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Spatial Data Base Creation For Effective Irrigation Management: A Model Study

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Abstract

The land use/land cover has been dramatically changing in Asian countries in the last few decades due to the population pressure. Generally, the forested lands have been converted into agricultural lands, as well as the productivity has been improved because of more irrigation, use of chemical fertilizer, mechanization and so on. There is, however, increasing concern about some of the irrigation potential created but not brought into the functional system, lower operating efficiency, lesser crop productivity etc. Improvement in agricultural productivity has become a necessity due to the limitations in expansion of cultivated acreage and ever increasing food demand. A large number of irrigation projects have been commissioned in India in the post-independence era for improving food production and economic development. These irrigated croplands though limited to about 30 percent of the gross cropped area in India, contribute more than 50 percent of the total agricultural production. However, optimistic forecasting of production cannot be expected, because there are limits of suitable cropland, limitations of productivity and shortage of water resources. Monitoring, estimating and forecasting crop production are quite important for the management of food demand and supply balance at local level, regional level and Worldwide. According to the FAO (Food and Agricultural Organization) statistics, the crop production has increased corresponding to the population increase in the last 40 years. This means, scientific management of irrigation croplands through integrated systems approach is the only way to make our agriculture productive and competitive. Keeping this trend and importance the prime objective of this study is proper develop the effective irrigation management to preparing the physical characteristic information maps such as Drainage, Geomorphology,

Landuse/Land cover, Slope, Structures, Ground water potential, Ground water Infiltration, Physiography, Transport network maps has been prepared using Satellite Remote sensing images of IRS-LISS data based on the spatial maps data Irrigation techniques has been discussed for effective management.

Keywords: physical characteristic information maps, irrigation management, Remote sensing, GIS.

Introduction

National agricultural production, on a sustainable basis, depends on the judicious use and management of natural resources like soil, water, animal resources and crop/plant genetic resources. With an acceptable technological input under prevailing socio-economic infrastructure. In order to achieve an economically sound society, environmentally benign development and judicious utilization of natural resources, it is necessary that a comprehensive Integrated Information System be developed to provide systematic and periodic information and its status to the planners, decision-makers and developmental agencies. These resources need proper evaluation that can be done through interactive interpretation in a relational database system. Also, digitizing socio-economic database along with biophysical factors is important to objectively monitor and evaluate the current and future agricultural growth and development. the aim of developing and demonstrating the use of spatial decision support for integrated planning and management of resources for micro level planning for entry, storage, manipulation, analysis and display of spatial data on a low cost computer configuration. Remote Sensing has shown great potential in agricultural mapping and monitoring due to its advantages over traditional procedures in terms of cost and time effectiveness in the availability of information over larger areas. In agriculture, Remote Sensing has been employed to the development of precision farming for the better crop production and environmental protection.

Objectives

1. To create spatial digital database consisting Drainage, Geomorphology, Land use/Land cover, Slope, Structures, Ground water potential, Ground water Infiltration, Physiography, Transport network maps using IRS-ID LISS-III satellite data, SOI toposheets and field data on ARC/INFO GIS platform.
2. To generate attribute data base consisting of statistical details of each of the above thematic maps
3. To extract and understand the Terrain characteristics of the study area for effective management and future development

Description of Study Area

The study area is located along east coast of Andhra Pradesh, has around 200 km of coast line. It consists of toposheets numbered as 65D11, 65D12, 65D15, 65D16, 65D8,

