**THEME 3: SECURING SOCIAL TENURE FOR THE POOREST**

**TNR2: Technology for low-cost land rights recognition and natural resource management**

# "A state-wise LIS for NRM & disaster monitoring: Scope for land administration"

*March 9-10, 2009 Washington DC*

Dr. Y. V. N. Krishna Murthy, Director, RRSSCs,
Indian Space Research Organisation, Bangalore, India
**yvnk@isro.gov.in**

## I. Introduction

Land is the most precious resource and the essence of human civilization. In India, land continues to be of enormous economic, social and symbolic relevance. The way in which access to land can be obtained and its ownership documented is at the core of the livelihood of the large majority of the poor, especially in the rural and tribal areas and determines the extent to which increasingly scarce natural resources are managed. It has been one of the most sought after possessions wherein, the survivability and the status are linked to the extent of an individual's land property. Currently, due to pressure of human population and rapid technological advancements, traditional cadastre and land registration systems are undergoing major changes worldwide.

Many countries, particularly the developing countries are facing challenges on the issues of land administration. The traditional systems are no longer adequate to support the sustainable development as they were designed long back to satisfy the limited needs then. But today the diverse needs of land information and technological advancements have driven the necessity of changes in land administration systems. Hence, there is an urgent need for the development of a Land Information System (LIS), which is efficient, reliable, cost effective, scale independent, interoperable, capable of adopting information from various sources and compatible to the other information systems. The system should also address an individual farmer/stake holder with parcel (survey) number as the unique identity derived from the cadastral map and integrate the corresponding thematic maps and action plans generated in other information systems. The proposed integrated LIS should act as a planning and developmental tool addressing all the issues of a national/regional/local level planning exercise, it's implementation and subsequent temporal monitoring of the impact of developmental activities.

A commitment to the reduction of poverty has been a defining characteristic of the Indian state from the time of Independence to the present day. The Indian state that has emerged after Independence was deeply committed to industrialisation, economic growth and a modicum of income redistribution. In terms of poverty reduction, this

involved an early attempt at improving agricultural productivity through the implementation of land reforms, agricultural co-operatives and local self-government. From an early stage in this process, the reduction of poverty and the empowerment of poor and politically marginal groups in India have been strongly associated with at least some form of decentralization. The Government of India passed a series of constitutional reforms, which were intended to empower and democratise India's rural representative bodies the Panchayats. The 73rd Amendment to the Constitution formally recognised a third tier of government at the sub-State level, thereby creating the legal conditions for local self-rule or Panchayati Raj. The 73rd and 74thAmendments are designed to promote self-governance through statutory recognition of local bodies which are expected to move away from their traditional role of simply executing the programs handed down to them by higher levels of government and to formulate and implement their own programs of economic development and social justice. The Eleventh Schedule of the 73rd Amendment identifies 29 areas over which Panchayats can legitimately have jurisdiction such as agriculture, minor irrigation, animal husbandry, fisheries, social forestry, small-scale industries, and implementation of land reforms.

Developmental planning with integrated approach has been accepted world over for optimal management and better utilization of natural resources towards improving living conditions of the people and to meet the growing demands of an increasing population. Timely inflow of appropriate information and its reliability is a pre-requisite for integrated developmental planning. Satellite remote sensing from vintage point in space, with a large synoptic coverage, timely, accurate and cost effective data provider, is an ideal tool for generating such spatial information base. The pragmatic action plans for land and water resources development are prepared with due consideration of conservation and development. Further, to meet the people's requirement and imbibe local wisdom in the action plans, integration of the information available at the parcel level (LIS) with spatial information base(GIS) on natural resources is a pre-requisite.

The proposed system acts as a planning and developmental tool addressing all the issues encountered during local level planning, implementation and subsequent monitoring of the impact of developmental activities. An ideal LIS should be (i) comprehensive enough to cater all the information requirements of the community with respect to the land resources; (ii) sound enough to be financially self sustaining with structured business model; (i) robust enough to accommodate newer technological developments; (iv) integrity of the data – format, completeness, latest, security, audit and history. The LIS is also supposed to address the issues related to disaster management and mitigation at grass root levels.

**Land information** refers to physical, legal, economic or environmental information or characteristics concerning land, water and sub-surface resources. The information has been used in a variety of systems over the years, from register of deed indexes to surveyors tie sheets or soil surveys. Today, many organizations are moving land information into Geographic Information Systems (GIS).

**Land Information System** (LIS) is similar to GIS but more focused on land records. GIS and LIS systems provide tools that support many types of record keeping, analysis and decision-making. Land information is an integral part of government, non-profit and private sector activities. The GIS/LIS techniques advance broader social purposes by helping to make more effective decisions for using natural resources in a more optimal way. The International Federation of Surveyors defines Land Information System as a tool for legal, administrative and economic decision-making and an aid for planning and development. A land information system consists, on the one hand, of a database containing spatially referenced land-related data for a defined area and, on the other, of procedures and techniques for the systematic collection, updating, processing and distribution of the data".

It is essential to analyse the status of existing village cadastral maps to understand the importance of integration of cadastral maps into LIS. The elements such as the archival, updation, retrieval, survey and settlement, scale, accuracy, definition of the parcel, projection, elevation, etc. are needed to be analysed for understanding the status and limitations of the existing cadastral system in India. In addition to the deficiencies of above parameters, the traditional cadastral systems fail to meet requirements connected with supervision, management, decision-making, forecasting and development planning. The most significant problems in the traditional cadastral systems are (a) low precision of geometric data quality and speed of data access, (b) divergence between the map and the register and (c) lack of supervisory tools. These shortcomings have led to the non improvement of the cadastre in many countries. A modern cadastral system can be referred to as a multitask cadastre with a possibility of linkage with other subsystems, leading to their integration within the frame of LIS/GIS.

## 2. Need for LIS

The importance of a Land information system cannot be overemphasized as the Land records provide the basis for

- Recognition of owner's title, boundaries, & usage
- Collection of all land and property based levies, like Property Tax, Vacant Land Tax, and Water Tax etc.
- Develop and maintain a Geodetic Control Network for referencing maps, maintain all records in integrated digital form in a central repository and make available the database for various govt. & non - govt. users
- Planning by Governmental agencies to provide Value-added Services in areas like development planning, welfare activities and implementation of livelihood sustenance programmes.

The main driving forces influencing development of LIS are: (i) Status of the natural resources, (ii) Sustainable development, (iii) Globalisation, (iv) Microeconomic reforms, (v) Technological reforms, (vi) Changes in planning process, (vii) Legislation for local level planning, (viii) Implementation of developmental plans and (ix) Monitoring mechanism. These drivers do not exist in isolation, but have mutual relation, individual and integrated impact. An understanding of all these forces is

essential to develop a framework to facilitate consideration of the substantive components of the popular rhetoric "holistic" approach.

## 3. LIS in Indian Context

The creation and maintenance of records/information relating to land related activities is a state subject in India and is generally under the control of more then one entity like:

I. **Survey and Land Records Department,** which conducts cadastral surveys and creates & maintains basic records for each revenue village
II. **The Revenue Department,** which manages Land Records by way of updation of titles as and when required
III. **The Registration Department,** which undertakes registration of deeds pertaining to transactions of land involving sale, purchase, gift etc.
IV. **The Urban and Rural Local Bodies,** which maintain ownership information necessary to collect taxes, and undertake planning and developmental activities within Panchayat and municipal towns.

