CHAPTER 10

Satellite-Image-Based Water and Land Development Plan

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ABSTRACT

Water and land planning and management have always been areas of concern as these are prime natural resources, basic human needs and precious national assets. In the present unstable climatic conditions, heavy rainfall and draught affect vast areas of the country, transcending state boundaries. In this situation, water management has been a Herculean task. As the country has entered the twenty-first century, it has become one of the most crucial elements in development planning to develop, conserve, utilise and manage these precious national resources in a sustainable manner.

Every year, central and state governments have started programmes like Drought Prone Area Programmes (DPAP), Waste Land Development Programmes and *Gramin Rojgar Yojna* for construction of various water-recharging structures to overcome problems like unemployment, migration and water scarcity. These programmes involve various surveys for identifying enough and appropriate sites for the construction of various water-recharging structures. Generally, these surveys are based on conventional methods of surveying. The usage of geo-informatics has immense potential for such works as it provides accurate information and greatly reduces the overall cost and time of the project.

This research paper discusses geo-informatics-based water and land information system for the state of Gujarat.

Introduction

Land and water are essential for the existence of life on earth. For the sustainable development and management of these natural resources, a data base with an efficient information system is a prime requisite for resource planning. A standardised information system with user interactive display was developed to provide micro-watershed-wise and village-wise land and water resource action plans on the satellite image of a desired area of interest with just one click. The system has contributed significantly to help the common people of the state, for the decision makers of the Rural Development Department and for educating the youth about the Indian remote sensing satellites.

