has been dictated by their use for efficacious management of resources related to agriculture. This capability has been further enhanced manifold by Geomatics during the last few years, especially with the availability of high resolution satellite images from IRS and IKONOS satellites.

In the twenty-first century, to steer the agricultural achievements towards the path of an 'evergreen revolution' there is a need to blend the traditional knowledge with frontier technologies. Information and communication technology; space technology; geographical information systems (GIS) are the tools of such frontier technologies which would help in creating agricultural management systems; making plans for sustainable agriculture; and bringing new areas (through development of wastelands) into productive agriculture.

The role of remote sensing and GIS in agricultural applications can be broadly categorized into two groups – inventorying/mapping and management. While remote sensing data alone is mostly used for, inventorying (crop acreage estimation, crop condition assessment, crop yield forecasting, soil mapping, etc) purposes, the management (irrigation management, cropping system analysis, precision farming, etc.) needs various other types of spatial physical! environmental information. The latter has to be integrated with remote sensing data, where the functionality of GIS will be used.

Agriculture is the backbone of Indian economy, contributing about 40 percent towards Gross National Product (GNP) and providing livelihood to about 70 per cent of the population. So, for a primarily agrarian country like India, accurate and timely information on the types of crops grown and their acreages, crop yield and crop growth conditions are essential for strengthening country's food security and distribution system. Pre-harvest estimates of crop production are needed for guiding the decision makers in formulating optimal strategies for planning, distribution, price fixation, procurement, transportation and storage of essential agricultural products. Advance forecasting about crop condition and crop production has a strong bearing on national economy as well as day-to-day life of the masses.

2. OBJECTIVES

The study has the following objectives:

- To prepare agriculture and natural resources inventories by analysis of temporal satellite data, including agricultural land use / land cover; cropping systems; irrigated crop land; soils; degraded land; geomorphology; ground water potential; drainage characteristics cultural; features etc.
- To collect agro-climatic and agricultural data for agro-ecological characterization and agro-climatic regional planning.
- To develop a database for Agricultural Practices, Seeds, Fertilizers, Plant Protection, Agricultural Implements, Agricultural Credits, Insurance Schemes, Subsidy, Agriculture Market Infrastructure, Weather Information, Socio-economic Infrastructure etc., in GIS. .
- Development of Spatial Decision Support System (SDSS) for agro-climatic planning and information bank for agricultural reform process as well as the management of agricultural land and other agricultural allied activities.
- Suggesting sustainable agricultural land use plan based on integration of land capability, land productivity; soil suitability; terrain characteristics and socio-economic etc. information using GIS

3. STUDY AREA

To carry out detailed study using ground truthing, maps, field observation, high resolution IRS multispectral and multitemporal images in GIS environment, in 1:10,000 scale large scale mapping for agriculture areas and 1:50,000 scale maps for forest and steep hilly areas, the study chosen was Champawat district of Uttarakhand State, India. All spatial features are being carried out with a detailed study at 1:10,000 scale, for agricultural areas and forestry/hilly terrain at 1:50,000 scale.

Parameters Studied:

See the following table.

Sl. No.	Parameters	Source	Period	Utilization
1	Soil Mapping	Satellite & detailed field survey data	March/Ap ril	Land use Planning; Soil management
2.	Dominant Crop Types	Satellite data	Rabi & Kharif	Agriculture Management, Crop production forecasting
3.	Landuse	Satellite data	Rabi & Kharif	Landuse planning
4.	Land degradation	Satellite data	March	Land reclamation, planning control measures
5	Geomorphology	Satellite data	March	Geological hazard assessment & Ground water potential
6.	Ground water potential	Derived from geomorphology & other terrain information		Water resources planning; irrigation planning
7.	Irrigated / unirrigated land areas	Satellite data and irrigation command area information	Rabi & Kharif	Irrigation water management
8	Soil physicochemical properties	Field survey & Lab. Analysis of soil samples	Any period	Soil classification & Soil management
9	Terrain characteristics (elevation, slope, aspect)	Derived from DEM (Toposheet)	Any period	Agricultural planning, agro ecological zonation

