INTEGRATED LAND AND WATER RESOURCES CONSERVATION AND MANAGEMENT-DEVELOPMENT PLAN USING REMOTE SENSING AND GIS OF CHEVELLA SUB-WATERSHED, R.R.DISTICT, ANDHRA PRADESH, INDIA

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KEY WORDS: Watershed, Groundwater, Geomorphology, Remote Sensing, GIS

ABSTRACT:

The study area Chevella located at a distance of about 42 km from Hyderabad city covers an area of about 5000 ha, is one of the drought prone areas in the Rangareddy district of Andhra Pradesh. Groundwater is the main source for irrigation and for drinking purpose. The primary objective of the study is the soil and water conservation through multi-thematic information derived from remote sensing data for optimal management of soil and water resources for drought proofing on long-term basis. An attempt is made in the present study to suggest an action plan for the sustainable development of the area using GIS and Remote Sensing techniques. For the present study IRS P6 LISS III, IRS 1D LISS-III and IRS 1D PAN Imagery have been used for the preparation of land use/land cover, hydrogeomorphogy and soil maps. Geologically most of watershed is covered by Deccan basalt formation comprising nearly horizontal lava flows. In the northern part of the study area, the basalts are lateritised whereas in the southern part moderate to thick soil covers the granites. The major geomorphic units mapped in the area are moderately dissected plateau, moderately thick buried Pediplain, moderately thick Lateritic plateau and structural valley. Among all moderately dissected plateaus, cover most part of the area. In the study area good to moderate ground water prospects are there in structural valleys with distinct lineaments and moderately thick buried Pediplain. Moderate ground water prospects occur in moderately thick Lateritic plateau with weathered and fracture zones. Similarly, moderate to poor ground water prospects are found in moderately dissected plateau. Massive basalts have limited prospects until they encounter intertrappeans without clay formations. In such areas dug wells have been successful. Most part of the area is very gently sloping. Some patches in the southern part of the area are nearly level. In view of the vital importance of water for human and animal life, for maintaining ecological balance and for economic and developmental activities of all kinds, and considering its increasing scarcity, the planning and management of this resource and its optimal, economical and equitable use has become a matter of the utmost urgency a complete action plan for the development of land and water resources has been suggested. Arc Hydrology model of ArcGIS 9.0 version is been used to propose various soil moisture conservation and water harvesting structures. Vegetative barriers have been suggested to prevent soil erosion and to preserve soil moisture covering the area where severe erosion occurs particularly in the Kharif Un-irrigated land. Similarly, six check dams, two percolation tanks is suggested at different locations across streams and farm ponds, in the agricultural lands for the development of ground water. Similarly, some alternate land use practices like horticulture, Silvipature, nurseries is been suggested for the optimum utilization of land & water resources. The Chevella sub-watershed with rolling topography and gentle slopes tending towards south direction and elevations of 575 to 670 m above mean sea level is drained by numerous streamlets. Thus from the study it is recommended that water harvesting should be given importance to avoid the wastage of rainwater from the watershed. This will also increase the groundwater recharge besides providing supplementary irrigation during Rabi season. Farmers should be encouraged with regard to making of farm ponds and soil conservation measures.

1. INTRODUCTION

Water resources are increasingly in demand in order to help agricultural and industrial development, to create incomes and wealth in rural areas, to reduce poverty among rural people, and to contribute to the sustainability of natural resources and the environment. Reliable and timely information on the available natural resources is very much essential to formulate a comprehensive land use plan for sustainable development. The land, water, minerals and biomass resources are currently under tremendous pressure in the context of highly competing and often conflicting demands of an ever expanding population. Consequently over exploitation and mismanagement of resources are exerting detrimental impact on environment. In India more than 75% of population depends on agriculture for their livelihood. Agriculture plays a vital role in ours country.s economy. In order to mitigate droughts which occur frequently in several parts of the country especially in dry land areas the Ministry of Agriculture and co-operation has launched an integrated watershed concept using easy, simple and affordable local technologies. Watershed approach has been the single most important landmark in the direction of bringing in visible benefits in rural areas and attracting people.s participation in watershed programmes (Singh J.et.al., 2005). The programmes under watershed approach broadly fall into soil and water conservation, dry land and rain fed farming, ravine reclamation, control of shifting cultivation and improvement in the vegetative cover. The basic objective is to increase production and availability of food, fodder and fuel; restore ecological balance. Watershed management is an iterative process of integrated decision making regarding uses and modification of lands and waters within a watershed. Development of the watershed needs better understanding about the various natural resources their relations with each other and their relations with livelihood of the stakeholders. The present study is an attempt using Remote Sensing and GIS techniques to propose various water harvesting and soil conservation measures in order to suggest integrated land and water resource development plan for Chevella sub-watershed covering 5000 ha in Chevella mandal of Ranga Reddy district in Andhra Pradesh.