65D7, 65D4, 65D3, 66A1, 66A2, 66A5, 66A6, 66A9, 66A13&14. Latitude and longitude values ranging from 80°35'E, 16°30'N to 80°14'E, 15°35'N. The study area is well connected with state highways and district roads. The NH5 passes through Ongole which is a major highway connecting Howrah-Chennai, a part of Asian highway network. The railway in the study area comes under south central railway zone and has good connectivity on Howrah-Chennai main line. The study area has abundant mineral resources of Cement Grade limestone, Iron ores, Copper, Lead minerals, Barite, Quartz, Silica Sand and Granite. Other minerals found in this study area are Diamonds, Diatonaceous Earth, Gypsum, Kankar and White Clays. The average Population density of study area is 174 persons per square kilometre. The loacal cuisine includes typical south Indian style varieties namely Idly, Dosa, Vada etc,. Other famous items include Gongura Pickle, Mirchi Bajji, Avakai Pickle with Traditional Andhra Style Meals. Mostly available fruits and vegetables include Sapota, Mango, Custard Apple, Guava, cucumber, Mirchi etc,. The major commercial crops grown are cotton, tobacco and chilli which are exported to different parts of the world. The study area hosts the largest Asian Market for red chillies. The Indian Tobacco Board is head-quartered in Guntur. The study area suffers from hot climate, the summer especially being extremely tiring. The average temperature of the study area ranges from 23°C to 36°C. The average precipitation during rainy season is around 84mm.

Methodology

DATA COLLECTION :

Different data products required for the study include SOI toposheets bearing the numbers 65D11, 65D12, 65D15, 65D16, 65D8, 65D7, 65D4, 65D3, 66A1, 66A2, 66A5, 66A6, 66A9, 66A13&14 on 1: 50, 000 scale, data of IRS-1D LISS-III satellite imagery obtained from National Remote Sensing Centre (NRSC) and collateral data collected from related Government organizations and demographic data. Data Input and Conversion Satellite imageries collected from NRSC are geo-referenced using the ground control points with SOI toposheets as a reference and further merged to obtain high resolution output in ERDAS Image processing software. The study area is then delineated and subsettee from the data based on the latitude and longitude values and a final hard copy output is prepared for further interpretation.

DATABASE CREATION AND ANALYSIS :

Creating a GIS spatial database is a complex operation, which involves data capture, verification and structuring processes. Raw geographical data are available in many different analogue and digital forms such as toposheets, satellite imageries and tables. Out of all these sources, the source of toposheet is of much concern to natural resource scientist and an environmentalist. In the present study, different thematic layers viz., Drainage, Geomorphology, Land use/Land cover, Slope, Structures, Ground water potential, Ground water Infiltration, Physiography, Transport network maps are generated from toposheet and satellite data using visual interpretation technique. The study-based maps are converted to digital mode using scanning and

automated digitization process. These maps are prepared to a certain scale and show the attributes of entities by different symbols or coloring. The location of entities on the earth's surface is then specified by means of an agreed co-ordinate system. It is mandatory that all spatial data in a GIS are located with respect to a frame of reference. For most GIS, the common frame of reference co-ordinate system is that of plane, Orthogonal Cartesian co-ordinates oriented conventionally North-South and East-West. This entire process is called geo-referencing. The same procedure is also applied on remote sensing data before it is used to prepare thematic maps from satellite data. This digitized data is then exported to ARC/INFO and further processed in Arc View GIS software to create digital database for subsequent data analysis.