10	Agro-meteorological data	Meteorological station	Daily/wee kly /monthly	Agricultural planning; crop yield prediction
11	Cultural features (roads, canal, rail network, villages, towns etc.)	Satellite data, Toposheet	Any period	Infrastructure planning
12	Drainage characteristics	Satellite data, Toposheet	Any period	Watershed management
13	Soil loss	Soil map & soil properties data; climatic & terrain characteristics data; modeling	Any period	Soil erosion hazard assessment, soil conservation planning
14	Soil suitabilities for crops	Soil map & soil properties data; climatic & terrain characteristics data	Any period	Soil management, landuse planning
15	Hydrological soil grouping	Soil map & soil properties data; climatic & terrain characteristics data	Any period	Watershed hydrology, run-off estimation
16	Land irrigability	Soil map & soil properties data; climatic & terrain	Any period	Irrigation development, irrigation water management
17	Land productivity	Soil map & soil properties data; climatic & terrain characteristics data	Any period	Soil management, landuse planning
18	Land capability	Soil map & soil properties data; climatic & terrain characteristics data	Any period	Soil management, landuse planning

4. DATA PRODUCTS

As part of the data products, the high resolution Satellite Imageries that of Cartosat-I and Resource Sat P5 LISS-IV are procured from NRSA and associated Topo Sheets from Survey of India in 1:25,000 scale collected. Soil Samples Testing Detail Soil Survey were carried on at an interval of 200-500 metres interval based on soil variability covering all villages, of the District, for agricultural area. Spatial Agro-meteorological Characteristics Rainfall, Air temperature (Minimum & Maximum), Solar radiation (if available) monthly basis for past 10 to 15 year were collected from Indian Meteorological Dept., Pune. Socio-Economic Data Village wise and social group wise gender data (Census 2001) were procured from Census Department.

Revenue Maps of Villages

Revenue Maps are collected from Department of Agriculture, covering up to cadastre. Further GPS/DGPS data are being collected to augment these maps for necessary corrections for reliability.

Agronomic Practices

Location specific Packages of Agronomic Practices in vogue were collected from the Department of Agriculture.

5. DELIVERABLES

Spatial Database

The strength of APIB is a powerful state-of-the-art image analysis and GIS facilities to assess the natural resources endowments to agro-climatic region and would present them in the spatial and temporal domain. The spatial information made available with APIB: are

Natural resources thematic maps on 1:10,000 scale

Agriculture & other Land use (Rabi & Kharif seasons).
Detailed Soil Map & Soil Characteristics Attributes maps
Land Degradation map. -Geomorphology map.
Ground Water Potential map.

Spatial Terrain Characteristics on 1:10,000 scale

DEM (Digital Elevation Model).
Elevation map.
Slope map.
Aspects map.
Satellite ortho-images.

Spatial Agro-meteorological Characteristics-

Rainfall, Air temperature (Minimum & Maximum), Solar radiation on (if available) monthly basis for past 10 to 15 year collected from District Met-Stations and Meteorological Dept., Pune.

Drainage Characteristics -Type -Density -Sites for water harvesting structures/ground water recharge structures.

Cultural features viz. road, village, town, rail & canal network etc.

Soil & Terrain characteristics based interpretative maps, namely Land Capability, Land Irrigability, Land Productivity, Hydrological Soil Grouping, Model estimating Erosional Soil Loss, Soil & Terrain suit abilities for various crops, GIS analyzed optimal land use map showing action plan, Digitized Revenue map (Cadastral maps)

Process Methodology and Analytical Framework

The Natural Resources databank are generated at 1:10,000 scale for eighteen themes, except in case of very steep and steep hilly areas under forest, where the level of mapping are reduced to 1:50,000 scale. The field observations are judiciously limited to meet the required level of mapping.

Land use / Land cover Mapping

Agricultural seasons geometrically corrected satellite data are analyzed following hybrid approach-digital supervised classification using ground truth information followed by on screen computer interactive refinement. Final land use/land cover map of the area are generated by GIS based integration of two seasons land use maps.

Soil Resource Mapping

Soil resource mapping are carried out by visual analysis of satellite False Colour Composite (FCC) following sample strip approach supported with high intensity soil observation. Characterization of soils in the study area with respect to physico-chemical properties viz. texture, mechanical analysis (Pipette method), pH, E.C., CEC, exchangeable Na^+, K^+, Ca^{++}, Mg^{++}, organic matter content, macro and micro nutrients (selective) contents etc. are done by laboratory chemical analysis of model profiles soil samples collected during field survey. Fertility status of surface & subsurface are determined for agricultural areas, Digital soil and soil attributes maps are generated using GIS by linking soil map & soil characteristics data (field and laboratory).