2. LOCATION AND EXTENT

The study area Chevella is situated at a distance of 42 kms from Hyderabad and 31 kms from the Vikarabad. The study area is situated in the South-West part of the Rangareddy and lies between North Latitudes 17o 14. 15. and 17o 19. 18. and East Longitudes 78o 4. 40. and 78o 8. 49. and falls in Survey of India Topo sheets Nos.56K/3SE, 56K3/SW, 56K/4NW and 56K/4NE (Fig-1). The area experiences semiarid type of climate. The average annual rainfall of the area is about 776mm. The mean maximum and minimum temperatures recorded in the area are 28.6o C and 13.6o C respectively. The extent of area is 5000 hectares.

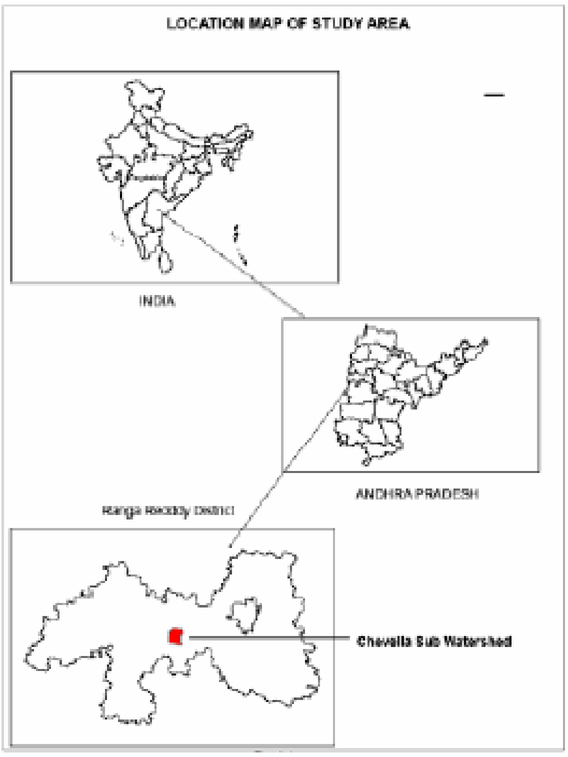


Figure-1

3..SCOPE OF THE PRESENT STUDY

In large number of cases the failure of watershed development is largely due to maladjustments with diverse facets of nature, caused by lack of awareness of the natural resources. In order to generate optimum utilization of existing natural resources like land, vegetation and water in watershed proper scientific surveys should be conducted. Geo-scientific studies of the terrain, socioeconomic appraisal of the stake holders and the use of Remote Sensing Data for faster assessment of natural resources such as soil, geology, drainage etc. as well as assessment of economic activities through land use and infrastructure of the watershed area is well known. This is also used for monitoring of watershed development at later years. GIS is a very powerful tool for development of the watershed area with all natural and socioeconomic facets for better planning, execution and monitoring of the project.

4. OBJECTIVES

The main objective of the present study is to generate information/databases on 1:25,000 scale pertaining to hydrogeomorphology, Drainage, surface water bodies, watershed, transport network etc. using multi-temporal satellite data. Conversion of these databases into digital form for future analysis and utilization and to prepare location specific land, water resources development plans, by integrating these databases with socio-economic data and contemporary technology in the GIS environment such that control of soil & moisture conservation and land degradation, optimal management of croplands and conservation and management of water resources can be achieved.