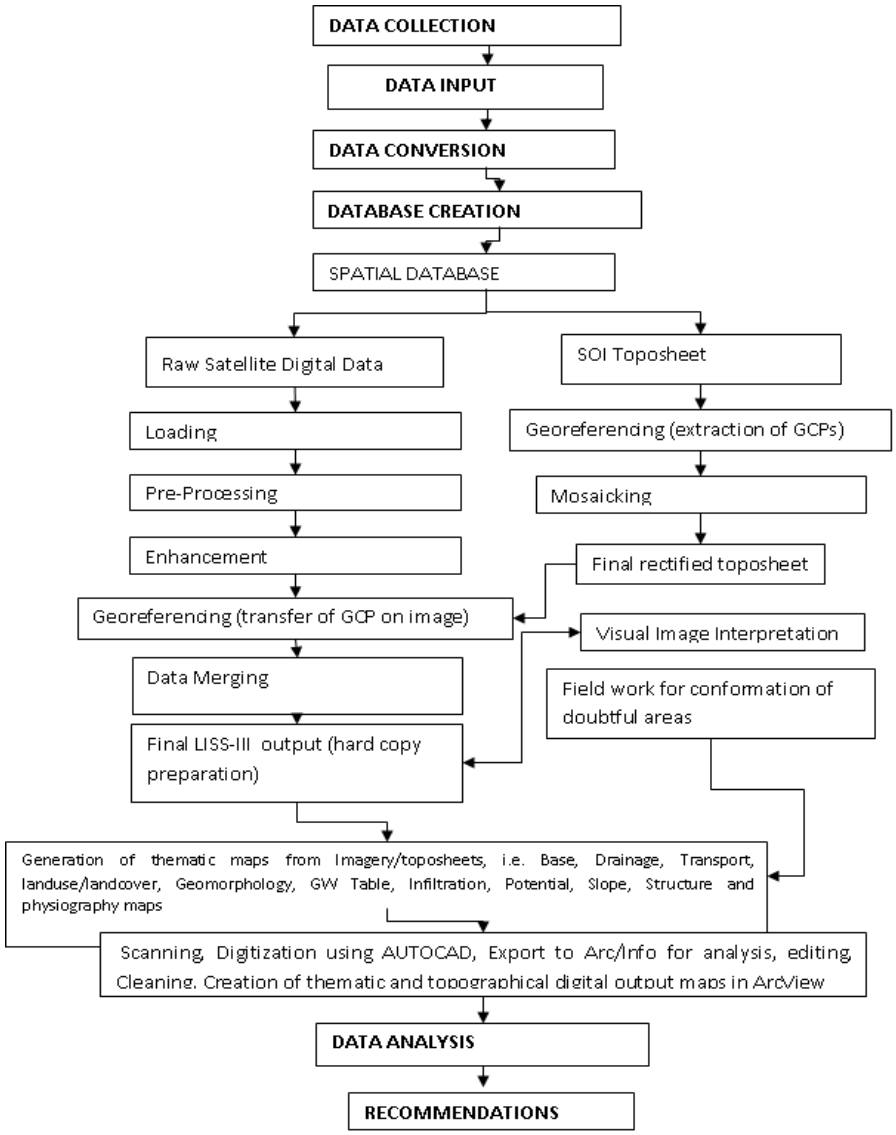


Figure 1: Flow chart showing the methodology adopted for the present study

Results and Discussion

Base map :

A topographic map is a representation of the shape, size, position and relation of the physical features of an area (IMSD Technical Guidelines 1995). The base map is prepared using SOI toposheet on 1: 50, 000 scale and updated with the help of satellite imagery. It consists of various features like the road network, settlements, water bodies, canals, railway track, vegetation etc. delineated from the toposheet. The map thus drawn is scanned and digitized to get a digital output. The information content of this map is used as a baseline data to finalize the physical features of other thematic maps. Since the topo sheets are very old all the features like roads, railways, settlements etc are updated with the help of rectified and scaled satellite imageries of the area. The major settlements in the present study area are Mangalagiri, Ponnur, Tenali, Duggirala, Bapatla, Chirala, Chinaganjam etc.

Drainage pattern :

The drainage map prepared from the toposheet forms the base map for the preparation of thematic maps related to surface and groundwater. All the rivers, tributaries and small stream channels shown on the toposheet are extracted to prepare the drainage map. All the drainage lines are examined very closely and final drainage map is prepared (Thomas M Lillesand et al, 2000). The catchment area of the study area is about 3837 square kilometers. The catchment lies in Guntur and Prakasam Districts. The majority of study area has been observed in Dendritic Drainage pattern, near coastal region parall Drainage pattern and trellis Drainage pattern has also been observed in some area.

Slope map :

slope is one of the principal factors influencing watershed operations. The slope of the land influences the intensity and extent of runoff. The velocity of water flow varies as a square root of the vertical drop. Hence, if the slope increased four times, the velocity of water flowing on the slope is doubled. If the velocity is doubled, the energy and consequently the erosive or cutting capacity is increased four times (APSRAC Technical Guidelines, 1997). In this way the erosive capacity of runoff varies in direct proportion with the slope of a land on which the runoff occurs. The degree of slope sets limits on land use for annual crops, plantation and even on land reclamation, depending on soil depth, nature of the soil, etc. A critical analysis of the basin slope helps in modifying its effect on runoff by the use of transverse channels or terraces or by bounding along contours.

