TARUN BHARAT SANGH

TECHNICAL REPORT
FOR
A CUSTOMISED GIS APPLICATION SOFTWARE FOR ARVARI WATERSHED

SUBMITTED BY

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Technical Report for A Customised GIS Application Software For Arvari Watershed

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Abstract

The Arvari Watershed – An Integrated Management Information System portrays the effort of the Sweden International Development Cooperation Agency (SIDA) to take the applications of space technology to the grass-root level. The initiative was the preparation of application software with user interactive display system providing land and water resource action plans along with other information of desired area of interest with slice and dice data and generate reports and maps at finger tips. The paper describes the basic objectives, methodology, the salient features of the software and how the sustainability of the project was ensured. It also briefly describes the various functions of the software. The customized GIS software is a modest attempt to take IT to the rural development.

1.0 Overview

Arvari Watershed Management Information System is an analytical tool designed to assist Arvari project team professionals with displaying Watershed information, analyzing Watershed events, predicting outcomes, and planning strategies.

The primary purpose to develop this Application is to contribute to improving the knowledge of the **Tarun Bharat Sangh (TBS)** team regarding socio economic and resource details of the people living in Arvari region for development, enhancing techniques to save natural sources, increasing the standards of living, and maximizing resources.

A Customization GIS Application in financed small river basin to help TBS and it partners prepare, present, and interpret facts that pertain to water resource development. The design should enable TBS to capture, store, display, and update, manipulate and analyze local data in order to help TBS attempt to find solution to complex integrated water resource management problems.

2.0 Watershed Area:

The Arvari watershed occupies between Alwar and Jaipur bounded by Thanagazi on north, Rajgarh in east, Jamwa Ramgarh in south and west and Virat Nagar in North-West direction. Geographically the Arvari watershed is bounded by longitudes 76° 04' 44.78" E and 76° 17' 36.11" E and latitudes 27° 21' 13.94" N and 27° 00' 46.69" N. The total area of the watershed is 488 sq.km with perimeter as 116.5 km.

3.0 Motivation

We are a developing nation and along with the advent of new technologies and solutions, it becomes extremely important that we extend its advantages to the grass root level. There should be a fair chance provided for all for apportioning access to development. Villagers, NGO's and local level officials (i.e. Public at grass root level) with their treasure of indigenous knowledge are able to conceptualise solutions for their problems. The need therefore is to expose them to the possibilities of development through the use of advanced science and technology techniques. Water and Land Planning and Management have always been areas of concern, since water shortage, more than its management has been an issue for a very long time.

4.0 Objectives

Considering the background of the work, the main objectives were defined as shown below:

❖ To develop an integrated Remote Sensing and GIS technique to establish and evaluate the relationship between land-use and groundwater hydrology

❖ To Propose and suggest measures for water and land conservation which are implementable at village level.

❖ To provide information on watershed at village level to the local level officials.

❖ To prepare an interactive system for the use by TBS 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 monitor and locate the existing water harvesting structures

❖ To delineate areas favorable for recharge by integrating various themes with different recharge possibilities and to recommend suitable recharge structures

5.0 Project Components

❖ Identification and Geo-referencing of satellite datasets.

❖ Preparation of Base-maps for arvari watershed comprising information on settlement, road, rivers, water bodies, etc.

❖ Feature marking on the satellite image (of various elements like drainage, watershed information, roads, river, and large water bodies, important settlements, thematic maps etc), for entire watershed area.

❖ Identification of existing water harvesting structures for all the villages of Arvari Watershed area using multi-temporal satellite imagery.

❖ Proposing water resource conservation actions.

❖ Proposing land resource conservation measures.

❖ Team identification and methodology for quality checks and standardization of information.

❖ Conceptualization and designing of a map layout so that TBS team can also interpret it.

❖ Exporting all the maps in Shape format.

❖ Designing and preparing of software which combines all the information displays it with a demonstrative user interface menu, as well as allows retrieval of information at both tehsil and village level.

❖ Preparation of software for decision support systems with its operability independently after its deployment at various places.

6.0 Human Resources

A team of 8-12 Project Scientists from multidisciplinary backgrounds like Urban and regional planning, Agriculture, Geology, Environmental Planning, Water resources, Civil engineering, Computer Technology, Information Technology etc were involved in preparation of land conservation measures, Water Resource Action Plans and Software.

7.0 Methodology

7.1 Data Used

Type of Data	Source of Data
Survey of India (SOI) topo sheets Scale of 1:50000	54 A/3, 54 A/4, 54 A/8
Thematic maps: Geomorphology, geology, Drainage/Watershed, Land use/Land cover, Transport Network, Settlements/Villages, Slope etc.,	Generated by Gaea Systems
Remote Sensing digital data sets of IRS Images (LISS IV 5.8m Resolution)	National Remote Sensing Agency (NRSA), Hyderabad
Groundwater data: Depth to water level of wells, boreholes etc	Field Survey, Tarun Bharat Sangh

Socio-Economic Data: Demography, Vulnerable groups, Households, Education, Occupation, income, Live Stock etc	Field Survey, Tarun Bharat Sangh
Water Source/Usage: Domestic, Live Stock, Agriculture, industrial, commercial etc	Field Survey, Tarun Bharat Sangh
Water Structures: Nala Bunds, Ponds, Check Dams, Type of construction, Storage Capacity, Depth of Water, Ground Water Table , Recharge etc	Field Survey, Tarun Bharat Sangh
Hydrological Data	Metrological Department, New Delhi

7.2 Identification and Geo-referencing of Satellite datasets:

Multi temporal satellite imagery was used for the exercise. The existing check dams / Johads and proposing thematic maps were prepared and features were marked on post monsoon LISS-IV satellite data of November 2006 and LISS-IV data of January 2005. A team of scientists and supporting staff worked for geo-referencing the required datasets.

7.3 Preparation of Base-maps:

Preparation of base-maps for entire Arvari Watershed area comprising information on location of settlement, roads, rivers, water bodies was undertaken. Attributes like names of the rivers, settlements, and types of roads were also incorporated in the datasets.

Using the geo-referenced image the base layer was prepared using visual interpretation. Details like drainage, watershed information, roads, river, and large water bodies, important settlements, were mapped from satellite imagery. The settlement names, type of roads, name of the rivers are taken from collateral data. Collateral data in the form of maps, charts, census records, reports and topographical maps on 1: 50,000 scale was used.