### REQUIREMENTS FOR CREATION OF LIS

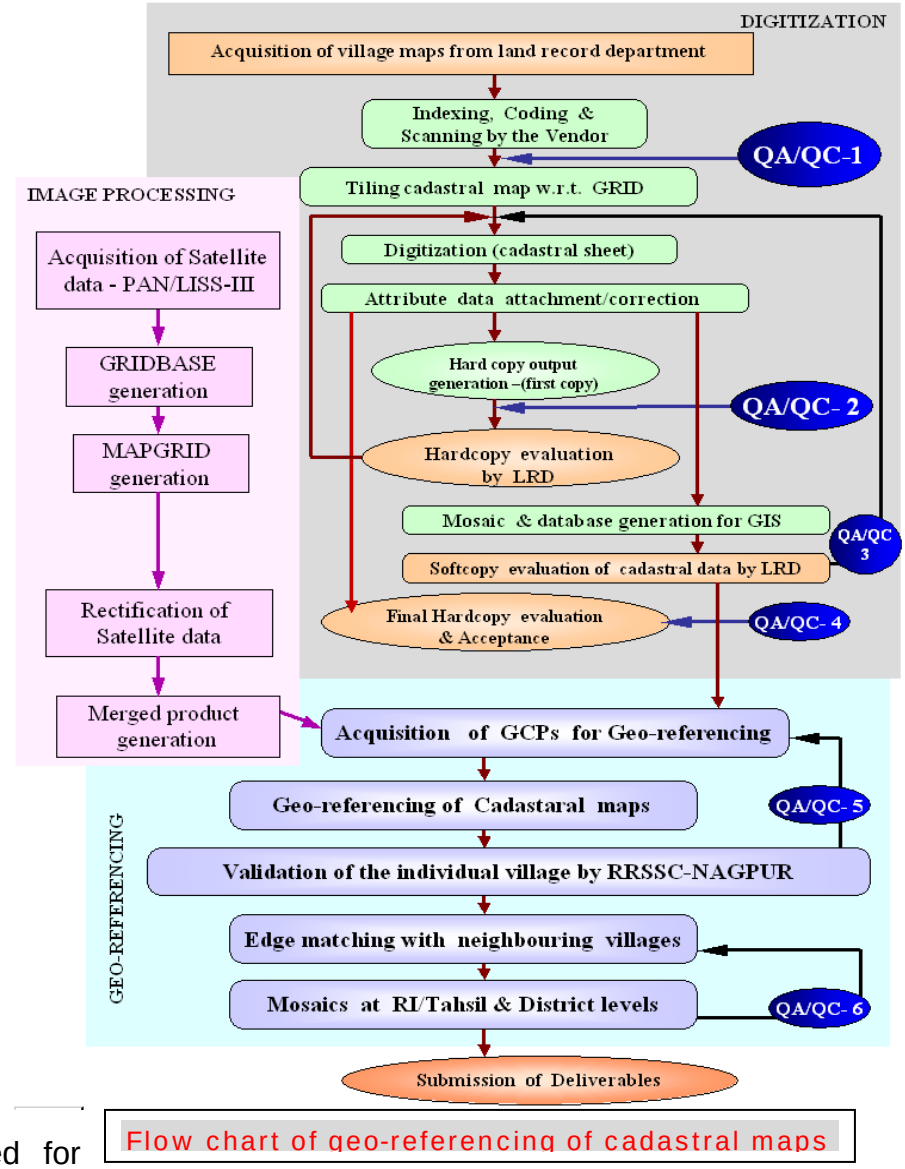
The LIS basically consists of village cadastral maps as the base layer over which various thematic maps are built upon. The thematic maps on natural resources generated using satellite images in GIS environment are linked to LIS. The basic requirements for creation of LIS are (i) Accurate, up-to-date and standardized village cadastral maps in digital environment; and (ii) Geodetic control framework for geo-referencing of high resolution satellite images and correspondingvillage cadastral maps.

### GEO-REFERENCING OF VILLAGE CADASTRAL MAPS AND LIS

The geo-referencing of village (cadastral) maps involves vectorisation of the analog cadastral maps, geo-referencing of these maps using high-resolution satellite data as the reference and generation of value added products. This involves identifying the procedures for generating the softcopy products and standardization of each product for unique identification of each cadastral map in the entire country and content (legend) codification so that each feature in the map is uniquely defined. The digital cadastral maps are carried forward for deriving geodetic coordinates for each parcel and in turn for each vertex of the cadastral map. This is achieved through geo-referencing the maps using real world coordinates of the ground control points (GCP's). The GCP's are derived from high-resolution satellite data. The accuracy of geo-referencing of the cadastral maps using ground coordinates from satellite data is analyzed. Finally, the spatial information generated using remote sensing & GIS techniques, and socio-economic data are integrated with geo-referenced cadastral maps. Village level planning will be attempted using spatial/non-spatial information. This has enriched the utility of cadastral maps in the present day context. The application potential of geo-referenced village cadastral maps has been demonstrated with relevant examples.

## METHODOLOGY OF GEOREFERENCING OF VILLAGE CADASTRAL MAPS

It consists of mainly three modules. The cadastral maps available in analog format at 1:4,000 or 16"=1 Mile scale are scanned using raster scanner at 200 DPI. To make the scanned map to orient perfectly north and remove all the rotations and internal distortions, the scanned map is rectified with a mathematical grid developed at the sheet level. The gridded map is used for heads-on-digitization of features. Topology is created for point, line and polygon features. The codes for each sheet and village files are standardized for unique identification in a given state. The features are codified based on the standards designed for the point, line and polygon features. To facilitate seamless mosaic of geo-referenced satellite data or cadastral maps at different hierarchy and to establish a one-to-one correspondence between different information systems such as GIS and LIS, a unique projection and coordinate system is necessary. The projection to be adopted for a given area depends upon location, size and shape. A coordinate system that induces lesser distortions in terms of angular, linear and area distortions is identified and adopted for spatial database generation.



Flow chart of geo-referencing of cadastral maps

The standard products of the IRS/Cartosat series of satellites like IRS 1C/1D PAN & LISS III or LISS IV, Cartosat 1/2 PAN sharpened multispectral images are used for

processing. From these standard products, precision products are generated using ground control points from reference map base or DGPS surveys. Merged products are generated using digital image processing techniques. An approach has been developed to geo-reference the cadastral maps using high-resolution satellite data, and thereby providing seamless mosaic of the village cadastral maps at the taluk level. Value addition to the geo-referenced village cadastral maps will be done by linking the spatial and non-spatial information at the village level.

The sequence of the steps involved are broadly categorised under three headings and explained briefly below.

**Vectorisation of village Maps**

This process consists of (i) Making available the village maps; (ii) Indexing, Coding & Scanning; (iii) Tiling map using GRID; (iv) Digitisation of village maps; (v) Attribute Data attachment; (vi) Hard copy output generation; (vii) Hard copy evaluation by land Records Department (LRD); GCPs from DGPS surveys (viii) Database Generation in GIS environment; (ix) Softcopy validation by LRD in GIS environment; (x) Final hard copy generation; and (xi) Final Hard copy validation.