5. METHODOLOGY

To achieve the above objectives, the following methodology and procedure is adopted in the present study. Collection of satellite data and Survey of India Topographical maps, collection of rainfall and temperature data and other collateral data covering the study area, preparation of base map on 1:25000 scale using Survey of India Topographical Maps, preparation of Drainage, watershed and Surface water bodies using SOI topographical maps, preparation of contour map of 5mts contour interval using SOI topographical maps, preparation of DEM (Digital Elevation Model) from contour map, preparation of Slope, Aspect and Relief maps from DEM, preliminary pre-field interpretation of Hydro geomorphology using Satellite data on 1:25,000 Scale, ground truth data collection, verification of doubtful areas and correction, modification and transfer of post field details of Hydro geomorphology on to original maps, recommendation of land & water resources development plan.

6. GEOLOGY

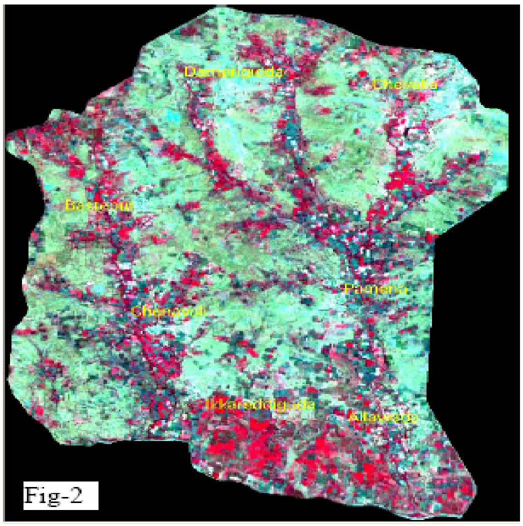
The prominent geological formations in the study area are Deccan traps, laterites and Archeans. The basalts overlying the Archean crystalline rocks occupy most of the study area. These trap rocks were formed by the solidification of lava and in the form of layers of different texture and thickness. Weathered basalts have medium permeability and vesicular basalts have relatively high permeability. Laterites are found capping the weathered basalts. The alluvium in the watershed is of limited extent found along the Musa River.

7. GEOMORPHOLOGY

Geomorphology is the study of forms and process of landforms, which are the products of various exogenetic and endogenetic forces. Landforms play a significant role in land resource mapping, watershed studies, terrain evaluation and soil classification in addition to ground water studies. The ground water conditions vary from terrain to terrain.

For the present study IRS P6 LISS-III path/row 99/60 4th December 2003 (Fig-2) and IRS 1D PAN path/row 99/60 11th June 2002 merged satellite imagery and SOI Toposheet 1: 25000 scale have been used to map various geomorphic features in order to delineate ground water potential zones in the area. Based on the interpretation of the satellite imagery and SOI toposheet the following hydro-geomorphic units have been delineated on 1:25000 scale.

Satellite Imagery of Study



P6 , LISS IV MX Data Dec 2003

Moderately Dissected Plateau is composed of basalts, which is associated with shallow valleys / gullies with gently sloping land developed due to stream erosion. These formations are generally located between weathered valleys and highly dissected plateaus in the area. This is the most prominent geomorphic unit occurring in the area. Fractures / lineaments are the significant structural features identified in the area. This unit is mostly seen in the central part of area covering 2937 ha.

The ground water prospects in this unit are poor to moderate. In general yield of the bore wells in these formations is about 600 GPH to 2000 GPH and yield of dug wells range from 40 to 60 m3/d.

Moderately Thick Lateritic Plateau (MLP) is an elevated flat land surface covered by thick lateritic capping in the northern part of the study area with an aerial extent of about 406 ha. Fractures / lineaments are the structural features identified in this unit though not that significant. The drainage density in this unit is moderate. The yield of dug wells in these formations varies from 40 to 100 m3/d and bore wells from 800 to 3000 GPH.