The IRS P6 LISS-IV, satellite data (geocoded false colour composites) of November 2006 and January 2005, generated from bands 2, 3 and 4 were visually interpreted. Various thematic maps viz. geomorphology, slope and land use / land cover, geology etc, were prepared by the standard procedures outlined in the IMSD guide lines. Based on resource constraints site specific recommendations were made and action plan map generated for the management and conservation of under utilised areas for optimal returns on sustainable basis.
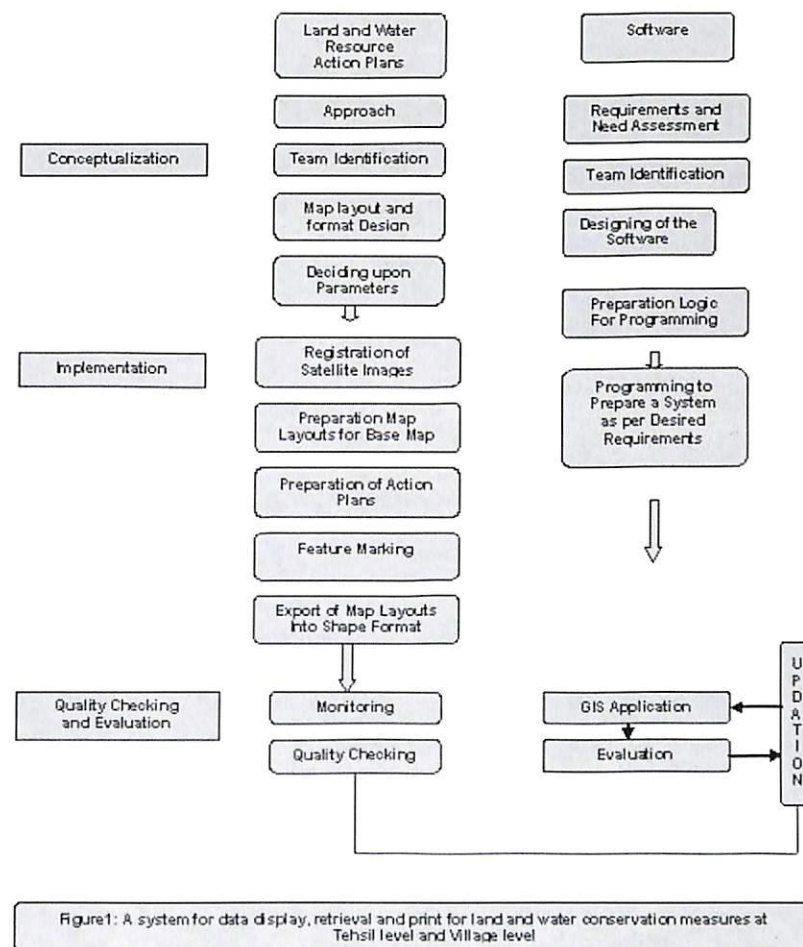

Figure1: A system for data display, retrieval and print for land and water conservation measures at Tehsil level and Village level

7.4 Feature marking on the satellite image:

Realizing the fact that just giving a key to image would not solve the issue of easy interpretation of the satellite image by TBS man, it was decided to actually mark prominent features like roads, *settlements*, wasteland areas, railways, water bodies, agriculture fields, etc. This was done for all villages of arvari watershed area.

7.5 Water Resource and Land Resource Action Plans:

The aim of preparing these plans are to identify the various tasks which can be carried out for watershed development program implemented by TBS for the development of rural areas in Rajasthan state. GIS and remote sensing technology was used to prepare these plans. Information technology was used to distribute these at common man at village level. Possible land and water conservation measures were suggested for each village. Possible actions are suggested taking into consideration the local status of natural resources and technical guidelines for different structures. Check dams or Johads, and construction of ponds are the actions suggested under the water conservation measures and land resource management areas are identified which require plantation with water conservation measures, land conservation and drip irrigation.

7.6 Standardization of Datasets and Quality Checks:

The database contents, formats were standardized for all the layers being created. The system design involved deciding about database contents, the sources of datasets, the scale at which the information was needed, entities- what objects exist, relationships-how their geometry and attributes interrelate, descriptions of term, terminology used, output format/ deliverables. This allowed easy compatibility, accessibility and interoperability of the datasets. The quality check was done regularly.

A multi disciplinary quality assurance team was identified. Each scientist on the quality assurance team was responsible for one of the major tasks being carried out.

As part of the control checks, the QAS team regularly checked the datasets being prepared in terms of the contents, the codification and the accuracy levels. The corrections suggested were incorporated immediately. The databases created were finally checked when the various datasets like water and land resource maps, feature marking, settlements, rivers and water bodies were all integrated together in the system.

8.0 Conceptualization and designing of the map layout

In this phase the idea was to conceptualise and design the layout so that the information is depicted in a manner that TBS team can also understand and interpret it. Aspects of a quality cartographic presentation and visual appeal were taken care of. This included a proper title, map legend, scale bar or representative scale, and north arrow, as well as the proper, standardized use of symbols, patterns, and colours. All the thematic maps of arvari watershed area generated by Gaea Systems are shown below.
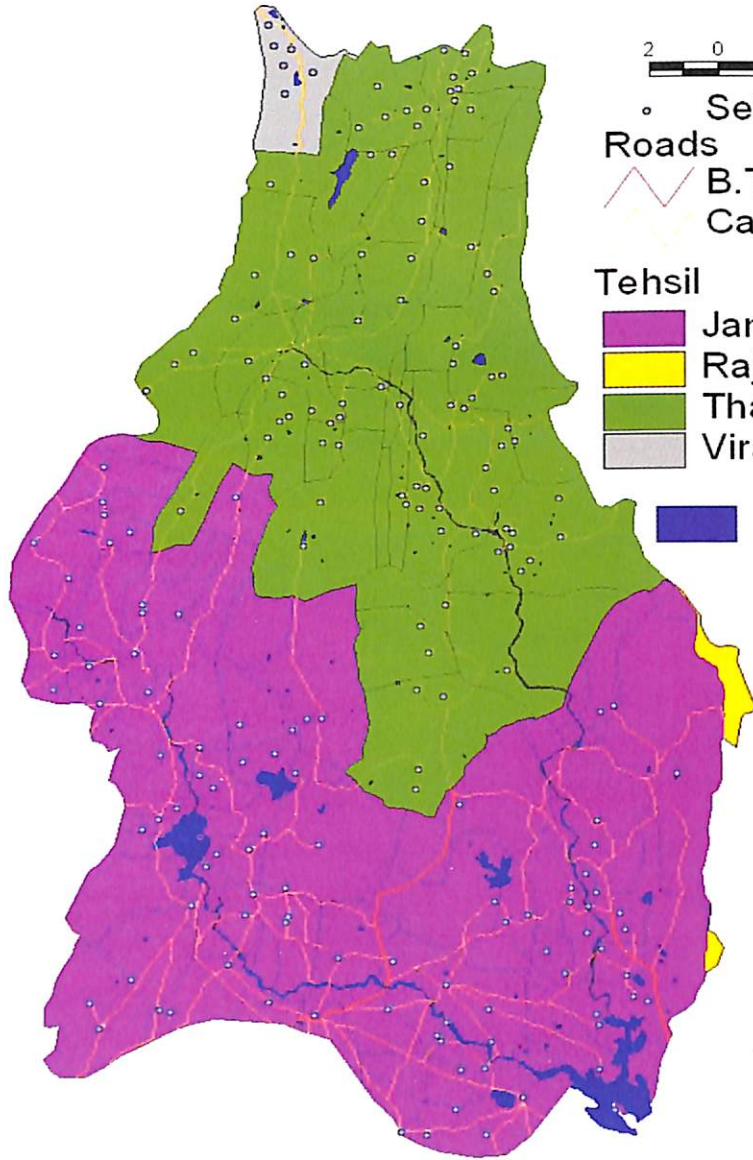
ARVARI WATERSHED GEOGRAPHIC LOCATION