**Satellite data preparation**

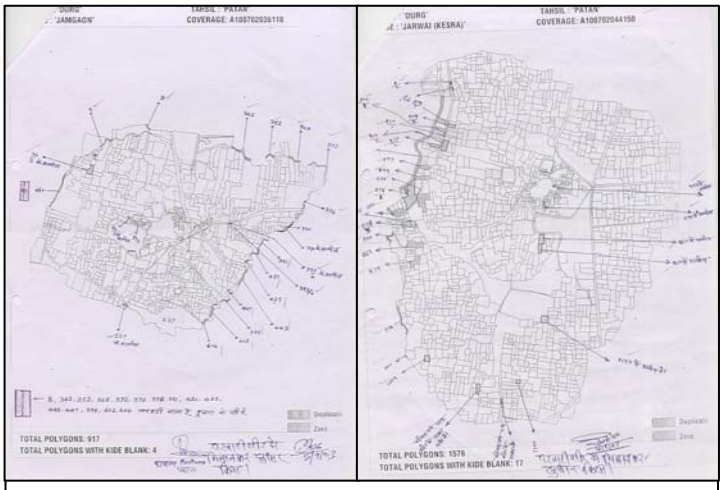
This process consist of (i) Acquisition of satellite data; (ii) GRIDBASE generation; (iii) MAPGRID generation; (iv) Geo-referencing of IRS LISS Images; (v) Registration of IRS PAN data; and (vi) Merged product generation.

**Geo-Referencing of village map**

Geo-referencing of village map consists of (i) Acquisition of Ground Control Point (GCP); (ii) Geo-referencing of Village map with high resolution Satellite data; (iii) Validation of geo-referenced output; (iv) Edge-Matching of neighboring village maps; and (vi) Mosaic generation at RI, Taluk & District Level.

**Quality Assurance**

Well-defined set of procedures is established for quality assurance of the database. The Quality Check procedures are both qualitative and quantitative. Indigenous Software packages/procedures have been developed by Indian Space Research Organisation (ISRO) for the quantitative methods and procedural documents are prepared for qualitative QC. All coverages or hard copy maps of the project generated by various agencies have to go through the quality check procedure before acceptance.



Quality checking of the digital cadastral maps - Quality assurance of the features abstracted from the sheets for type, location, attribute and checking **duplicate IDs and Null IDs**

## DELIVERABLES

The information from the cadastral maps is extracted and organized in GIS environment as polygon (16 features), line (14 features) and point (76 features) layers. The deliverables of the project consists of raster scanned files of cadastral maps, digitised files, village level raw coverages and geo-referenced coverages, mosaic coverages of village cadastral maps at taluk level and village boundary coverage up to district level and various intermediate files. Hardcopy outputs are also generated at the sheet level for the benefit of revenue department. Georeferenced Satellite images with village cadastral overlays are value added products.

## 4. Utilisation of geo-referenced village (cadastral) maps and LIS

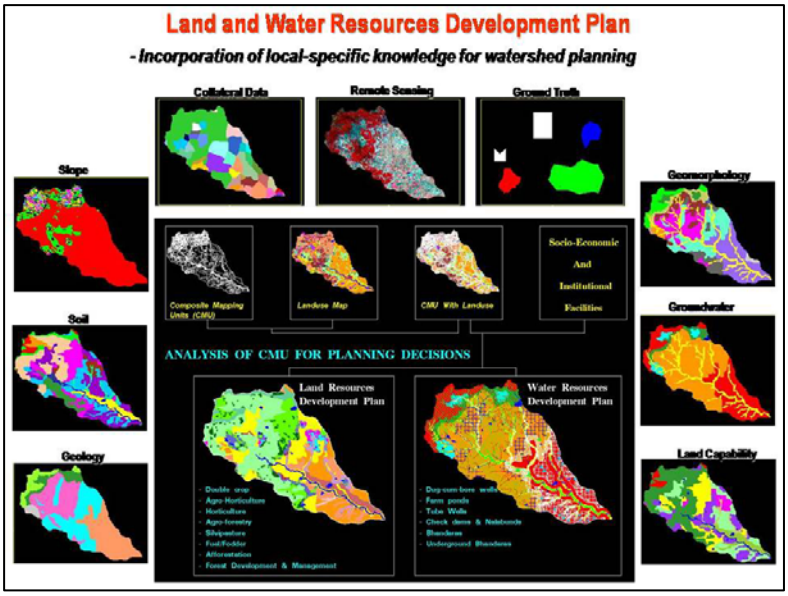
The LIS, generated from the geo-referenced village (cadastral) maps has large potential to address the issues related to the parcels at large scale using high resolution PAN sharpened multispectral satellite data. The dynamic information provided by the satellite images compatible with the cadastral maps has applications in crop identification, monitoring the impact of developmental activities at the parcel level, land value assessment using multiple themes and their potentials, and the content updation of cadastral maps such as new transportation network, drainage network, land treatment measures, surface water harvesting structures, etc., that can be derived directly from the high resolution satellite data. The parcel based thematic maps and action plans has give a breakthrough in reaching the people, understanding their requirements and modifying, wherever necessary and finalise the action plans for land and water resource development as per the local needs. It has also facilitated in monitoring the impact of plan implementation at watershed level and at the individual farmer level. Some of the applications of LIS are mentioned below

### Utilisation of geo-referenced Village Cadastral Maps and LIS in Micro-level Planning

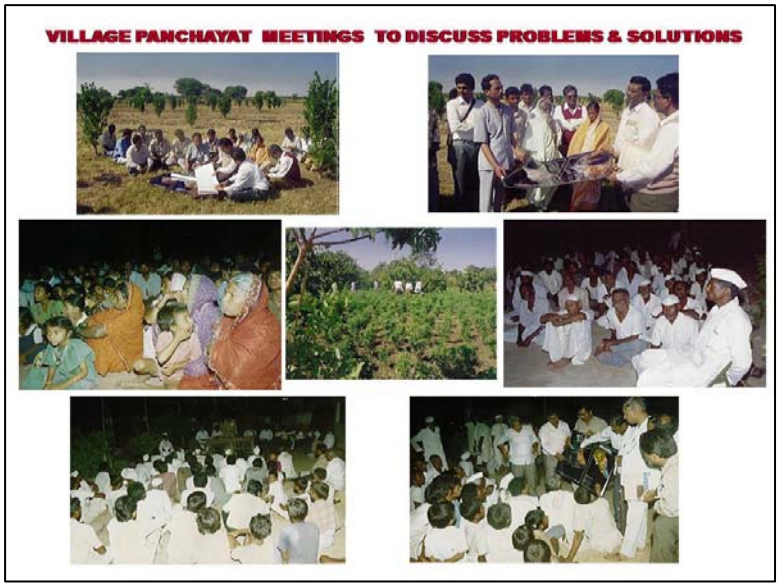
Integrated Mission for Sustainable Development (IMSD) project, initiated and funded Under by Department of Space (DOS), thematic maps of natural resources and action plans for land and water resources management at watershed level have been generated on 1:50,000 scale. For pinpointing the location for a specific activity, action plans on the cadastral scales (1:8,000 to 1:4,000) with survey numbers and landowner details (private, govt. etc.) are needed for an effective implementation. A simple methodology to transfer the action plans from 1:50,000 scale to the cadastral maps in the Uma-Gani nadi watershed of Chandrapur district, Maharastra, India with the participation of the farmers, NGO's and state machinery has been evolved. The action plans at the village level with the cadastral boundary overlay formed the base for project planning, implementation and subsequent monitoring of the impact in the watershed. This study has resulted in successful utilisation of cadastral maps, geo-referenced with high-resolution satellite images for micro-level planning.

**Implementation & Monitoring the Impact**

An awareness programme for all the stake-holders (Officers involved in plan preparation/ implementation and monitoring, Non-Government Organisation, Women organisations, gram sevaks and farmers) involved in the project, i.e. Uma-Gani nadi watershed in Chandrapur district of Maharashtra, has been carried out through village level meetings and the block level interactions. The watershed is being monitored using satellite data for change detection in terms of Land use/ Land cover and field studies to establish the increase in the yield of crops, status of ground water and reduction of run-off.