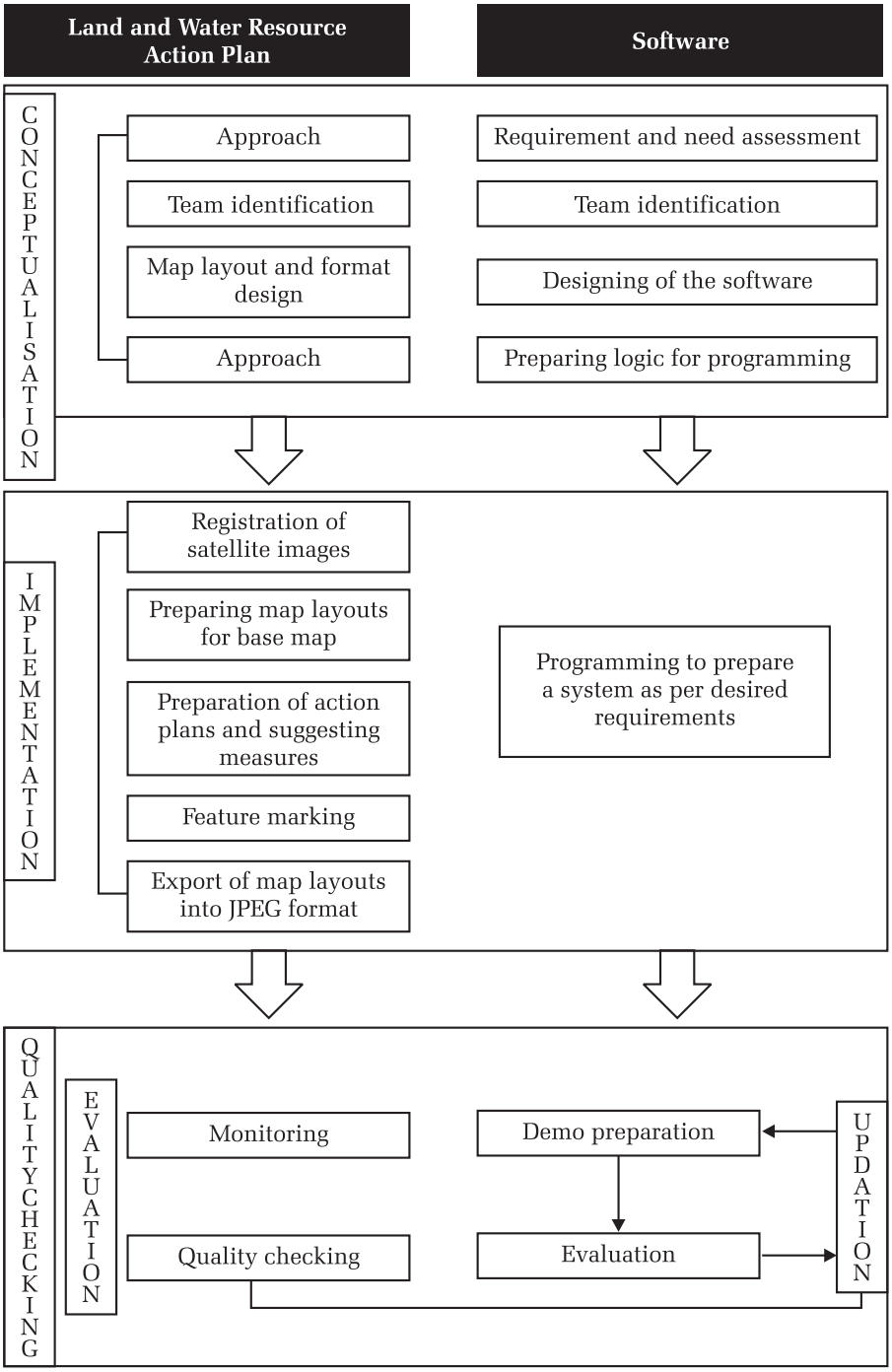
Objectives

- To propose and suggest measures for water and land conservation that are implementable at the village level
- To provide information on micro-watershed boundaries at the village level to local-level officials
- To prepare an interactive system for use by the general public in an easy-to-use and understandable format
- To provide necessary support through interactive training and capacity building to the officials concerned with rural development
- To accomplish the work in such a way so that it also addresses the issues of district rural development authorities concerning the *Rojgar Yojna*

Project Components

- Identification and geo-referencing of satellite data sets
- Preparation of base maps at 1:50,000 scale for each of the 18,500 villages of Gujarat state, comprising information on settlement, roads, rivers, water bodies, etc.
- Feature marking on the satellite image (of various elements like road, settlements, fields, railways, wastelands, etc.) for 18,500 villages of Gujarat state
- Identification of existing water-harvesting structures for all the villages of Gujarat state by using multi-temporal satellite imagery
- Proposing water resource conservation actions
- Proposing land resource conservation measures
- Team identification and methodology for quality checks and standardisation of information
- Conceptualisation and designing of a map layout so that a common man can also interpret it
- Village-wise automatic map layout preparation software
- Exporting all the maps into JPEG format
- Designing and preparing of software that combines all the information in different formats, and displays it with a demonstrative display menu in the local language, and also allows retrieval of information at both *taluka* and village level
- Preparation of support systems for the software with due consideration to its independent operability after its deployment at various places
- Accomplishing a task of huge magnitude, i.e., of writing and inspecting each CD for various *talukas* of Gujarat state
- Replication of the *taluka*-wise CDs for all pantheists of Gujarat state
- Dispatching of *panchayat*-wise CDs
- Capacity building/training the officials

Methodology



Identification and Geo-Referencing of Satellite Data Sets

Multi-temporal satellite imagery was used for the exercise. To map the existing check dams, post-monsoon LISS-III satellite data of October 2005 was identified. For proposing the water resource action plan and land resource action plan, base map preparation and feature marking was marked on January 2004 LISS-IV data of 5 m resolution. A team of scientists and supporting staff worked for geo-referencing of the required data sets. The geo-referencing of an image is done in the following way. Two images are required to register an image.

Base Image

The base image is geo-referenced using GPS. The latitude and longitude of major objects were determined for entire Gujarat using GPS. These points are considered as ground control points (GCPs). The GCPs are marked on the image manually, and the image transformed by comparing and adjusting these points to the GPS point values. This image thus became geo-referenced. It contains geographical reference of the entire image.

