Development and Dissemination of Remote Sensing and GIS Technologies at SAC

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Keywords: technology dissemination, technology development, remote sensing applications

Abstract

Over the last three decades, SAC has been engaged in the development and dissemination of remote sensing and GIS technologies for national development. These developments have originated from various initiatives related to national projects, sensor related research and in-house research and development on applications. A large multidisciplinary team of scientists develop technologies in various fields of applications like agriculture, coastal zone management, urban planning, forest and environment, etc. In addition, significant efforts are directed towards technology development for generic applications like photogrammetry and applications involving synergistic usage of remote sensing, GIS, GPS and satellite communication. Some specific examples of recent technological developments pertain to simulation modeling of crop yields, horticultural crop management, site selections for aquaculture, location of cold storage plants, large area crop production forecasting, base map creation, telegeoprocessing, mobile satellite services for fleet management, automated procedures for linear infrastructure planning, urban land use allocation planning.

An overview of these technologies and the modalities for their effective utilization by government, industries and users are summarized. Dissemination of these technologies for public bodies and private sector has been taken in the form of promotion of consultancy services in different application areas. Some major areas where these sectors have benefited through consultancies are estimation of cash and other field crops, city development planning, site selection for industry, land use change detection studies for environmental impact assessment, coastal regulation zone compliances and land use scenario, forestry related applications like catchment area treatment, forest fires monitoring, etc. Examples of consultancy services for private sector are included.

Overview

1. Introduction

Indian space programme is an application driven programme aiming at use of space technology for benefit of the society. Remote sensing, communications and meteorology are the main applications thrust areas of Department of Space (DOS). Over the last three decades DOS has developed a comprehensive end-to-end technological capability for space based remote sensing. Operational usage of remote sensing by user agencies has been addressed through nation-wide coordination under National Natural Resources Management System. Liberalization of economy, trend towards increasing need for spatial information in private and non-government sector, general awareness of technology through media and institutions have given impetus to the need for improved data and information services of remote sensing and GIS. Hence development and access to technology for commercialization has become a natural imperative. The basic philosophy is to catalyze, facilitate and promote remote sensing and GIS applications amongst the industry and academia for much larger outreach of space technology in the society. The route to facilitate this is through encouraging technology consultancy and technology transfer. While the former helps to propagate the technology to end users, the latter provides the industry with easy access to fruits of research.

An overview of recent developments in applications technologies and some highlights of technology consultancy and transfer activities are dealt with.

2. Technology Development Scenario

Remote sensing and GIS related applications were initiated by DOS through its main centers like SAC and National Remote Sensing Agency (NRSA) and later through Regional Remote Sensing Service Centres (RRSSCs.) Charged with the responsibility of developing, demonstrating and propagating the applications of

remote sensing and GIS, the Centres eventually developed many technologies for applications in different areas of natural resources management. SAC with its mandate of thrust on R&D, developed early methods of mapping, crop inventory, crop modeling, atmospheric and ocean parameter derivation, GIS and image processing softwares etc. The wider applications of these technologies were realized and implemented initially through joint projects with many state and central agencies and later through service and commercialization provisions with industry. Large central projects gave impetus to rapid growth of industry and consequent build up of capability in Indian industries for technological developments and improvisations. Revenue focus and resource crunch limits the capacity of industry to undertake sustained research in many areas. In this context role of DOS / ISRO centers is important – particularly in the areas related to natural resources. Dispensation of technology, due to its very nature, has been done through training programs organized by various DOS centers. Industry continues to have proprietary technologies in specialized markets like infrastructure, business geographics, generation of large databases for public administration etc.

World wide, the industries in west continue to show strong initiative in technology development due to reasons of size, reach, budgets and environment. Some of the prime space agencies like NASA have turned facilitators through a network of affiliated centers dealing with technology dispensing, transfer and consultancy. European Union like-wise devises imaginative programs for entrepreneurship and utilization of technology. A much greater coordination between industry, academia and government research is evident in the functioning of these models from west.