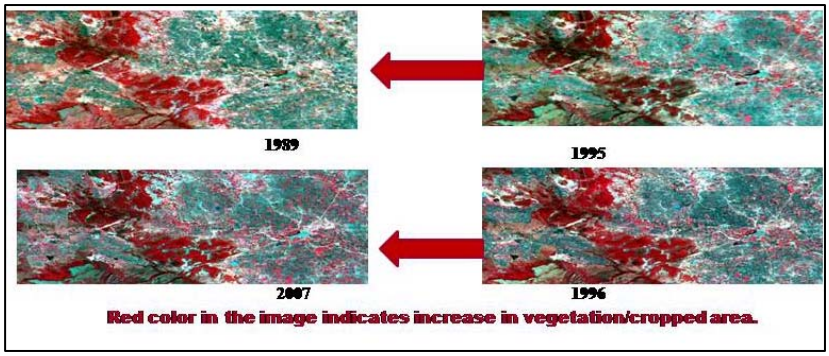

An amount of $ 0.2 Million has been spent for the implementation in selected villages covering an area of 15,000 ha on priority basis. The results are quite encouraging. It was observed that the run-off has substantially reduced, the ground water recharge is effective and water tables have raised.




The satellite data for the years 1989, 1996 and 1997 and 2007 are evaluated for changes in Land use/land cover and the impact. After five years of plan implementation, the cropping intensity has increased from 107% to 127%. The average yields of crops like rice, wheat, and cotton have increased from 1.6, 0.65 and 1 ton/ha to 2.4, 1.1 and 2.1 t/ha respectively. Area under horticulture has also increased by 1%.

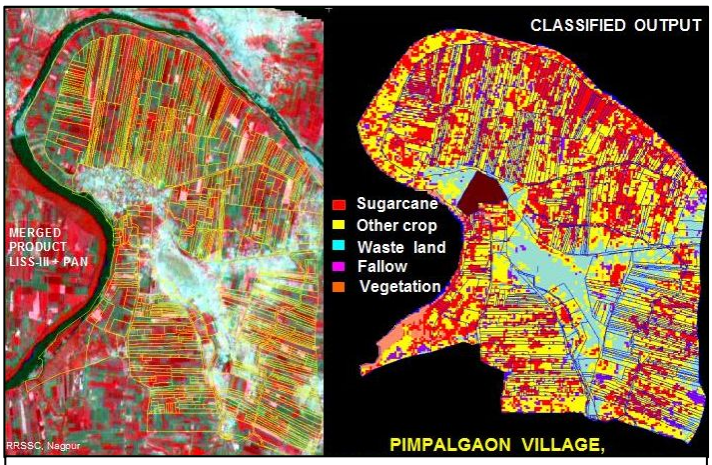
The ground water table level has increased attaining equilibrium condition and the problem of drinking water has been solved in the watershed using ground water conservation and recharge measures. Although the rain input in the year 1996-97 is around 60% of the average annual rainfall, the cropping intensity and yields have

increased significantly showing trends of sustainable development. The results also show on a sample basis, the farmer has achieved good economic returns to the tune of 10 folds in marginal lands (100$ to 1000$), 4 folds in moderately developed lands (300$ to 1200$) and more than 2 folds in developed lands (600$ to 1400$).




## Utilisation of Geo-Referenced Village Cadastral Maps and LIS for Revenue Collection

Revenue Targeting is an important application of LIS, which is helping the irrigation department in collecting proper levy from the farmers. Government organisations are investing huge financial resources for constructing dams and reservoirs and other developmental projects. If the money invested flows back to the government in the form of water cess and land cess. The resources are re-invested in the project maintenance and overall development of the commands in the country. The financial returns will also indicate the success of the project and help to analyse and incorporate due corrections in the project performance. The LIS has be successfully used for crop identification and revenue targeting in command areas.



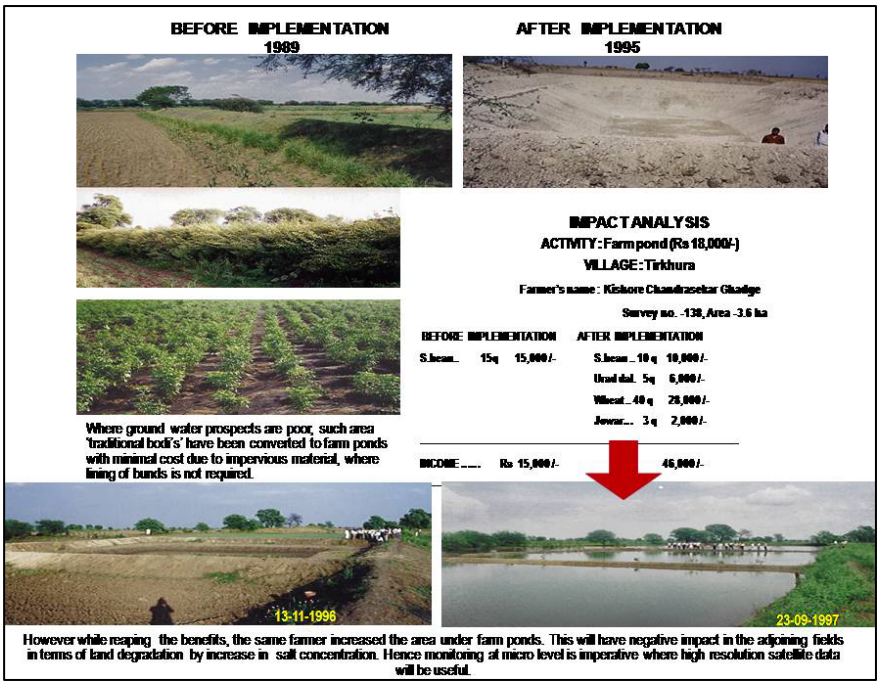

Cadastral level sugarcane cane crop identification in canal irrigated area. Government revenue collection increased by 3 fold due to water cess collection

The geo-referenced village cadastral maps integrated with the crop maps from satellite images has facilitated in identification of parcels where respective crops are grown. Village wise crop area statistics provide revenue target for the field officer to identify the farmers and to collect levy. The crop map in the LIS environment enables the irrigation supervisor to verify the information given by farmer and to assess the water levy. It helps farmers in crop planning at the parcel level and in judicious use of the water. The Maharashtra Krishna Valley Development Corporation (MKVDC) has successfully utilised geo-referenced village (cadastral) maps for sugarcane crop identification and revenue targeting in command areas. The Maharashtra Engineering Research Institute (MERI-Nasik) and Maharashtra Remote Sensing Application Centre (MRSAC-Nagpur)

are carrying out the project regularly, on operational mode, in the command areas of Krishna and Godavari river basins in Maharashtra. The initial investment by the govt. is $ 12 per Sq km for generating the base line information of georeferenced village cadastral overlayed with high resolution data and subsequent monitoring at $ 4 per Sq Km. with technological advancements in satellite imaging, the cost has further come down to $ 1.6 per Sq Km. the returns for the Govt. from water cess is $ 1800, 2400 and 7200 depending up on the type of irrigation Viz, well, lift or canal. The revenue collections of Govt have increased substantially by meager investments in creating a georeferenced village cadastral database and LIS. This model is very successful and sustainable.