Warp Image

Warp image is generally raw data that has no geographical reference. To apply geographical reference to the warp image, we use the base image (geo-referenced image) in one window and the warp image is opened in another window. Major points like road/rail intersection, field boundary corners, etc., are pointed out on both the images. Warp image is transformed on to the base image using these GCPs. This image is superimposed on the base image or other geo-referenced images.

Preparation of Base Maps

Base maps were prepared at 1:50,000 scale for each of the 18,500 villages of Gujarat state, comprising information on location of settlement, roads, rivers and water bodies (Fig. 1). Attributes like names of the rivers, settlements and type of road were also incorporated in the data sets. Using the geo-referenced image, the base layer was prepared with visual interpretation. Details like major roads, rail, major rivers, large water bodies and important settlements were mapped from satellite imagery. The settlement names, specifications of roads, name of the rivers were taken from collateral data. Collateral data in the form of maps, charts, census records, reports and topographical maps on a scale of 1:50,000 were used.

Feature Marking on the Satellite Image

Realising that giving a key to the image would not solve the issue of easy interpretation of the satellite image by a layman, actually marking prominent features like roads, *gamtal* areas, wasteland areas, railway lines, water bodies and agriculture fields was considered. This was done for 18,500 villages of Gujarat in Gujarati language.

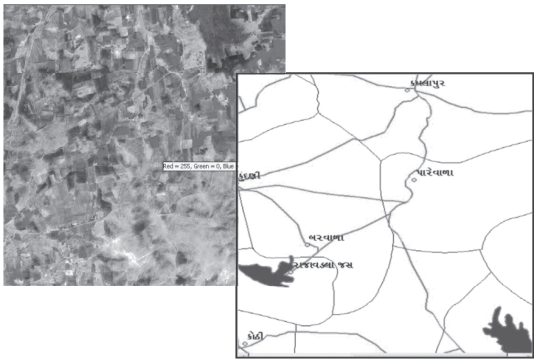


Fig. 1 *Base map preparation from satellite imagery*

Water Resource and Land Resource Action Plans

The aim of preparing these plans was to identify the various tasks that can be carried out under the *Gramin Rojgar Yojna* and other rural development programs implemented by the state and central governments for the development of rural areas in Gujarat state. GIS and remote sensing technology are used to prepare these plans. Information technology is used to distribute these at village level, and satellite communication technology is used for providing training to the *taluka*-level official and the common man at the village level.

Possible land and water conservation measures are suggested for each village. Possible actions are suggested taking into consideration the local status of natural resources and technical guidelines. Check dams, *nala* plugs, *bori bandhs* and construction of ponds are the actions suggested under the water conservation measures, and for land resource management, areas are identified that require plantation with water conservation measures, land conservation and need-drip irrigation measures. To achieve these, the following criteria are adopted for suggestion of measures.

Bori Bandh

Bori bandh is a type of embankment constructed from *'bori'* using available local material for blocking active and erosion-prone first-order drains.

Objectives

- To encourage vegetation for stabilisation of gullies and to reduce silt load transportation downstream.
- To increase ground water recharge.

Specific Site Condition

- Upstream of check dam/reservoir.
- Across first- and second-order streams and on slope up to 2%.
- *Bori bandhs* are used in places where foundation conditions are weak, to provide masonry or loose rock structures. They are constructed across small and medium or first- or second-order drains, particularly in places where the flow rate of runoff is low.

Nala Plug

Nala (a natural water course) plugs are structures constructed across drains for checking velocity of runoff, increasing water percolation and improving soil moisture in rock regime. They are constructed from the rock available locally.

Objectives

- To facilitate an improved runoff from catchments, encourage percolation of stored water for recharge of the ground water and increase the ground water level in the zone of infusions
- *In situ* harnessing of rain water in order to check the velocity of runoff, to hold silt flows which would reach the multi-purpose reservoir and reduce their capacity
- To improve the soil moisture regime

Specific Site Conditions

- Upstream of check dam/reservoir
- Across *nalas* on first- and second-order streams and on slope up to 5%
- Area needs soil and water moisture conservation measures
- Availability of construction material in nearby area

Check Dams

A check dam is essentially a masonry or earthen-overflow-type barrier constructed across a stream having a good base flow after rainstorms.