N

2　0　2　4　Kilometers

○ Settlements
Roads
　B.T.Road
　Cart Tracks
Tehsil
　Jamwa Ramgarh
　Rajgarh
　Thanagazi
　Virat Nagar

　Waterbodies

ARVARI WATERSHED SETTLEMENT MAP

N

2　0　2　4　Kilometers

● Settlements
Roads
　B.T.Road
　Cart Tracks
　Waterbodies
　Village Boundary
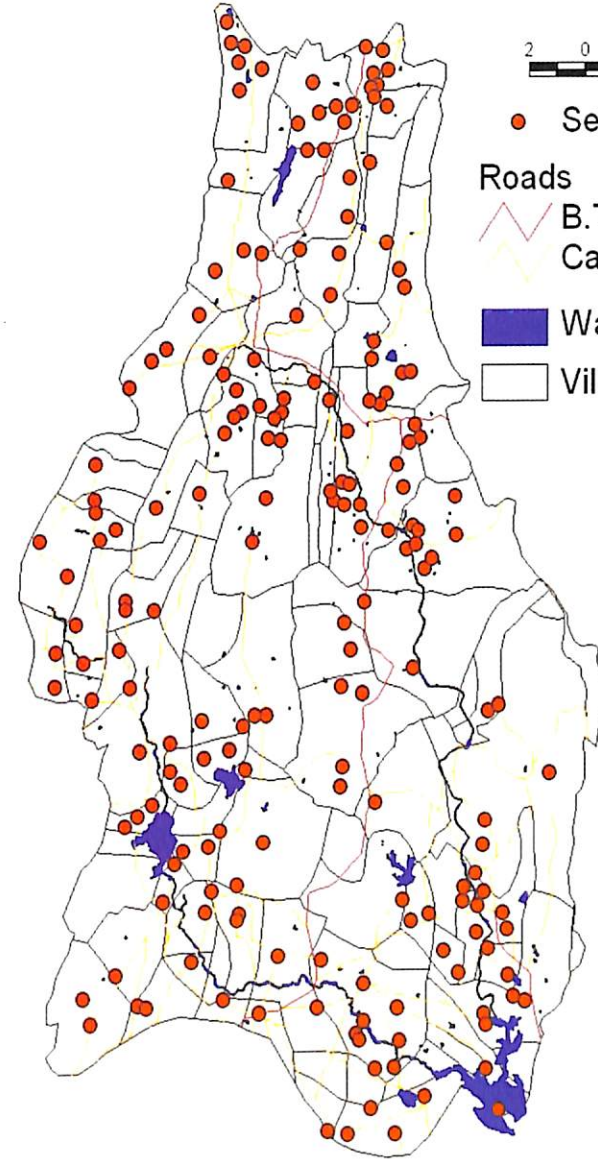
ARVARI WATERSHED
JOHAD MAP

N

2 0 2 4 Kilometers

Johad Location:
☐ Earthen
■ Pakka

Drainage Order:
〰 1
〰 2
〰 3
〰 4
〰 5
〰 6

■ Waterbodies
☐ Village Boundary
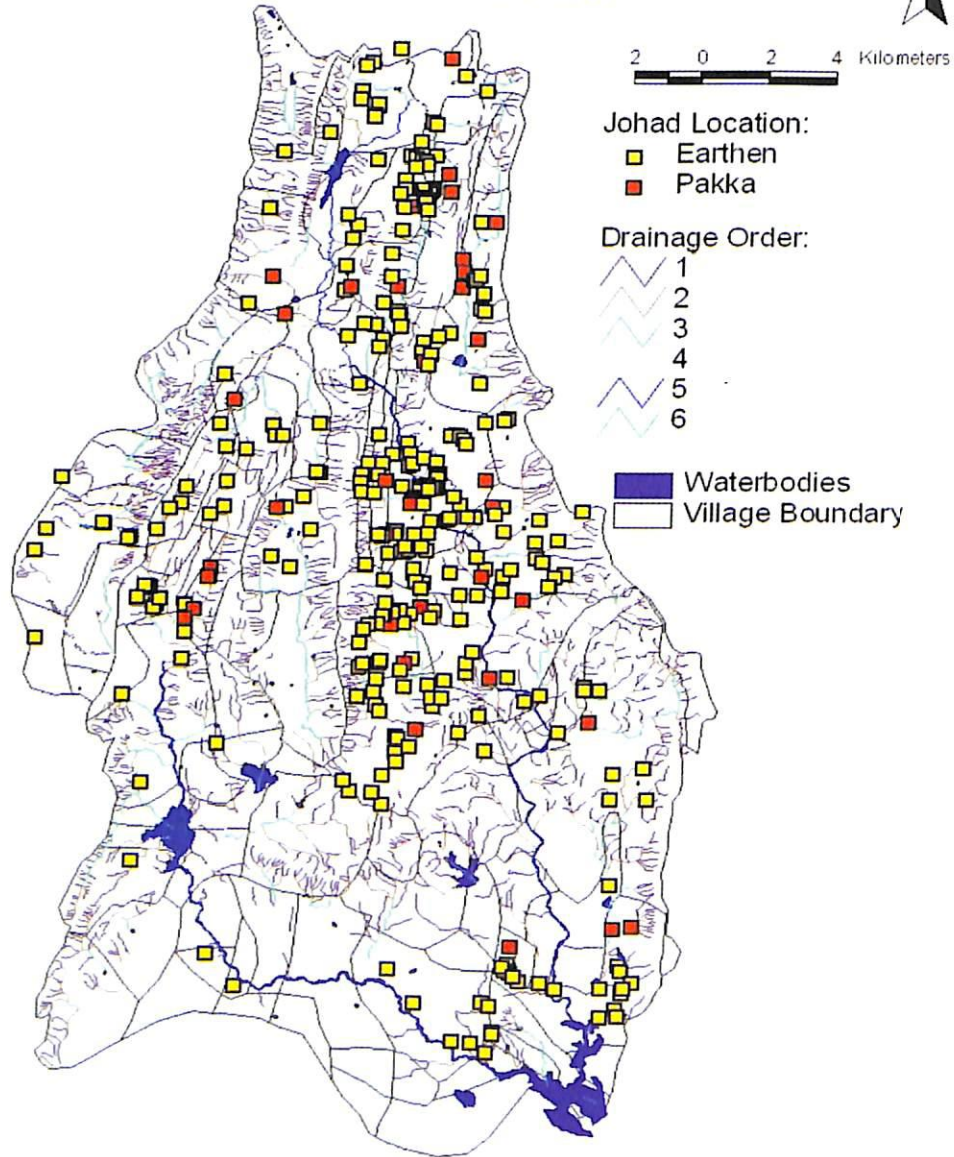
ARVARI WATERSHED
SLOPE MAP