**Impact assessment at parcel level using geo-referenced village cadastral maps and LIS**

Impact assessment is another important application of LIS enabling the personnel to monitor the impact for mid-course correction, if necessary, and to assess the cost-benefits of the measures, e.g. the monitoring of the salt affected and water logged areas. While reaping the benefits, the farmers increase the area under farm ponds to bring more area under irrigation. This will have an impact on the adjoining fields in the form of land degradation by increase in salt concentration and there by reduction in crop yields. The LIS periodically updated using satellite data helps in monitoring such landuse changes and provide timely advisories to the concerned farmers.




**Digital Village Boundaries**

The village boundaries that are available from LRD and revenue department are at the scale of larger than 1:50,000. These are generalized boundaries and are available at the taluk and district levels. One of the important outputs from the project is accurate village boundary in digital format. These village boundaries are aggregated to generate precise Halka, RI, taluk, district and state boundaries. These boundaries are generated at the scale of 1:4,000 (the scale of cadastral maps), and geo-referenced using high-resolution satellite data and hence these are very precise. These boundaries can be

used to update the existing administrative boundaries and generate new-boundaries in case of newly formed administrative units.

**Geo-referencing of Village (Cadastral Maps) – Maharashtra State**

The Maharashtra Govt. has completed the task of computerisation and geo-referencing of village maps covering 44,000 villages covered in more than one lakh map sheets in the state. The project is totally funded by Govt. of Maharashtra.The project is completed within 2 years with support from 7 entrepreneurs identified in this project. The Maharashtra govt. is utilizing these databases effectively in various projects such as sugarcane crop identification, cotton crop identification, identification of the damaged crops at the parcel level, land assessment, etc.

**Developmental planning in Chhattisgarh State – Chhattisgarh GIS Project**

In order to optimize and sustain outputs from primary systems to meet the growing demands of rising population, developmental planning with integrated approach has been accepted world over. This approach helps optimal management and better utilization of natural resources towards improving living condition of the people. The practical approach in planning directed at preservation, conservation, development and management of natural resources of the region for the benefit of people has to operate within the framework of physical and biological attributes, socio-economic conditions and institutional constraints . The physical and biological attributes comprise baseline data on geology, hydrology, soil, land use / land cover, climate, demography, flora and fauna. Socio-economic condition relates to information on basic needs of people, input-output relationship, marketing and transportation arrangement, developmental incentives and facilities, such as technologies, equipments, labor, material, energy/power etc. Institutional constraints relate to laws, regulations and ordinances; Governmental policies and priorities; political acceptability; accepted customs, beliefs and requirements of the people, and administrative support.

The newly formed State of Chhattisgarh, 28$^{th}$ state in India has laid emphasis on e-governence The database of Natural Resources, Socioeconomic, Infrastructure and other collateral information is prerequisite for project planning, implementation and impact assessment.

Focused and frequent interactions with Honorable Chief Minister, Chief Secretary, and the respective Ministers & Secretaries specifically from Panchayat, Rural development, Revenue and Chhattisgarh Infotech and Biotech Promotional Society (CHiPS), an autonomous organization under the Government of Chhattisgarh, has resulted in a mega project comprising *generation of natural resources database* for the State of Chhattisgarh on 1:50000 scale using IRS LISS-III data, *development of spatial database for road network* using IRS PAN data and *geo-referencing of village (cadastral) maps* using high resolution IRS PAN + LISS-III data. Having convinced the utility of such an information system under Chhattisgarh GIS project, Government of Chhattisgarh generated resources of around $ 4 millions funded from the Gram panchayats through the 'Basic plan', 'Jawahar Gram Samrudhi Yojana' and other resources of panchayat,

amounting to $ 200 per village (20308 villages), in two financial years. The focal point from the Govt. of Chhattisgarh is CHiPS and in collaboration with Regional Remote Sensing Service Centre, Nagpur, ISRO/DOS, has implemented the project within a time frame of 24 months.

This mammoth task has been planned and organized, by RRSSC, Nagpur with the participation of 12 entrepreneurs having a support technical staff of more than 300. Stringent quality check procedures have been adopted for the generation of digital databases; with periodic validation by the respective user departments. National Natural resource Management System ( NNRMS) standards and codification scheme has been adopted for the digital databases(GIS) for the seamless data retrieval across the State through district, tahsils and village, and further linking with the geo-referenced village (cadastral) maps (LIS).

Integration of natural resources information facilitates in identifying the potentials and limitations of different parcels of land and when matched against the demand, alternative suggestions are developed within the unrealized production potential for both the land and water resources.

The overlay of geo-referenced village (cadastral) maps on the satellite data is providing invaluable information for better planning of rural development programmes. Many examples have been demonstrated to the officials of the state government, NGOs and other related institutions on effective use of this technology for better management of rural resources. Some of the observations are drainages not shown in the existing maps and cadastral maps have been updated from high-resolution satellite data which are vital for soil conservation and water conservation.

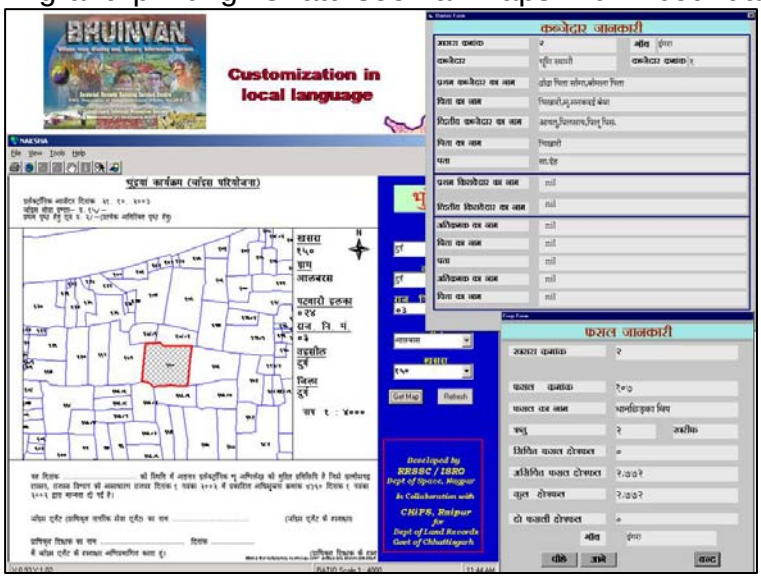
- Micro watershed boundaries could be delineated even in relatively flat areas.
- Mapping and monitoring of inherent soil moisture available along drainages in different kind of terrains.
- Identification and prioritization of silted small and medium water bodies and village tanks for de-silting purpose.
- Identification of eroded lands that need to be treated in the upstream of the water bodies.
- Locating suitable wastelands for energy plantation in the catchments of village tanks.
- Identification of survey numbers (farmers) that are affected by natural calamities for compensation.
- Identification of water-logged and salt-affected lands, survey number-wise for treatment and reclamation.
- Collection of water levy for the water being provided through various irrigation schemes to farmers growing cash-crops.