Slope has been categorized into different classes following a guidelines of all India Soil and Land Use Survey (ALS & LUS). To prepare the slope map on 1: 50, 000 scale survey of India topo sheets with 20m contour intervals have been used. Slope classes 1, 3, 4, 5 and 6 are observed in the study area (Figure). Most of the study area is covered by nearly level slope class (99. 8% of the study area). Small part of the study area comes under gently sloping (0. 017%), Gently sloping (0. 024%) and Moderately sloping (0. 019%) class and 0. 18% study area comes under the steep sloping (IMSD Technical Guidelines, 1995).

Physiography :
The purpose of Physiography layer is to understand disposition and distribution of barriers of winds. The Physiography (Figure) is prepared using the contours derived from Survey of India topo sheets. Their physiography categories are demarcated in the map as Plains, Undulating land and Hills. The plains (99. 65 %) occupy the major part of the study area. The next major unit is the undulating terrain (0. 27%),. The third class is hills (0. 08%). (CPCB Technical Guidelines, 1995).

Land Use/Land Cover :
The LU/LC map of the study area is prepared from satellite imagery using visual interpretation technique. This technique consists of a set of image elements, which help in the recognition or interpretation of various land use /land cover features systematically on the enhanced satellite imagery during the classification of features (Lillesand and Kiefer 1994). The land use/ Land cover classification system used in this study is the system, which is pioneered by United States Geological Survey (USGS) and is modified by National Remote Sensing Agency (NRSA) according to Indian conditions. A preliminary image classification key is prepared for the fused pictorial data and is used during interpretation process. The base map is overlaid on the satellite imagery. Then the features of LU/LC classes are extracted and transferred from the satellite pictorial data. The doubtful areas (due to similar spectral response and spectral signature) identified during the preliminary image classification are listed out before ground verification. The doubtful areas are physically verified by field observation, based on which, corrections and modifications of misclassified land use/land cover details are carried out for preparation of final maps so as to extract the entropy or information content in accordance with the above thematic maps. Land use / land cover map showing the spatial distribution of various categories and their aerial extent is vital for the present study. The land use/land cover categories such as built-up land, agriculture, forest, water body and wastelands have been identified and mapped for the study area (Figure). Major part of the study area is covered under Double cropped irrigated region (53. 7%). About (0. 7%)of the study area is under Aquaculture, area under plantation is (4. 7%.), triple cropped irrigated area is about (31. 72%), land with scrub (6%), land without scrub is (2. 8%). Though Kharif un irrigated has been observed at various parts of the study area, Kharif irrigated has been observed on the north east part of the study area plantations are observed at some places of the study area. About 1% of the study area is under Barren stony/sheet rock area.

Geomorphology Map :
Information on landforms is an important input for land management, soil mapping and identification. The aspects of morphography, morphogenesis, morphochronolgy are vital inputs in preparation of geomorphologic maps (Figure). The geomorphological processes, which result from manifold effects of geological and climatological changes, leave their distinctive imprint upon landforms and each geomorphological process develops its own particular assemblage of landforms. Different landforms are identified through interpretation of satellite imagery together

with ground truth data to enable the evaluation of groundwater potential of the watershed. The geomorphological classes observed in the study area (Figure) are pediplain with moderate weathering (PPM) (43%), pediplain with shallow weathering (PPS) (22%), Residual hill (RH) (3%), Coastal plain with deep weathering (CPDW) (11%), Coastal plain with moderate weathering (CPMW) (10%), Coastal plain with Shallow weathering (CPSW) (11%).

Structures map :
Structural features (Figure). found in the study area are lineaments i. e., conformed lineament and inferred lineaments. The conformed lineaments are observed in the central portion of the study area towards west to east and major conformed lineaments are observed in NS corner of the study area. The inferred lineament is observed in SE corner of the study area. These structural-geological studies commence by deciphering planar discontinuities in the rocks, with a view to understanding their characteristics, decomposition and spatial relations.