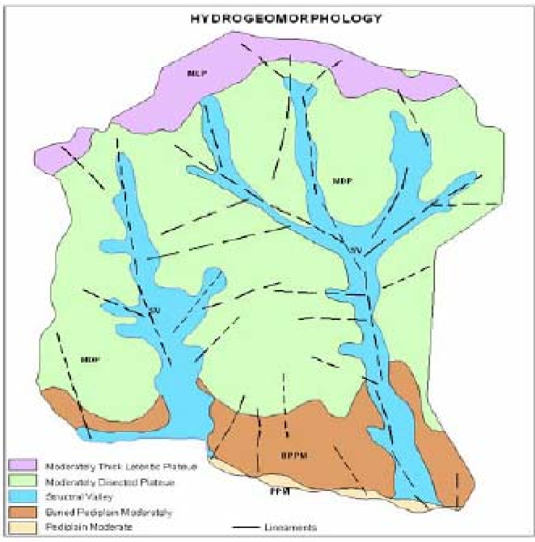


Figure-3

Buried Pediplain with Moderate Weathering (BPPM) is a flat and smooth Pediplain surface composed of granite gneiss with 8 to 20m thick weathered material mostly covered with black soils. This geomorphic unit is observed in southern part of the study area covering an area about 645 ha.

Moderate to good yields are expected in these formations. The recharge through precipitation to these formations is limited as these formations are covered by low permeable black soils. The yield of dug wells in these formations varies from 60 to 100 m3/d and bore wells from 1600 to 3600 GPH.

Structural Valley (SV) are composed of weathered basalts to a considerable depth, which are associated with fractures and lineaments. This unit is mostly seen along the major streams in the study area covering an area about 990 ha. The ground water prospects in this unit are moderate to good. However, good yields are along the fractures / lineaments in this area. These formations generally form good aquifers in the study area. The yield of dug wells in these formations varies from 80 to 120 m3/d and bore wells from 1600 to 3800 GPH (Fig-3).

Remote Sensing & GIS: The success of planning for developmental activities depends on the quality and quantity of information available on both natural and socio-economic resources. It is, therefore, essential to devise the ways and means of organizing computerized information system. Remote Sensing (RS) data and Geographical Information System (GIS) play a rapidly increasing role in the field of land and water resources development. One of the greatest advantages of using Remote Sensing data for natural resource management is its ability to generate information in spatial and temporal domain, which is very crucial for successful model analysis, prediction and validation. Examples from recent literature spotlight several uses of GIS as applied to groundwater exploration. Gustafson (1993) used a GIS for the analysis of lineament data derived from SPOT imagery for ground water potential mapping. Minor et al. (1994) developed an integrated interpretation strategy to characterize ground water resources for identification of well locations in Ghana using GIS as a unifying elem of Northwest Florida Water Management District, Richards et al. (1996) took the advant ent. For the assessment of ground water resources age of GIS for the spatial analysis and data visualization. Krishnamurthy et. al. (1996) developed a GIS based model for delineating ground water potential zones Marudaiyar basin, Tamil Nadu, India by integrating different thematic layers derived from Remote Sensing data. The field verification of this model established the efficacy of the GIS in demarcating the potential ground water reserve. Similarly Sander (1997) and Teeuw (1999) have applied GIS for ground water resource assessment.

In the present study most of the analysis was done using Hydrological analysis tools in ArcGIS 9.0 software.

The hydrological analysis process in GIS is one of the effective methods in terms of cost and time in proposing various water harvesting structures. This process deals with assessing various hydrological characteristics of a surface. The basic parameter that controls the surface water flow (run-off) is the shape of the surface (terrain). Slope and aspect play a vital role in determining the shape of a surface. The basic inputs required to generate a hydrological model for a region are slope, aspect, sinks, flow direction, flow accumulation (Fig-4), pour points and a possible stream network. The whole hydrological process can be broadly divided into 2 phases i.e. (1) Surface analysis and (2) Hydrological analysis.