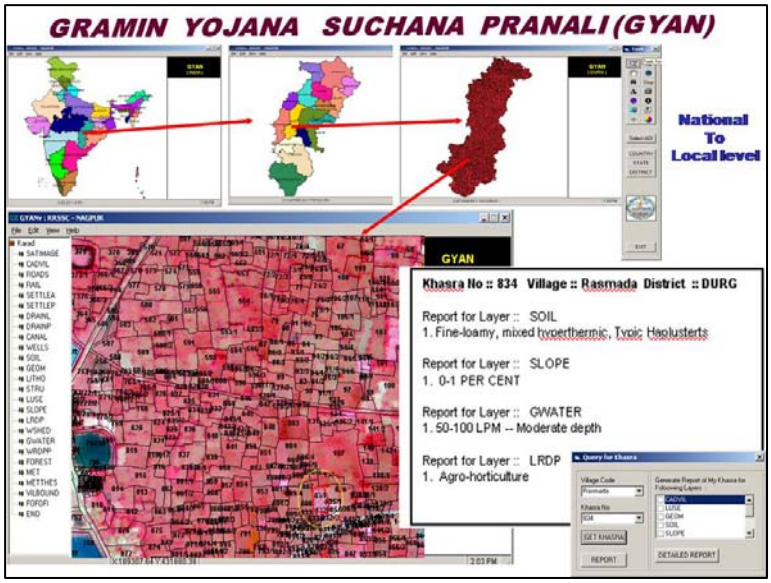
In general, satellite data has been used for mapping natural resources, and derive land and water resources development plan upto micro-watershed level for implementation through state government. To assist in implementation of such plans and identifying the

beneficiaries, the action plans have been transferred on cadastral maps. Since the watershed is a natural management unit, the villages falling within a watershed have been geo-referenced using high-resolution satellite data and mosaiced to identify the beneficiaries from ridge to valley. Implementation of the action plans in the field is a complex process as it involves the transfer of the technology from lab to land. In most of the cases the administrative head of Zilla Parishad is the nodal officer for plan implementation with active participation of officials from line departments, non-governmental organizations (NGOs), voluntary agencies, Self Help Groups and progressive farmers. The prescriptive measures in the developmental planning include area specific activities like check dams, nala bunds, continuous-contour-trenches (C.C.T.), social forestry etc. and locale specific activities like tube wells, farm ponds, paddy bunding, agro forestry etc. The funding for the plan implementation emphasizes the involvement of individual farmer and also should benefit certain strata of society i.e. landless population, below poverty line population, small and marginal farmers, target group population etc. Depending upon the socio-economic status of the farmer, the associated beneficiaries, and the nature of activity, the funding norms will vary. The ownership of land under study is a pre-requisite to identify the individual farmer; his socio-economic status and his willingness to participate in developmental programmes, which play a major role in successful implementation of the action plan in the field. The cadastral maps that have the parcel boundaries, which define the land ownership, do not have any geodetic coordinates. Hence it limits the direct access to the landowners, the databases on the potential of their land and developmental alternatives that are populated on geodetic coordinates. To meet such a requirement, a unique approach and methodology has been developed to geo-reference the cadastral maps with the high resolution satellite data providing seamless access to the databases and resultant action plans from regional level to local level. This has given a breakthrough in reaching the people, understanding their requirements and refining the action plans of land and water resource development involving the local wisdom. Further it has also facilitated the monitoring the impact of plan implementation at watershed level as well as the economic benefits accrued to individual farmers. This technique has facilitated in monitoring survey number-wise impact of the developmental activity in the watershed on temporal basis.

The database and GIS integration has been made with flexibility of map scale, abstraction levels and modeling capabilities for planning alternative impacts and forecasts. The customized GIS solutions for watershed characterization, watershed prioritization, runoff modeling, demand based irrigation scheduling, decision support system for water resources development plan and Land resources development plans have been achieved through software like SAMRUDDHI, NRIS-GEOLAWNS, GARDSS, GEOMORSIS, VARUN, etc.

Based on the user requirements certain indigenous GIS packages have been developed like NAKSHA for viewing and printing "Chaturseema" maps with boundary to farmers along with ownership and crop details needed for obtaining agricultural loan from Banks as a document of the individual farmer's property. This tool is available both in LINUX and WINDOWS environment and placed in different schools of the villages for obtaining such documents –"any where any time" in Durg District; GYAN (Gramin Yojana Suchana Pranali) for visual display and query of natural resources and socio-economic data to understand the potentials and limitations of the land parcels.



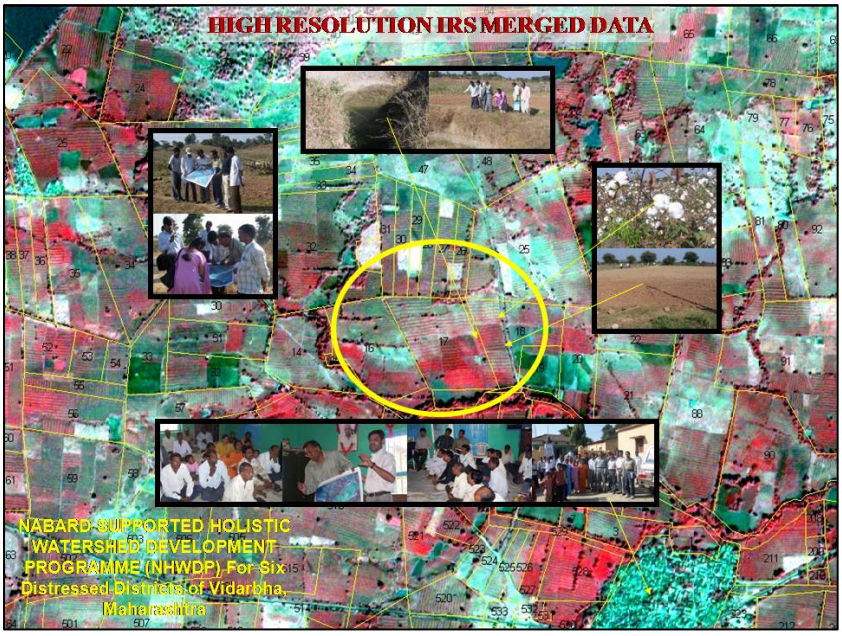

The advantages of the establishment of digital databases on natural resources have been optimally realized for the priority requirements of various departments of the state of Chhattisgarh and some of the major applications accomplished are:

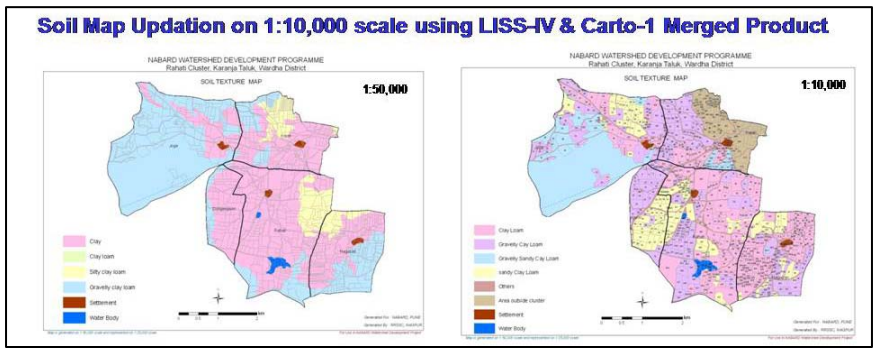
- Prioritization of watersheds and water resources development plan for priority watersheds, for the Department of Panchayat and Rural Development, Govt. of Chhattisgarh.
- Rural Road Connectivity to villages through the forest for 12th Finance Commission, Govt. of Chhattisgarh.
- Identification of suitable sites for horticulture, floriculture and vegetable crops.
- PURA (Providing Urban amenities in Rural Areas)
- Forestry Management Information System (FMIS), for Forest Department, Govt. of Chhattisgarh.
- Hydrology Project of Chhattisgarh State (Funded by World Bank), for Water Resources Department, Govt. of Chhattisgarh.