N

2 0 2 4 Kilometers

■ Waterbodies

Slope
■ Gentley Sloping
■ Moderate Sloping
■ Moderate Steep
■ Nearly Level
■ Strongly Sloping
■ Very Gentley Sloping
■ Very Steep Sloping
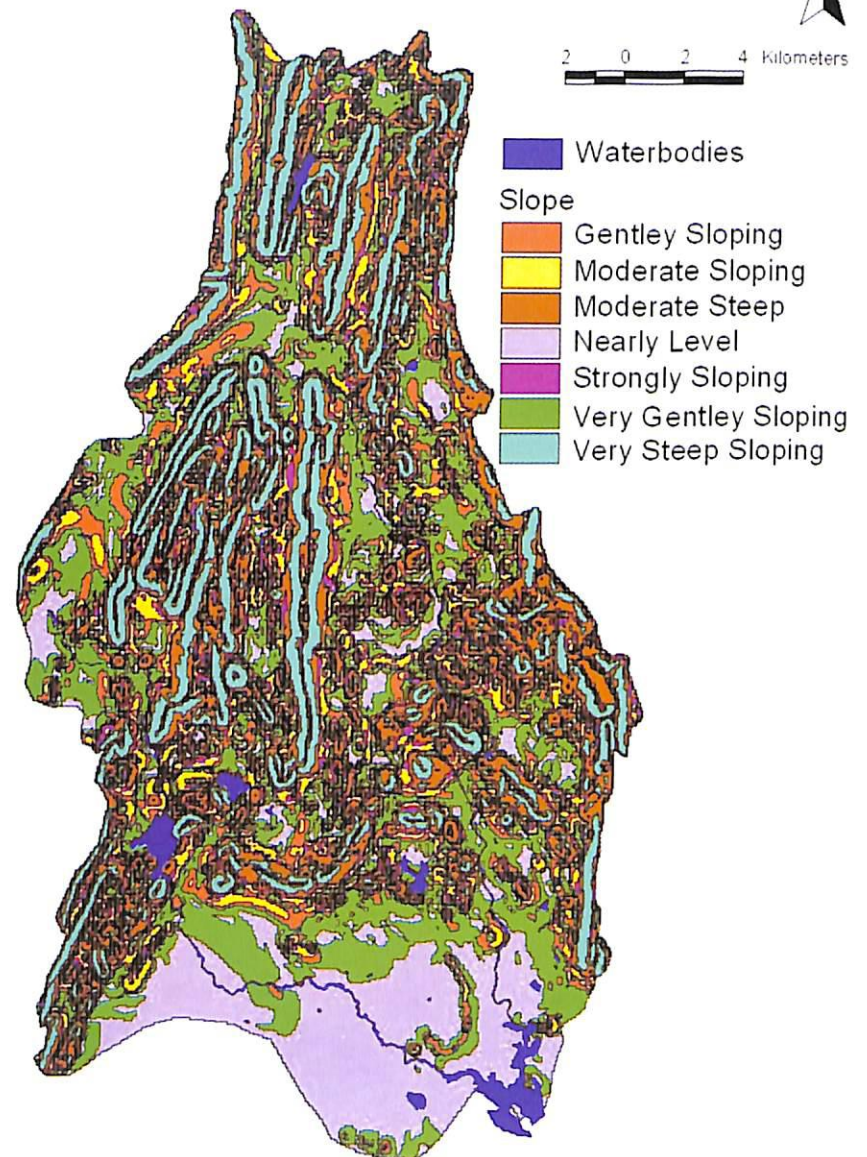
ARVARI WATERSHED
LAND USE/LAND COVER MAP

N

2   0   2   4   Kilometers

Roads
/\/ B.T.Road
     Cart Tracks
●   Settlements

Landuse
- AGAR P F
- BAMANWATI R F
- Barron Rock
- DANTALI P F
- DANTALI R F
- DOGETA R F
- Fallow Land
- Gullied Land
- JHIRI P F
- JHIRI R F
- KANIKHOR R F
- KANWAR BAS R F
- Karif
- MADHOGARH R F
- MAIRH R F
- Mining Area
- P F
- PRATAPGARH PF
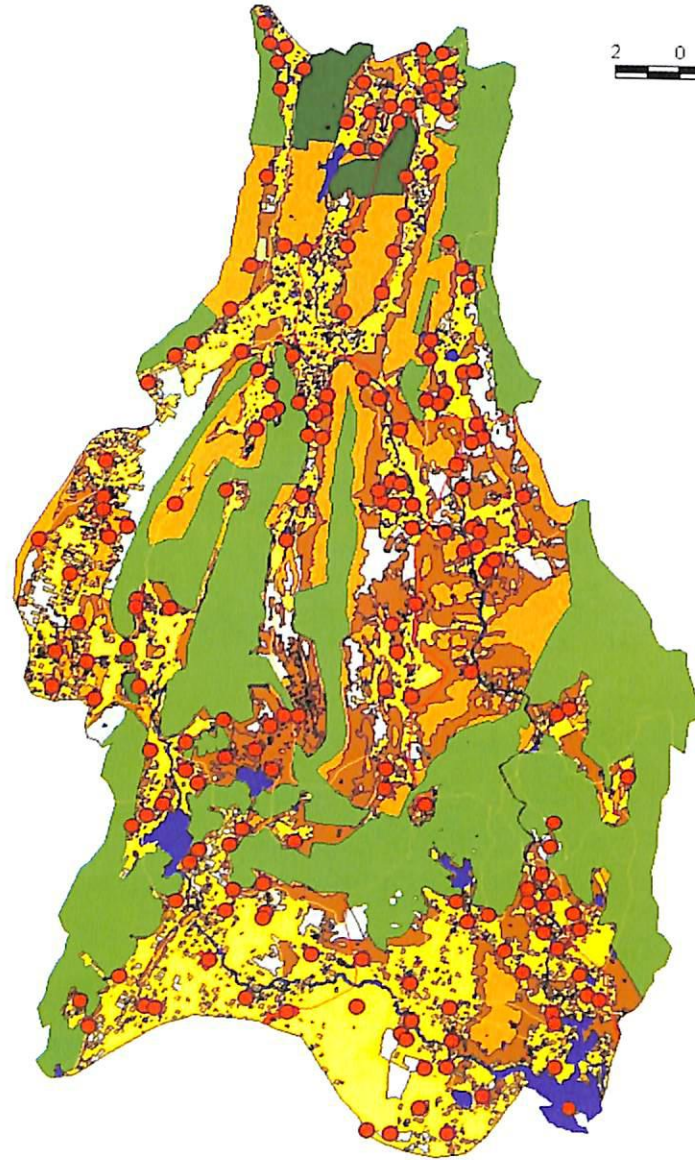- Plantations
- Rabi
- River
- Salt Affected Land
- Scrub Land
- Tank