Land Degradation map

Land degradation map of the study area is prepared by visual analysis of 5.8 meter spatial resolution multi-spectral IRS P6 LISS IV data. On screen computer aided visual interpretation technique are adopted. Various degraded land classes such as different kinds of eroded lands; open/degraded forest; water logged; steep sloping barren area; land slide affected area; scrub land etc (13 categories of Land Degradation are considered are identified and mapped. Drivers/causes of land degradation are also investigated to suggest suitable measures for arresting land degradation.

Geomorphology & Ground water potential maps

Standard visual interpretation technique using 5.8 meter spatial resolution multi-spectral IRS P6 LISS IV data are used for preparation of geomorphological and hydro-geomorphological maps. Ground water potential are prepared by integration of hydro-geomorphological map and terrain and drainage characteristics information. Depth of water table, ground water quality, and well discharge etc. data are correlated for accuracy of maps.

Terrain characteristics

Processing of digitized contour, GPS terrain elevation data in GIS environment is used to generate DEM of the area. TIN method of interpolation technique is used for generation of DEM. Slope and aspect maps are generated from DEM using specialized analysis in GIS. The derived DEM is used for generation of satellite ortho-images to remove ground distortion in hilly terrain.

Spatial maps of agro-meteorological parameters

Maps showing spatial variation of agro-meteorological parameters are generated by GIS aided geo-statistical interpolation of ground meteorological station collected point agro-meteorological data. These maps are utilized for preparation of agro-climatic and agro-ecological micro zonation and sub zonation suggesting agricultural management; estimation of erosional soil loss etc.

Delineation of watersheds & micro-watersheds

Delineation and codification of watersheds and micro-watersheds in the study area are done using drainage and contour maps. Codification and delineation are done on the basis of Watershed Atlas of India. Drainage map is derived from topographic map and satellite data.

Spatial cultural features

Spatial maps showing cultural features such as roads, canals, villages, towns etc. are prepared by digitization of these information extracted from satellite data and topographic maps and other large scale maps (Patwari maps).

Revenue Maps

Revenue maps (Cadastral maps) of districts showing cultural features such as village boundaries, roads, canals, agricultural fields etc. are scanned, registered, digitized and edge mapping are prepared with the help of satellite data, topographic maps and other large scale maps.

Interpretative maps derived from soil & terrain information

Various derived maps viz. land capability, land irrigability, land productivity; suitabilities for various crops etc. are prepared by GIS based integrated analysis using soil and terrain characteristics data following various modeling approaches. For land capability USGS approach; for land irrigability AIS & LUS method; for land productivity Storie Index approach and for soil suitability FAO Land Evaluation method are followed. Estimation of erosional soil loss is attempted by following well established Modified Universal Soil Loss Equation (MUSLE) using remote sensing inputs and GIS technique. Soil conservation measures and prioritization of watersheds/micro watersheds are worked out using information of soil loss estimates.

Sustainable agricultural land use planning

Sustainable agricultural land use and cropping pattern plans of the area are generated by GIS based logical integration of crop suitabilities, land productivity, land capability, socio-economic and terrain characteristics information. Specific action plans are devised for optimum management of land and water resources through integration of information on natural resources, socio-economic and meteorological data and contemporary technology. Action plans for land resources development include plans for Management of agricultural land Management of wasteland and Allied agricultural activities. The land resources data integrated with climatic variability, location specific agronomic packages of practices in vogue and management scenarios helps in optimum crop management practices and predicting productivity of the area. Wastelands which are identified by 13 different categories, require special attention for reclamation for conserving the fertility. So priority areas are delineated and their development plan are prepared. Most of the lands may be suitable only for Horticulture, Afforestation and other allied purposes. Land Capability Classification (Class I to IV-Culturable Lands & Class V to VIII-Non Cultural Lands) are to be used for spatial decision support systems.

6. CONCLUSION

Agro-Climatic Planning and Information Bank, (APIB), is a single window access to all agricultural related information and decision support to users of agricultural and allied sectors. The project on APIB exhibited the use of geo-spatial technology to collect scattered information and provide access to any type of information as and when needed. The development of APIB has taken into account the main users, namely, the farmers, financial institutions, agro-based industries and traders, extension officials, researchers/consultants/journalists and state level administration.

The APIB information can be retrieved from data base which includes crops that can be grown with farmers' soil and water resources, varietal/hybrid selection for principal crops, comprehensive package of practices from public and private sources, fertilizers, plant protection, cost of cultivation and prices in various markets, area under cultivation and yield, dairying and insurance. The APIB information is geared up to be made available to the farmers through a web based portal in local language interface.