- Identification of suitable areas for siting industries in the state, for Chhattisgarh State Industrial Development Corporation (CSIDC)
- Optimal routing of High Power Transmission Lines, for Chhattisgarh State Electricity Board.
- Developmental planning of major towns of Chhattisgarh State, for Town and Country Planning, Raipur.
- Development Planning of new Raipur City, for Town and Country Planning, Raipur.

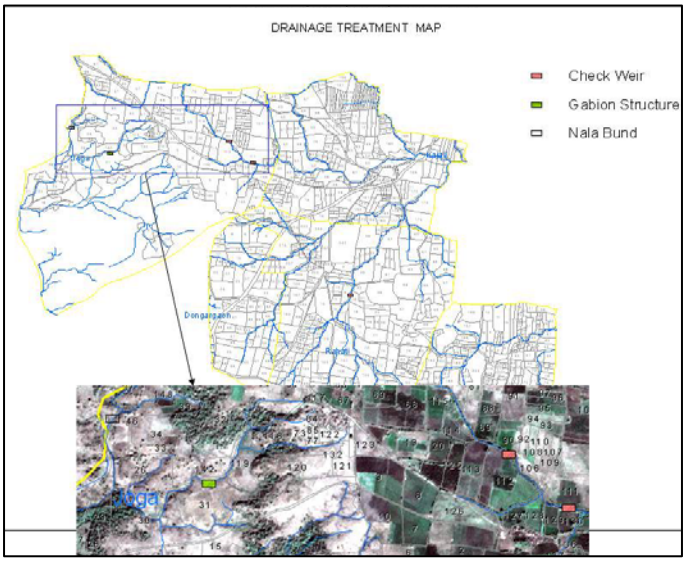
**Investment by Financial Institutions-National Agricultural Bank for Rural Development (NABARD)**

Holistic watershed development program is under taken by NABARD in 36village clusters covering about 90,000 ha of most drought affected agricultural belt under prime minister's package for rainfed region of Maharashtra state. The program envisages parcels/survey no. wise planning locally referred as Gat-level planning-Net level exercise. The main goal of the programmee is to enhance the capabilities of the Resource Support Organizations (RSOs), Project Implementing Agencies(PIAs) and Self Help Groups(SHGs) to use the LIS and geo-referenced village cadastral maps and corresponding natural resources information as GIS to prepare the action plans with the participation of the villagers. This could be successfully achieved through capacity building of the stake holders at various levels and investment by NABARD of less then one Dollar per hectare. The stake holders through participatory research could effectively prepare detailed maps on soil, ground water, land capability, slope etc,. To arrive at actionable maps on land & water resources development and soil conservation and drainage treatment.



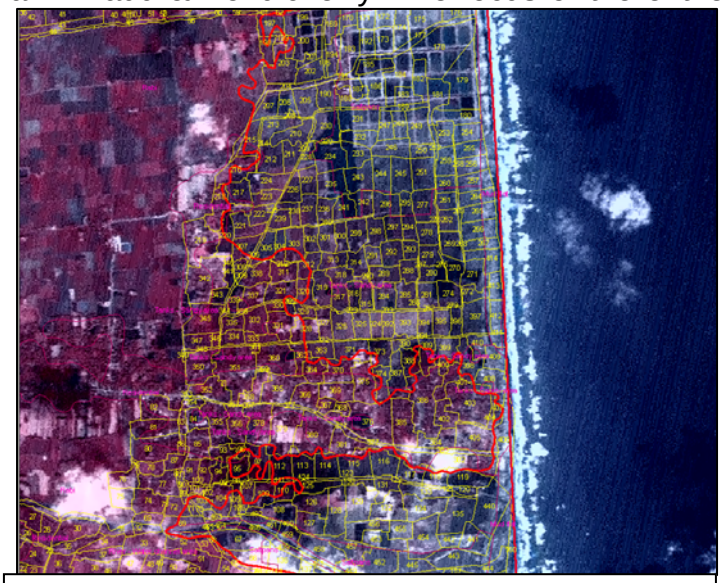



The plans are in the process of implementation through NGOs and concurrent monitoring to evaluate the impact of such programs of livelihood sustenance through LIS.




## Tsunami GIS for Relief & Rahabilitation

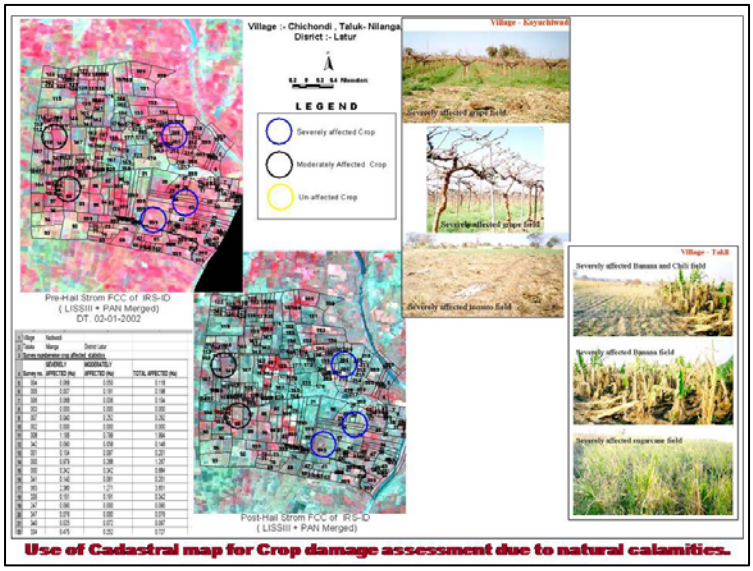
Satellite data of pre and post Tsunami were used in mapping at 1:12,500 scale covering major Tsunami affected districts of Tamil Nadu & Pondicherry. The focus of the entire work was to map the inundation and to establish a GIS on landuse/landcover, geomorphology, affected villages, transport and settlement etc. Vectorised cadastral map were integrated with the GIS layers for Nagapattinam coastal blocks to enable the State to make parcel-wise assessment of land use and geomorphology for every village. Digital database in GIS domain along with the corresponding Statistics related to inundation parcel-wise was made available to the Relief Commissioner's office through Officer on Special Duty (OSD) (Relief & Rehabilitation) for adopting necessary relief measures. The database was integrated with GIS / raster customization tools using a simple free-ware GIS package for interactive use.



West Coast of South India, part of Nagapattanam , Tamil nadu

## Crop damage assessment

High resolution data with cadastral over lay was used to asses the damage caused by the hail storms in the agricultural fields. The value added products were useful in parcel wise exact damage assessment at micro level and providing proper distribution of compensation & relief during the rehabilitation measures. The end beneficiary- land holder is identified through hierarchical database from district to cadastral and the linkage to National Informatic Centre(NIC) database in Latur district of Maharashtra.




## Cadastral Referenced Database (CRD) Project

Understanding the benefits and utility of the deliverables of geo-referencing of village (cadastral) maps and LIS, the Department of Space (DOS) has initiated a nationwide project, i.e., generation of digital Cadastral Referenced Database (CRD) project, as part of NNRMS program. The CRD project is executed with the support of State Remote Sensing Application Centres (SRSAC) and State Land Records Departments (LRD). While Maharashtra and Chhattisgarh have accomplished the establishment of such databases with their own resources, the State Remote Sensing Application Centres of Gujarat (BISAG) and Karnataka (KSRSAC) have taken up the works related to CRD with the support of Dept. of Space (DOS) and respective State Govt. The states of Kerala, Orissa, Andhra Pradesh, Rajasthan and Jharkhand have initiated on pilot mode. The deliverables of CRD project are basic inputs for providing natural resources advisories at Village Resource Centres (VRC). VRC program has been initiated by ISRO to provide single window advisory at grass root level using space technology applications like remote sensing, Tele-medicine and Tele-education. More then 600 such VRCs are functional across the rural India managed by reputed and lead NGOs in the respective regions.