ARVARI WATERSHED
GEOMORPHOLOGY MAP

N

2   0   2   4   Kilometers

Roads
/\/ B.T.Road
     Cart Tracks

Drainage Order
/\/ 1
/\/ 2
/\/ 3
/\/ 4
/\/ 5
/\/ 6

Geomorphology
- Pediment Inselberge
- Inselberge
- Linear Ridge
- Pediment
- Pediplain Shallow
- Piedmont Zone
-    Residual Hill
- Waterbodies
- Structural Hill
- Cuesta

7
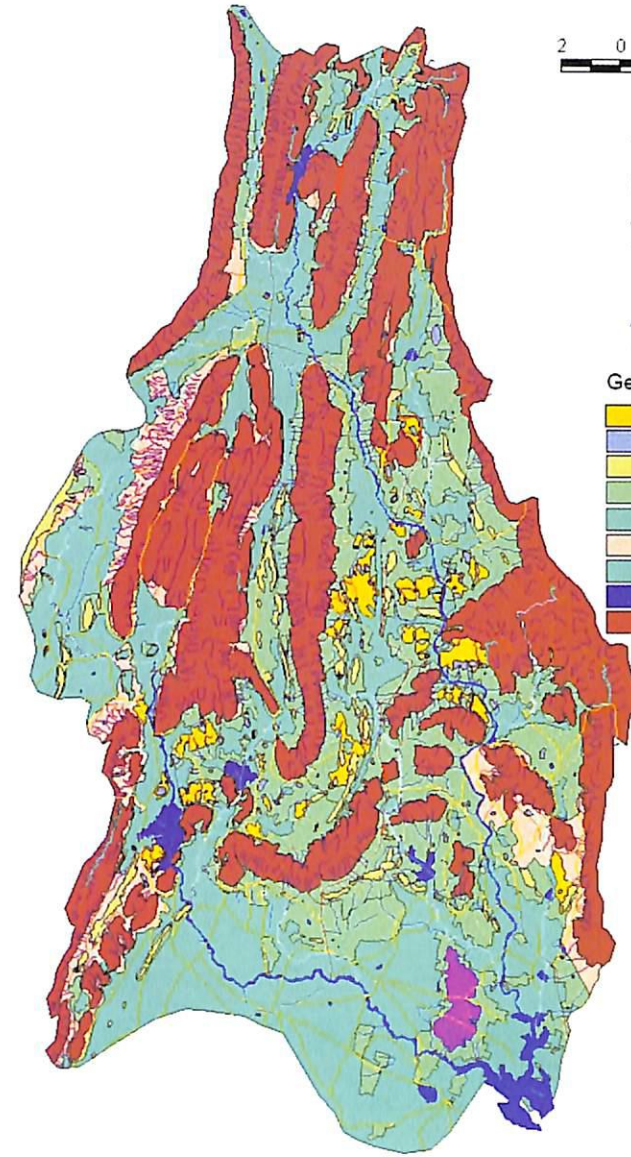
ARVARI WATERSHED
SATELLITE IMAGE - IRS LISS IV DATA

N

ARVARI WATERSHED
POPULATION MAP

N

2　0　2　4　Kilometers

Gender:
Male (red)
Female (blue)

Population Range:
0 - 353
354 - 911
912 - 1817
1818 - 3245
3246 - 6185
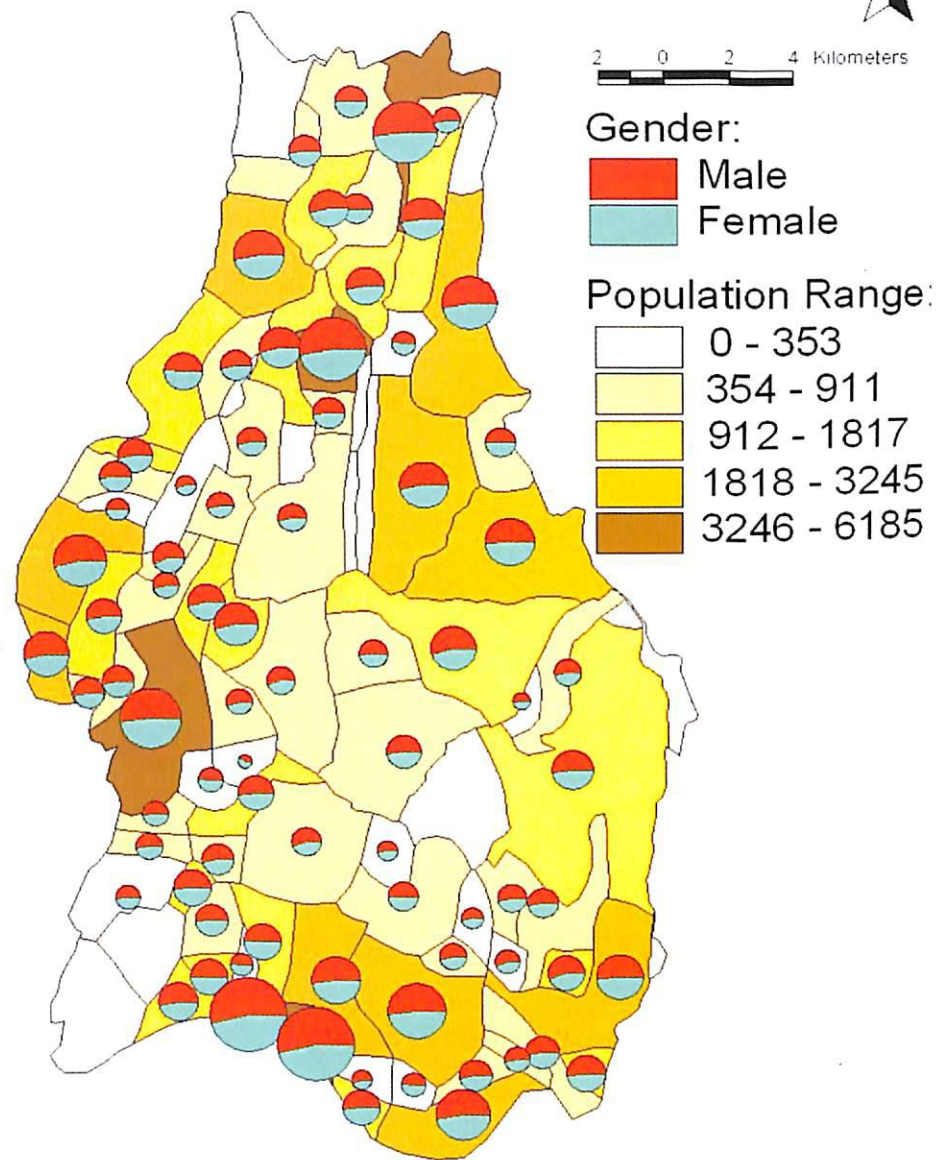
9.0 The salient feature of the software:-