3. Applications Technologies from SAC

SAC has long experience in conducting research and operational national projects on remote sensing applications for various resources under sensor definition, evaluation & utilization, national projects, user requested applications and in-house R&D programs. A vast pool of application scientists have varied background and rich technical and managerial experience in image processing, GIS, visual interpretation, data integration, modeling, quality evaluation, field experimentation and software development. Infrastructure includes well-equipped laboratories for digital image analysis, GIS, visual interpretation, signature studies and map and data library. Countrywide network of collaborating organizations having teams trained by SAC, and record of successful project execution for the central and state resource ministries, private agencies / business imparts a sense of confidence to SAC. Its in-house availability of satellite communications group has given rise to new initiatives on convergence technologies which utilize communications, remote sensing, GIS and GPS as single products for users.

4. Recent Developments of Technologies

Some of the technologies developed recently or under active development and demonstration, and having significant commercial usage, are listed here by application area.

Marine and Water Resources

OCM based ocean parameter retrieval algorithms: The algorithms for chlorophyll and other parameter estimations have been developed and packaged in form of a stand alone software for easy usage. The software has been licensed to many collaborating agencies**.**

Gravity anomaly mapping using altimeter data for offshore oil exploration: ERS altimeter data is used to derive gravity anomaly maps. This is developed under joint ISRO-ONGC project. The gravity maps are provided by ONGC for exploration bids.

Runoff models for evaluation of potential of microhydel projects in hilly areas: This model takes inputs on snow cover derived from satellite data and predicts the runoff during different periods which vary with climate.

Coastal zone management models: An information system weaves all the data layers for decision making related to aquaculture site selection and various developmental and conservation activites.

Environmental impact assessment of industrial activities on coastal areas: A simple method of delineating the context of deveopment in relation to regulatory demarcations has been developed. The method also provides current environemtal settings of a specified buffer zone.

Agriculture and Horticulture

Precision farming: Attempts are underway to evolve a method for accurate mapping of farm productivity using remote sensing images and GPS observations. Experiments at two sites of university research farms have shown encouraging results whereby variability in condition – both within and between plots, could be mapped.

Hydrological modeling for agricultural damage assessment: Assessment and distribution of evapotranspiration vis-a-vis water availability is an indicator of possible crop production potential and damages emanating from water scarcity.

Horticultural crop inventory and post harvest management: Methodologies for estimation of area under different plantations located in major growing areas of country have been taken up. Operational estimation of area and mapping of distribution of the horticultural crops is initiated with concerned agencies in the states.

Site selection for cold storage: Selection of cold storage site for their optimum location based on proximity of cropped area, roads and villages has been demonstrated

for potato growing areas of Bardhman district in West Bengal.

Crop production forecasting on large scale: Development of stratified random sampling procedure for crop acreage estimation and RS/weather based yield models has been done for major crops of country. State as well as national forecasts for major crops are being generated under the projects taken up on behest of Ministry of Agriculture.

Wheat crop growth and yield simulation models (incl crop management responses): Advanced modelling techniques for accurate production forecasting have been taken up. A method for GIS based generalization of point information on weather variables has been developed for simulation of daily plant growth.

Regional crop estimation using multidate data (continuous crop assessment at 10-15 days interval): Multidate satellite data is used to generate multiple sequential assessment of acreage and forecast of crop yield under the project FASAL.

Retrieval of Biophysical parameters of crop from satellite data: Methodology for deriving LAI from satellite data has been developed.

Environment, Urban and Cartography

Photogrammetry: DEM from stereo pairs: Method for deriving DEM from stereo pairs using software developed by SAC and also from commercial softwares has been extensively investigated and applied in a number of problems involving cartography and glacier studies.

Base map preparation methodology using GPS surveys and IRS data: Procedure for generating base maps of an area independent of Survey of India toposheets has been developed using differential GPS receiver and satellite RS data.

Urban land use suitability and allocation analysis: The method based on eleven layers of information generates suitability indices using a system of ranks and weights. The technique has been applied to many cities for perspective planning. New development on land use allocation has also been applied to Indore city development planning.

Forest biomass estimation models: A series of models for plantation crops have been developed for estimation of biomass using remote sensing derived parameters.

Digital land use change detection analysis: This technique has been developed for estimating the amount and distribution of change between two land use maps of different years and has been used in situations involving EIA of industry projects.

Infrastructure

Pipeline route planning using network and path analysis : A combination of thematic layers based on a set of ranks and weights is used generate a cost surface over which the least cost route joining two terminal points is analysed. This is validated for a pipeline project and useful for all linear infrastructure like rail, road, transmission lines.

Convergence Technologies

MSS Fleet Management: Hardware and software for satellite communications based fleet management has been developed. The technology pertains to GPS receiver, MSS transmitter and receiver, GIS package and front end for display of vehicle position, internet access of vehicle position.