## 5. Conclusions

The development of LIS through the geo-referenced village (cadastral) maps has facilitated number of applications in the areas of micro level planning and impact assessment. The system has evolved with time to improve the quality, set procedures for implementing the projects with out time over run and there by making it cost effective. The studies have also shown that the participation of industry and NGOs with Govt. agencies has enhanced the timeliness and out reach of the program. The value

addition of geo-referenced villages (cadastral) maps has been carried out using the indigenously developed software packages like GYAN, NAKSHA and GRAMINS for delivering interactive LIS products. Such databases are available for about 1 lakh villages covering 1/6$^{th}$ of the total villages of India. The georeferencing of village (cadastral) maps has been completed for the States of Maharashtra, Chhattisgarh and Gujarat and in progress for the States of Karnataka and Jharkhand. The States of Andhra Pradesh, Orissa, Tamil Nadu and Uttar Pradesh have already taken up pilot projects while the States of Assam and Bihar are in the process of preparing the project proposal.

The technological developments in space based remote sensing in India is providing timely high resolution data and DTMs from Cartosat series of satellites and in generating orthcorrected products for precise mapping and development of LIS. Multispectral data products from Resourcesat series of satellites are useful in cost effective periodic updation of databases required for LIS both for monitoring and modeling . Geo-referenced multi-spectral high resolution satellite data and the derived thematic information provide excellent database in understanding the carrying capacity of the natural resources and in suggesting alternative strategy for land and water resources developmental planning. Such high resolution data also enables georeferencing of village (cadastral) maps, which are useful in different developmental planning at micro-level. Additionally this facilitates participation of local stakeholders in site specific action plan preparation and in implementation of various beneficiary-oriented programmes.

The major applications of geo-referenced village (cadastral) maps and LIS by different states are in the areas of

- Micro-level planning and implementation of developmental activities with peoples participation
- Monitoring and evaluation of developmental program
- Reclamation and monitoring of sodic and saline soils and degraded lands
- Suitable sites for bio-fuel plantations
- Prioritization of village tanks for desiltation, restoration and improving groundwater recharge mechanism
- Identification of encroachments in forest land and mangroves
- Implementation of Holistic watershed program for livelihood sustenance
- Preparation of developmental plans for towns and cities
- Efficient implementation of National Rural Employment Guarantee Program (NREGP)
- National Resources Advisories for farmers at Village Resources Centres
- Crop acreage estimation for performance evaluation of irrigation commands
- Feasibility studies for implementing infrastructure projects like road, rail and pipeline alignments
- Rationalisation of wildlife habitat boundaries in National parks and Wildlife Sanctuaries
- Site suitability for locating new industries and townships

- Crop identification and water levy assessment
- Efficient settlement of compensation claim due to crop damage
- Identification of cotton growing farmers for effective procurement mechanism

The other application projects under active consideration by State Governments and a few of them have already been taken up on pilot mode, are:

- Ready Recknor for tax assessment
- Assessment of carbon credits
- Citizen services – in providing 'chaturseema' map with Record of Rights information for agriculture loans
- Identification of mine lease areas for environmental planning
- Preparation of soil health cards
- Crop Insurance
- Land acquisition and rehabilitation in infrastructure projects
- Smart Cards for farmers to facilitate e-governance and e-banking

## 7. Acknowledgements

The author gratefully acknowledges the World Bank, International Federation of Surveyors (FIG) for inviting for the conference and presenting this paper. The author is indepted to Dr. G. Madhavan Nair, Chairman ISRO, Secretary, DOS, Govt. of India who is the constant guiding sprit in carrying out these projects. Special thanks are due to colleagues from RRSSC fraternity and officials of State Governments and State Remote Sensing Centres for their contributions in the projects and the inputs.

## 8. Bibliography

- Dhal, N., Madame, R.S. and Krishna Murthy, Y.V.N. 1994. Cadastral Mapping and LIS. Proceedings, 14th INCA Congress, Bangalore.
- GOI. 1985. 73rd and 74th Amendment Acts. Govt. of India.
- Gopala Rao, M. 2000. LIS in India - Perspective and Retrospective. Proceedings, National Conference on Land Information System, New Delhi.
- Holstein, Lynn. 1990. The Cadastre as a Tool of Resource Management in Developing Countries. Proc., Sixth General Assembly & Technical Seminar. London.
- Kasturirangan, K. 1994. Sustainable development and role of Geomatics. Proceedings, GEOMATICS: VISION-2000, New Delhi, 1994.
- Krishna Murthy, Y.V.N. and Adiga S. 2000. Integrated Sustainable Development of Land and Water Resources Using Space Technology Inputs. SPACE FORUM, Special Issue on Indian Space Program, 2000.
- Krishna Murthy, Y.V.N., Srinivasa Rao, S., Srinivasan, D. S. and Adiga, S. 2000a. Land Information System (LIS) for rural development. Technical proceedings, Geomatics-2000.
- Krishna Murthy, Y.V.N., Srinivasa Rao, S., Srinivasan, D. S., and Radhakrishnan K. 1996a. Land Information Systems (LIS) for Rural Development. IX INCA conference, New Delhi.

- MOA. 2001. Watershed Development Guidelines – Revised 2001. Technical report, Ministry of Agriculture, Govt. of India.
- NRSA. 1995a. Integrated Mission for Sustainable Development – Technical Guideline. National Remote Sensing Agency, Department of Space, Hyderabad.
- NRSA. 2002. Integrated Mission for sustainable development- Path to Progress. Technical Report, National Remote Sensing Agency, Department of Space, Hyderabad.
- Pandit, D.S., Srinivasa Rao, S., Sinha, A.K. and Krishna Murthy, Y.V.N. 2000. Operational Methodology Development for Sugarcane Mapping Using Digital Image Processing and GIS. Technical Report, Regional Remote Sensing Service Centre, Nagpur.
- Rao, U.R. 1999. Space Remote Sensing for Sustainable Development of carrying capacity in developing countries. Space Forum, Vol.2, 345p.
- Srinivasa Rao, S., Krishna Murthy, Y.V.N., Adiga, S. and Ammineedu, E. 2003a. Performance Index for Watershed Development. The Journal of Indian Geophysical Union, Hyderabad, Vol.7, No.4 pp.239-247.
- Srinivasa Rao, S., Krishna Murthy, Y.V.N., Joshi, A.K., Das, S.N., Pandit, D.S., and Shantanu, B. 2003b. Computerisation and Geo-referencing of cadastral maps in Chhattisgarh State. Technical Document, Regional Remote Sensing Service Centre/ISRO, Nagpur.
- Srinivasa Rao, S. 2004. Application of high-resolution satellite data for development of Land Information System (LIS). Ph.D. thesis, Andhra University, Visakhapatnam.
- UN. 1992. Sustainable Development - Agenda 21. Website: www.un.org/esa/sustdev/agenda21chapter14.htm
- UNDP. 2000. Decentralisation in India – Challenges and Opportunities. Report, UNDP, New Delhi, India.
- Williamson, I.P., Ting, L. and Grant, D.M. 2000. The Evolving Role of Land Administration in Support of Sustainable Development - A review of the United Nations. The Australian Surveyor, Vol. 44, No.2, pp. 126-135.
- World bank report on India- land Policies for Growth and Poverty Reduction, 2007