The implementation of the new technology is designed to meet the immediate and long term objectives of the **Tarun Bharat Sangh (TBS)** team. All three views are interconnected, providing a direct means for navigating through each view to the "see" information in a different perspective.

Data View - the Data View provides information access as it relates to all categorical areas of interest. An Ad-Hoc interface with categorical tabs and a columnar display grid, allow the **Tarun Bharat Sangh (TBS)** to select desired attribute information and submit a custom query, and have the results immediately displayed.

Map View - based on GIS technology, the Map View displays Arvari watershed information as it relates to geographic areas of interest. A graphical interface and associated legend, allow the team to organize, analyze and display information for visual representation. Spatial variations, subtle patterns, and trends can be revealed to support decision making for analyzing and planning strategies.

Report View - the Report View provides a graphical interface by selecting reports through menu and hard copy output of selected information. The Report View includes charts and related information. The reports that are there in Report Viewer are all dynamic reports.

10.0 Software for showing water resource action plan at Village level

The issue which concerned us was that of communicating the action plans at local level. A system was required which can display and communicate the information in a simple straight forward way so that it is also understood by TBS Management Team. A flexible and easy to use system was required which can run on a computer without any complicated requirements of the system.

The software was developed by Gaea Systems which combined all the information on one platform and can be used to view, display, retrieve and print the resource management plans at village level. It displays the information at both Tehsil and Village level. No special expertise is required to operate the software. With just one click of Base layers of the desired

themes is displayed providing information on roads, settlement, rail, canal, river, agriculture area, etc. an attractive window is designed for people who do not possess any prior image interpretation skills, so as to familiarise them with satellite images.

11.0 Operation of the Software

The software is prepared to show the water and land resource management actions at village level. Once the software is opened, the application authenticates every user accessing the program to ensure security. The user has to login first with the user name and password provided by the administrator. For any problem related to login, contact the administrator. Based on the user Login user some permission to be given to the User Just like Viewing the data, Inserting data, modifying the data.

11.1 The Data View

The Data View (Figure 2.1) is where all of the data selection criteria are defined. The user can select Villages in Tehsil wise. The User can select the required criteria from Demography, Facilities, Domestic Water Source, Irrigation Source, Land Use, Johad, GroundWater, Rainfall, Well, Water Quality, Crop and LiveStock. A user must select a Village for Demography, Facilities, Domestic Water Source, Irrigation Source, Land Use and Johad (for remaining tabs Village selection is not required) and click Execute Query.

Johad:

This tab provides information about the Johads for the selected villages. The user can view the Johad image in the picture box for the selected Johad in the list box. Full View button is provided so that the user can view the johad image in full view in another form. The Radio button Johad data is used to view the data of Johad's in the Listbox. The radio button FullJohadData helps the user to view the details of all the Johads in Arvari region (Shown in Fig. 2.2).
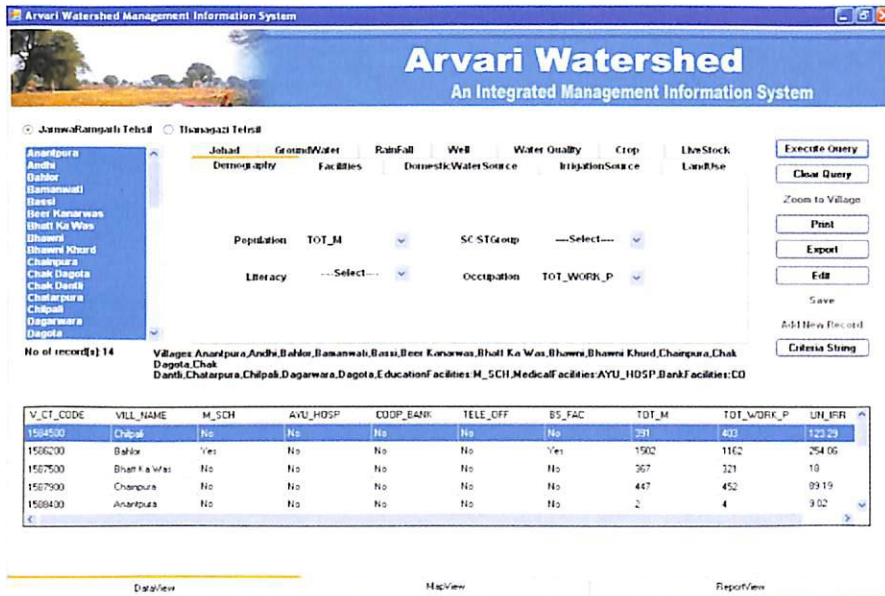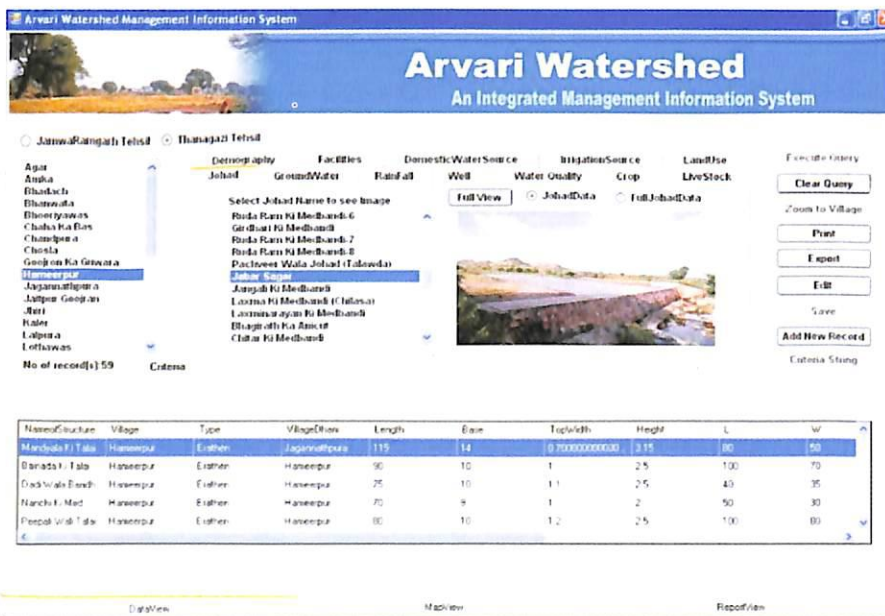
Fig.2.1 Data View