Objectives

- To recharge the ground water aquifer

- To provide for small supplemental irrigation needs
- To store the runoff water

Specific Site Conditions

- Downstream of catchments where sufficient water is available
- Good embankment height is available and supports the dam foundation.
- To minimise the construction cost, a narrow stream width is preferred.

Plantation with Water Conservation Measures

Objectives

- To use the available wasteland optimally
- To increase the production of fodder and firewood for domestic purpose
- To control further land degradation

Specific Site Conditions

- Wasteland, which are not under any particular use, but can be brought under use by minimum effort
- Where sufficient land is available

Land Conservation Measures and Drip Irrigation Method

Both these measures are suggested for areas under cultivation. Land conservation is suggested in single-area cropland, where the possibility of land erosion is identified using satellite images. Drip irrigation is suggested in areas under excess irrigation that has chances of water logging. Satellite images of *Rabi* season are used for the identified irrigation area.

Software for Water Resource Action Plan at Village Level

Introduction

Communicating the action plans at the local level was a very important and tricky issue. For this, a system was required that could display and communicate the information in a simple straightforward way, and that too in the local language, so that the common man can understand it. A flexible and easy-to-use system was required, which could run on a computer without any complicated requirements.

Software was developed to display the plan in the Gujarati language, so that the common man in Gujarat can understand it. The software could be

used to view, display, retrieve and print the resource management plans at the village level. It displays the information at both *taluka* and village level.

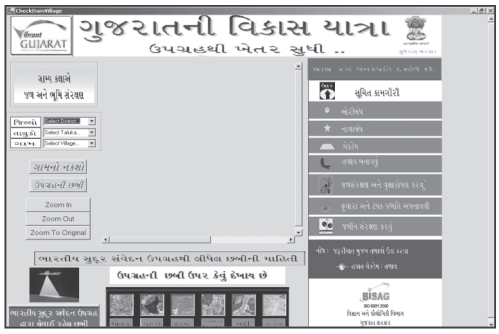


Fig. 2 *Menu and tool bars of the software*

Operation of the Software

- The software was developed to show the water and land resource management actions at the village level.
- Once the software is opened, the screen shows three buttons on the left (Fig. 2). The first one is for district selection. A selection box is provided along with it to choose from the options. After selecting the district, the user has to select the *taluka* from the selection box. The selection box will show *talukas* falling in that particular district. The selection box of the village will show all the villages of the selected *taluka*. The user can choose a particular village from the selection box.

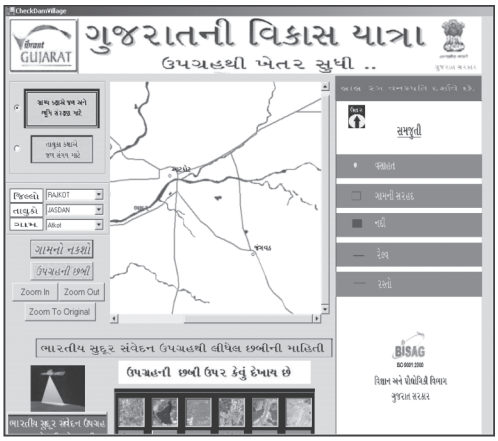


Fig. 3 *Base map of the selected village*

- After the selection of the village is done, two options are provided to see the village base map and the satellite image of the village selected.
- On clicking the option ગામનો નકશો , a base map of the selected village opens up (Fig. 3), showing the settlement, village boundary, rivers, railway and roads for the selected village. An explanation and the legend are also provided on the right side of the screen.
- The second option, ઉપગ્રહની છબી , provides the land- and water-related actions on the satellite image at village level (Fig. 4). On clicking the option, the user gets to see the probable locations of *bori bunds*, *nala*-plugs, check dams, places where ponds can be constructed, places for tree plantation, water conservation and land conservation. The existing water-harvesting structures are also shown on the image. The legend on the right of the screen explains the whole symbology.
- Tools like 'Zoom in', 'Zoom out' and 'Zoom to original' are also provided.
- On the bottom left of the screen, a picture of an Indian remote sensing satellite and the earth is shown. On the clicking the button below, a flash movie appears, showing how a satellite takes pictures of the earth as it follows a certain path.