Field data collection unit: A hardware and software combination is being developed for field data collection using GIS, GPS and internet. This will be useful for near real time data dissemination for various applications.

6. Technology Consultancy and Transfer Activities

6.1 Consutlancy Projects: A small subset of technologies has been used for consultancy services to various organizations in public and private sectors. The notable ones are city development planning for Ahmedabad, Indore and PCMC, CRZ and HTL/LTL demarcations for industries and ports in coastal areas, land use change detection studies for mining, chemical industries and conservation and treatment plans for dam projects. So far, a little more than 50 consultancies, as given in the table herewith, have been completed for user organizations spanning private sector to NGO and public bodies.

6.2 Technology transfer through training: was undertaken for Ahmedabad based RS/GIS industries through a one-month training program. Thirteen participants from four local industries were trained in basics of RS/GIS through lectures and practicals. In addition each participants did a mini-project to apply the knowledge in practical setting. The participating industries were: PAM Consultants, Geotech Digital, Technocad, CompuSense, Silicon Electronics, Multimantek

6.3 Industry Association for Projects: In some cases of urban planning and EIA studies, industry was provided SAC support in terms of expertise. The beneficiaries include Dalal Consultants (Bhachau & Sangli town planning).

6.4 Foreign Projects: The idea of promoting Indian industries and expertise with industry in front has been implemented in one case where SAC is collaborating with a local industry for an assignment in Mauritius.

6.5 Events for training and promotion: Beginning with 1999, industry is given exposure to basic techniques of remote sensing and GIS with special emphasis on a theme under the title of Commercial Applications of Remote Sensing and GIS (CARG). CARG series has so far trained 160 persons and has helped in exposure to 400 persons from various user segments.