Fig 2 2 Johad Identification

11.2 The Map View

The application opens with the 'Data View' as the active tab. Use the tab bar at the bottom of the screen to go between Map View, Data View and Report View. The Map View is where the Villages of the Arvari region were displayed. There are five main areas of the Map View (Fig. 2.3):

A. Map Window: The map window contains the Villages of Arvari region and optional polygon layers. Depending on the selection of the layers different maps like Transportation, Arvari Satellite Image, Villages, Geology, Landuse, Drainage, Geomorphology, Water Bodies, Slope Map, Settlements and Johads will be displayed. The map window is like a canvas to draw any of the above layers on the map.

B. Tool Bar: The toolbar (Fig. 2.4) contains tools to navigate around the map, Print the map, Add layer, Find, Satellite Image, Full map extent, Table, Zoom in, Zoom out, Pan, Identify, Spatial Select, Add Polygon, Labeler and Analysis(using pie-charts).

C. Menu Bar: The menu bar allows all the functionality of toolbar. It includes File, Edit, View, Layers and Help. In this Menu Bar / Help provides the video of Arvari Vision, which shows the past and present situation of Arvari Region.

D. Legend: The legend shows the Map Layers with classification symbols and colors.

E. Overview Map: The Overview map shows the outline of the Arvari Watershed region and the red outlined box is the extent of the main map window.
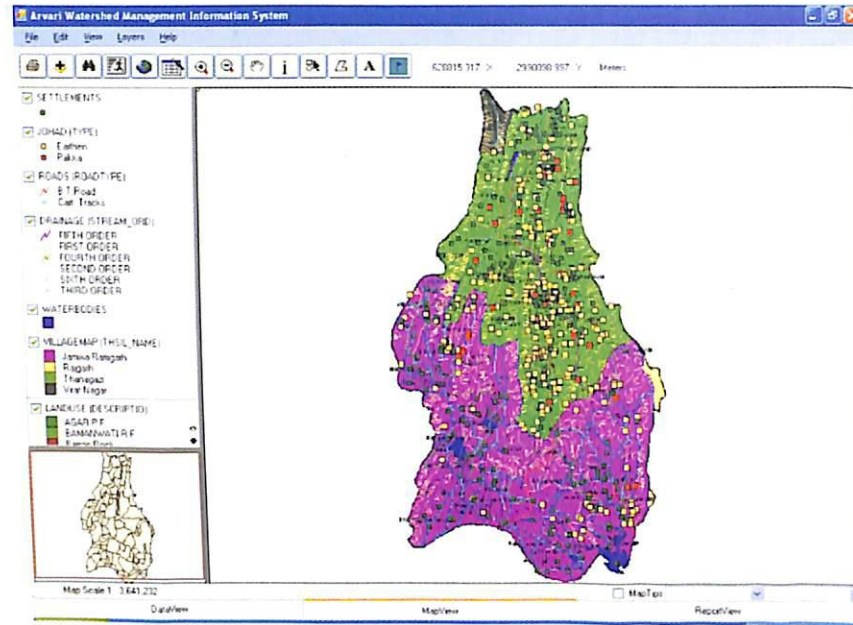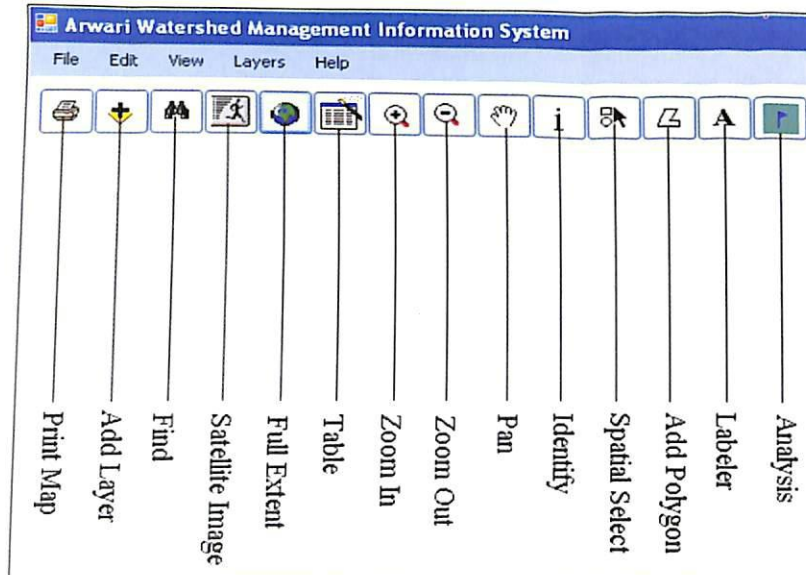
Fig. 2.3 Map View

Fig. 2.4 Map View Toolbar

Here is the brief description of the commands (Shown Fig. 2.4):

- **Print Map** allows the user to take a hard copy of the displayed map.
- **Add Layer** allows the user to add a Map Layer to the current view.
- **Find** allows the user to invoke the Find Features form. This Find Features form allows you to locate features by matching attribute values.
- **Satellite Image** allows the user to load and unload the Satellite image of the Arvari region.
- **Full Extent** allows the user to change the map extent in the Map control to include all the map features in all map layers.
- **Table** allows the user to get attribute values of the Settlements point coverage and Tanks in a tabular format.
- **Zoom In** allows the user to change the map extent to span two points that you set by dragging the mouse in the Map control.
- **Zoom Out** allows the user to decrease the map scale by a factor of two; centered on a point you click with the mouse.
- **Pan** allows the user to change the map extent of the Map control by dragging the mouse from one point to another.
- **Identify** allows the user to identify the features of the active layer at or near positions you click with the mouse. For this the user has to select and activate a layer and then click on the map.
- **Spatial Select** allows the user to invoke the Spatial Select form. The Spatial Select form allows you to select overlapping features between layers.
- **Add Polygon** allows the user to create a polygon layer.
- **Labeler** allows the user to Label the information of the particular selected layer.
- **Analysis** allows the user to create Pie charts on the Village Layer only for different selection criteria's provided. The selection criteria's are "Population, SC Population, ST Population, Literates, Illiterates, Water facility and School facility. The user has to select one among these and then click on the "Pie Chart" radio button to see the results on the Map.