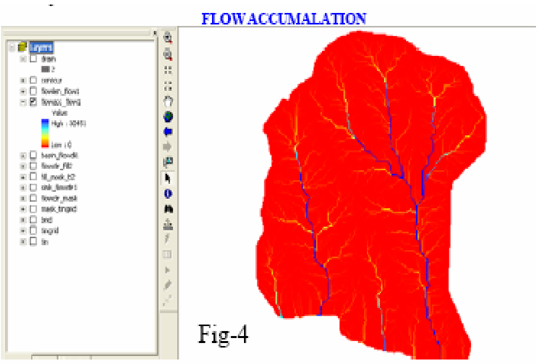


Fig-4

Water resource development plan has been prepared on the basis of integration of information on hydrogeomorphological characteristics, surface water availability, landuse/landcover (Fig-5), drainage, present status of ground water utilization and considering the present and long term needs of water in the study area. Conservation, management and development of water resources form integral component of the development plan. Suitable structures are suggested for surface harvesting / recharge. Proposing different soil and water harvesting structures plays a very crucial role, which requires a well-qualified and well-experienced work force with thorough knowledge in various water conservation programmes. For this purpose the following thematic layers like slope, flow direction and flow accumulation output raster maps along with drainage, land use/land cover, hydro geomorphology are used. Weightages are given to significant units (on priority basis) in various thematic layers such as Hydrogeomorphology, slope, drainage, soils and land use/land cover in raster form in order to prioritize locations for suggesting appropriate recharge structures. First, all the thematic layers have been converted to raster form in ArcMap using convert features to raster option to assign Weightages, since the analysis should be performed in raster mode. In the Hydro geomorphology layer high priority (1) is given to structural valleys, moderate (2) priority to moderately dissected plateau and low/least (3) priority is given to undissected plateau. In the land use/land cover layer high priority (1) is given to double cropped areas, moderate priority (2) to kharif un-irrigated areas and least priority (3) to fallow lands. In the soil layer top priority (1) is given to black loamy soils and least priority (2) to black soils. Similarly, the slope classes have been reclassified into 2 categories like class 1 (0-1%) and class 2 (1-3%). Slope class 2 is given high priority (1), class 1 is given least (2) priority. In stream order raster 3rd order streams are given high (1) priority, 2nd order streams are given moderate (2) priority and 1st order streams are given least (3) priority. These themes have been calculated using raster calculator in spatial analyst of ArcGIS 9.0, based on the Weightages decided. The formula for this raster calculation is as follows: ((Hydrogeomorphology)*0.2+ (Land Use/Land cover)*0.2 + (Soils)*0.1 + (Slope)*0.2 + (Drainage)*0.3)

A drainage raster indicating high and low priority locations has been generated by evaluating this equation. Based on this location priority raster, various water-harvesting structures have been proposed (Fig-6). All these functions are used either by themselves or in conjunction with other mathematical or statistical or simulation models for varied applications in GIS. There is a wide range of spatial analysis functions in a GIS. To take advantage of its capabilities, user must define his problem clearly; decide the data required and the spatial operations to be performed for reaching the goal. This will help in proper cartographic modeling of the decision problem and achieve the solution.

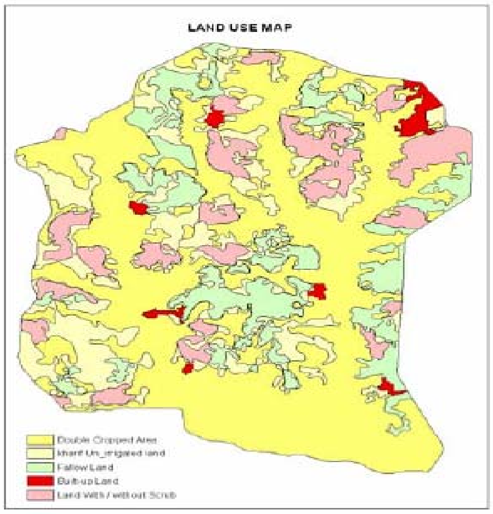


Figure. 5

8 .CONCLUSION

Chevella sub-watershed with rolling topography with gentle slopes tending towards south direction and elevations of 575 to 670 m above mean sea level is drained by numerous streamlets. Thus from the study it is recommended that water harvesting should be given importance to avoid the wastage of rainwater from the watershed. This will also increase the groundwater recharge besides providing supplementary irrigation during Rabi season. Farmers should be encouraged with regard to making of farm ponds and soil conservation measures.

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