Table 1: RS/GIS Consultancy Projects conducted by SAC

No	Proj_heading_full	User_org
1	Tree clad area mapping for a part of Kheda region, Gujarat	Sardar Sarovar Narmada Nigam Ltd
2	Land use mapping for a part of area near Khatrej village of Ahmedabad	Arvind Mills Ltd
3	Identification of rainwater harvesting structures for Shetrujaye Hills area using RS data	Mahajanam, Mumbai
4	Glacier inventory and identification of glacial lakes in Dhavaliganga basin	National Hydroelectric Power Corporation, Faridabad
5	Base line mapping for Gir forested area	Gujarat Forest Dept, Junagadh
6	Mentha crop acreage estimation in parts of Uttar Pradesh and Punjab	Everest Flavours Ltd
7	Revised development plan of AUDA for 2011	Ahmedabad Urban Development Authority
8	Near real time forest fire monitoring in Gir protected area fro summer 1998	Gujarat Forest Department
9	Catchment area treatment plan for 17 subwatersheds of Sardar Sarovar Project catchment	Maharashtra Forest Dept
10	Environmental imapct assessment of river weir construction	Gujarat Electrcity Board
11	Compartment level mapping and updation of working plan using remot sensing and GIS	Gujarat Forest Department
12	Working plan inputs for 18 forest divisions of Gujarat	GEER Foundation, Gujarat Forest Department
13	Forest Encroachment study in Sanjay Gandhi National Park	Maharashtra Forest Dept
14	Forest Encroachment study in Sanjay Gandhi National Park & CAT plan for SSP catchment	Maharashtra Forest Dept
15	Development of Crop Estimation Package	ML Map Info
16	Stratification of vegetation in three protected areas of North Gujarat	SHRISHTI, IIM
17	Mentha acreage estimation for four districts of UP 1999	Everest Flavours Ltd
18	EIA for two chemical industries in Surat	Clean Environment Consultancy Services
19	Annual monitoring and current status of mangrove vegetation near Mahul creek, Mumbai 1990-2000	Bharat Petroleum Corporation Ltd
20	HTL and LTL maps for Gulf of Khambhat	Enron Oil and Gas ltd
21	HTL and LTL mapping for Vaitarna creek near Saphale, Mumbai	Mumbai Subarban Electricity Supply (BSES) Ltd
22	Preparation of CRZ maps for Hazira area Surat district	Shell India Pvt Ltd
23	Preparation of development plan for newly merged areas of PCMC using RS and GIS techniques	Pimpri Chinchwad Municipal Corporation
24	Land use change detection study for two mining lease areas in Raipur district, MP	Guarat Ambuja Cements Ltd
25	Industry training course	Ahmedabad RS/GIS Industries
26	Preparation of CRZ maps for Hazira area in Surat district	Guajrat State Petroleum Corporation Ltd
27	Georeferencing and color priniting of one scene	Vector Infosys Pvt Ltd
28	Quality check of hydrogeological maps (3 sheets)	Vector Infosys Pvt Ltd
29	Perspective plan for Indore region 2025 and development plan for Indore and environs 2011	Town Planning Dept
30	Land use and land cover for mining lease areas of Gujarat Ambuja Cements	Gujarat Ambuja Cements Ltd
31	Hosting of national level CAD program	Water and Power Consultancy Serivces (India) Ltd
32	GIS training	Foundation for Public Interest
33	Preparation of Draft Development Plan for Bhachau town	Dalal Consultants and Engineers Ltd
34	Preparation of Draft Development Plan for Sangli, Miraj and Kupwada Municipal Corporation	Dalal Consultants and Engineers Ltd
35	HTL mapping for Vaitarna creek near Saphale Thane district using RS data	Bombay Suburban Electricity Supply Co
36	HTL/LTL delineation	Bharat Petroleum Corporation
37	Preparation of HTL and LTL maps for parts of Gulf of Khambat area	Enron Oil and Gas India Ltd
38	Preparation of CRZ maps for Hazira area in Surat district	Gujarat State Petroleum Corporation Ltd
39	EIA and integrated development plan for catchment and command area of Sidhumber reservoir	Clean Environment Consultancy Services Ltd
40	CRZ maps for Surat	Surat Urban Development Authority
41	OCM DAS Software	Collaborating Agencies of IRS-P4
42	Authentication of CRZ maps for Hazira area in Surat	Cairns Energy India Ltd
43	CRZ maps for Hazira area in Surat district	Cairns Energy India Ltd
44	Preparation of CRZ maps for Hazira area in Surat district	Gujarat State Petroleum Corporation
45	Authentication of CRZ maps for Hazira area in Surat district	Shell India Pvt Ltd
46	Coordinates of stations	Bharat Sanchar Nigam Ltd
47	Authentication of CRZ maps for Sikka area in Jamnagar district	Gujarat Electricity Board
48	Authentication of CRZ maps for Kandla area in Bhuj district	Kandla Port Trust
49	Land use / land cover study for GACL mining lease area in Chandrapur, Maharashtra	Guarat Ambuja Cements Ltd
50	Land use mapping for Atul	Atul Ltd
51	HTL/LTL for GACL	Guarat Ambuja Cements Ltd
52	CRZ maps for Hazira	Shell India
53	CRZ maps of Jamnagar	Essar Oil ltd
54	Mapping of Alibaug	Samrat Shipping
55	CRZ mapping for Porbandar	GMDC
56	Verification of CRZ maps for Maharashtra	Maharashtra Khar Land Development Circle, Thane

Table 2: CARG Series participation

Year	Venue	Theme	Tutorial participants	Workshop participants
1999	Ahmedabad	General	45	170
2000	Ahmedabad	Coastal Zone	33	150
2001	Mumbai	Urban Planning	35	135
2002	Goa	EIA	55	160

However given the range of technologies developed at SAC, the uptake in industry is below margin. The reasons come from factors of market demand, industry capacity, high-perceived cost and lack of awareness.

7. Plan for Technology Transfer and Consultancy

The future plan is dictated by the recognition that Indian RS/GIS industry has grown horizontally in terms of number of players and vertically in terms of capability and capacity. The latter set is endowed with significant ability to carry out customization and limited R&D. However sustained R&D particularly in natural resources is not available with industry. Synergistic collaboration of R&D organizations and industry is the prime focus of SAC in planning its transfer activities.

It is thus proposed to give wider publicity to available technologies – mostly emerging ones and to involve industry at primary stages of commercialization. This could mean packaging the knowledge and expertise and jointly carrying out user projects for validation. It is also mooted to involve industry and users for new technologies or new areas of endeavors on low risk basis.

8. Conclusions

A wide array of technologies in the field of natural resources management and infrastructure has been developed at SAC. A large pool of scientists and a stream of projects of national importance keep on adding to this list. A method for linking this technology to market is required. Involvement of industry so far needs to be improved by wider publicity and low risk associations.