11.3 The Report View

The Report View (Fig. 2.5) is where the Ad Hoc reporting capabilities are complemented. The canned reports were created by Crystal Reports XI. These reports can query the Watershed region in minute detail. The Microsoft Access Database and the Crystal Reports XI capabilities make the reports compelling and powerful.
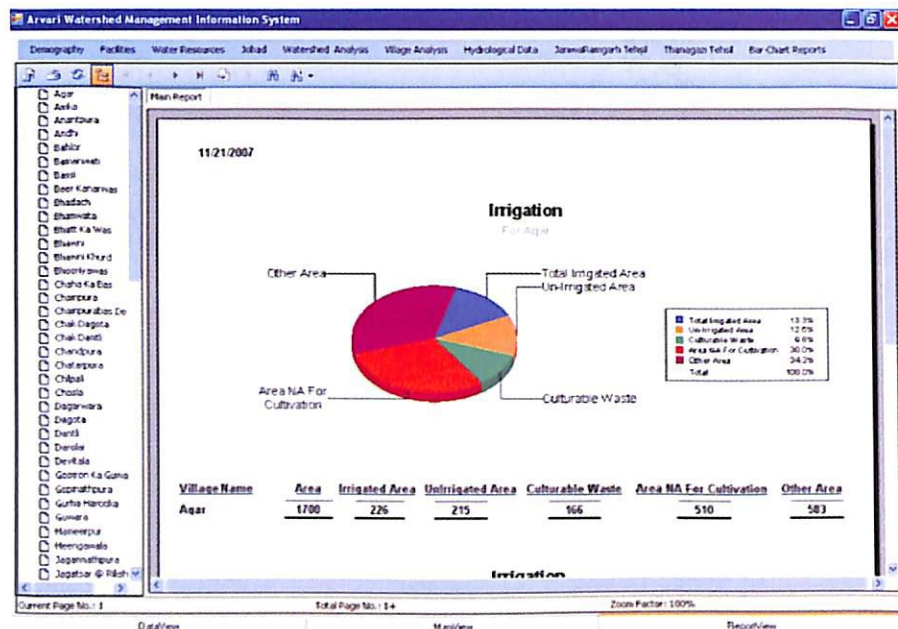

Fig. 2.5 Report View

11.4 Interactive mode of the software for acquainting the TBS team about the Indian Remote Sensing Satellite Data:

On clicking on satellite image button, the image is displayed. This shall help the user to understand how various features like water body, built-up area, plantation, agriculture area, forest cover, river look on a satellite image.

11.5 Technical Aspects of the Software:

Hardware Requirements

Intel Pentium IV 2.8 GHz

1 GB RAM

80 GB Hard Disk Drive

52 X CD ROM Drive (To read data)

24 X CD Writer (For Backup)

Software Requirements

1. MS Office 2003.

2. Supported Operating Systems:

- Windows XP with Service Pack 2
- Windows Server 2003

3. Required Software:

- Windows Installer 3.0
- IE 5.01 or later

4. Disk Space Requirements: 280 MB(x86), 610 MB(x64)

Technology

- The System is developed in VB.Net Technology with MapObjects 2.2

12.0 An Asset for the Decision Makers of Rural Development:

The software is an important asset concerning the decision making activities for the officials working for rural development. The application prepared provides information on the existing check dams or Johads and that too on a spatial basis; it thus forms an important tool for spatial comparisons. The image is also provided along with the information, this way the decision makers can get evaluate the existing condition and water status of the area. Further, the application also provides several sites for the construction of water harvesting structures as suggested by the experts and decided on the basis of pre-decided criteria and parameters. This would help the concerned officials to decide upon the site for construction, which immensely reduces the time and cost requirement.

13.0 Efficiency:

The endeavor envisages saving large amount of resources that are spent on the construction of water harvesting structures each year, which involves complicated surveys and ground truth sessions. After the marking of the features and structures on satellite image the issue that arose was that of dissemination of such knowledge and information. It would have been practically impossible to visit each place and explain the map layouts; further printing of such large scale information would also have been costly.

14.0 Creation of Comprehensive standardized spatial data of water harvesting structure and land resource action plan:

The Institute conceptualized and organised a multi-purpose common digital database for sectoral/ integrated decision support systems. This has provided impetus to developmental planning at grass root level and monitoring and management activities in various disciplines. The common usage of inter-sectoral data removes data gaps in various sectors and it prevents duplication of efforts during execution and planning by different departments/agencies and this ensures cost recovery.

A Comprehensive digital database having Water Harvesting Structures level information has prepared and linked to the GIS database maps for the project area on watershed basis.

The following information on GIS base maps:

1. Coded information on the base map of project area:
   - ➢ Village Location
   - ➢ Site Location
   - ➢ Social Composition
   - ➢ Transportation Network
   - ➢ Existing Water bodies

2. Water scenario inside the watershed area:
   - ➢ Type and cost of the water harvesting structure
   - ➢ Status of water harvesting structures
   - ➢ Average water level of the nearest water sources located with in the recharging zone of each structure
   - ➢ Stored Water Use
   - ➢ Benefited Population

15.0 Development of Software Solution: The software was developed to make the technology widely available, customizable and also low cost. This reduced the cost effectively, as the software developed was platform independent and could run on any PC.

16.0 Future Applications

In future more we can improve and expand the scope of the existing system through addition of the information like that of road infrastructure, its type, width etc. We can also develop the front end of the system is displayed in local language for the convenience of the rural populace. Similarly by updating the datasets at cadastral level we can also add and provided land conservation measures at farm level, site for inland fisheries, etc. The world is getting closer through the use of Internet and it is known to be a great source 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 as map printings and hard copies of such applications at a large scale are too costly and tedious.

अरवरी संसद का 15वाँ अधिवेशन
दिनांक: 24, 25 दिसम्बर 2005
स्थान- ग्राम सांवलसर (पारा वाला बाँध)
आयोजक- ग्राम सभा सांवलसर व तरुण भारत संघ

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