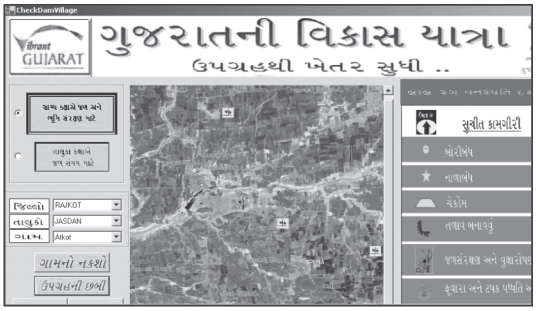


Fig. 4 *Water and land conservation measures with necessary legend*

- At the bottom, few photos are shown with legends like *Field*, *Water*, *Plantation*, *Settlement*, *River* and *Wasteland*. On clicking each of them, a satellite image will be opened on the screen at the centre of the displayed window, showing each feature as it appears in the image.

Characteristics of the Project

Capacity Building/Training

Training programmes were organised in the GUJSAT studio at BISAG, which facilitates one-way live video and two-way audio telecommunications. The programme was telecast at various places, where several *taluka* district

officers, representatives from leading NGOs, *sarpanchs, talatis,* village-level watershed self-help groups and other villagers were present.

Significance to the Common People of the State

Availability of the software at the local level will provide an opportunity to the people at grass-root levels to have a say and give opinions in the process for their development. The approach is very similar to the idea of e-governance. This is a concept in which the government is not only electronically controlled through the use of computers and newer technologies, but people at grass-root levels are more aware and conscious of the facts and issues concerning their development.

An Asset for the Decision Makers of Rural Development

It will be very helpful in the decision making process for the officials working at state as well as local levels. It provides information on the existing check dams on a spatial basis; thus, it forms an important tool for spatial comparisons. Using the images, decision makers can evaluate the existing condition and water status of the area. It also provides several sites for the construction of water-harvesting structures.

Extension Education for Trainers and Trainees

The application prepared can also be used as a teaching medium for imparting knowledge regarding water resources and their conservation measures. It is an excellent example of information technology used at the grassroot level.

Efficiency

This is an in-house efficient software application, which not only substituted the process of printing more that 1,80,000 maps, but also solved the purpose of distribution and capacity building to educate people.

User Convenience

The developed system displays information in the Gujarati language for the convenience of the rural populace. The user manual is also provided in the Gujarati language for the convenience of the people. A programme telecast through GUJSAT was specially prepared for providing the necessary capacity building to the rural populace, to familiarise them with the use of software and provide them with expert advice on the topic of water conservation and related subjects.

Citizen Centric

- Common people of the state specially designed the application, taking into consideration the usage.
- Considering the hierarchical structure of the administration, people are hardly involved in the process of decision making, because of which they are not fully aware of their own conditions. The application discussed here will give an opportunity to them to view and get acquainted with the natural resources of their own area.

Conclusion

In future, we can improve and expand further the scope of the existing system through addition of information like that of road infrastructure, its type, width, etc. Such an application will provide necessary insight and support to those involved in providing accessibility through road connectivities. Similarly, by updating the data sets at the cadastral level, we can also add and provide land conservation measures at farm level, site for inland fisheries, etc.

The world is getting closer through the use of the Internet, which is known to be a great means of communication. In future, such an application can be developed to formulate it as a web-based application. This would greatly reduce the overall costs involved in the project, since map printings and hard copies of such applications at a large scale are very costly and difficult to manage.