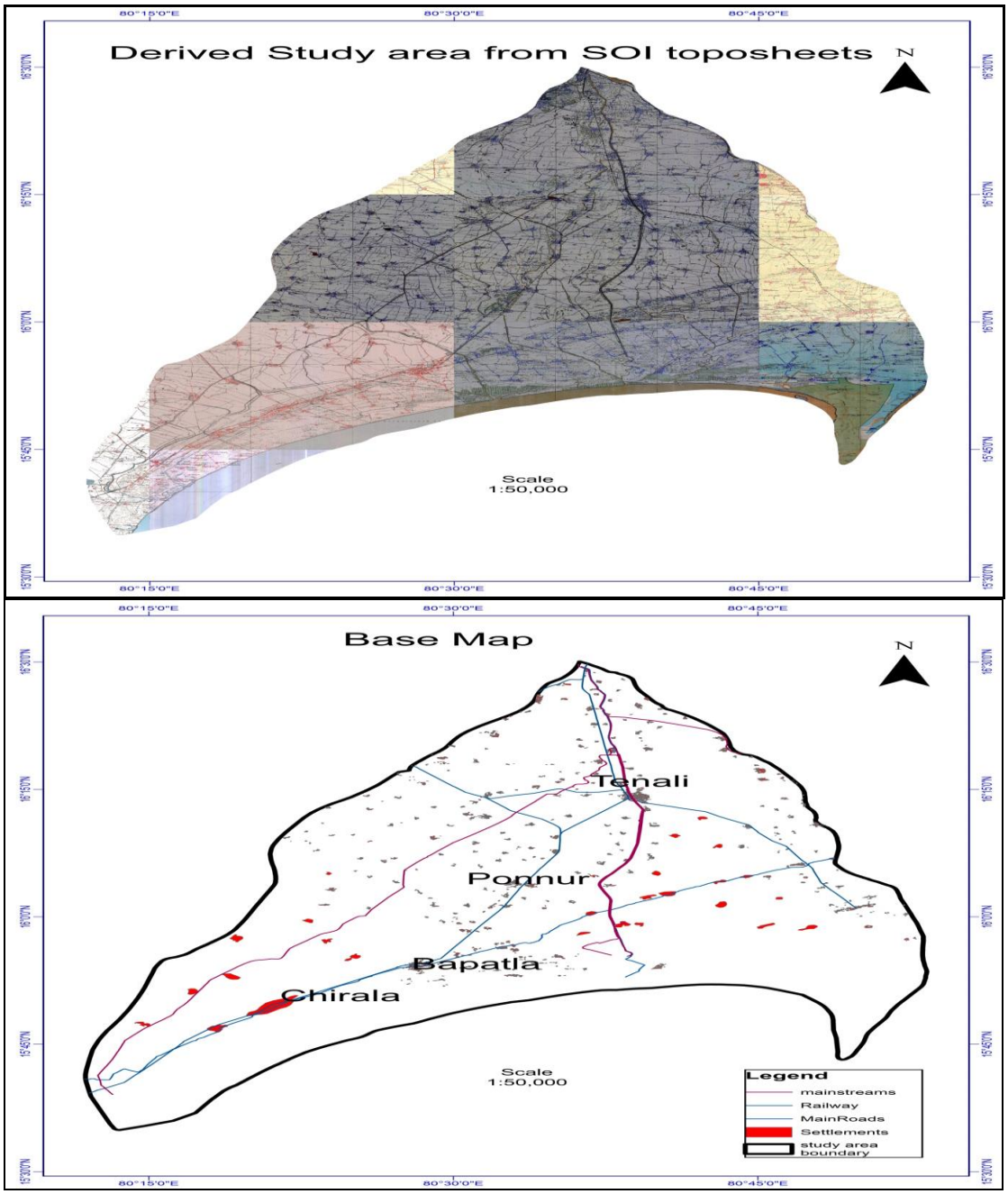
Infiltration rate map :
The infiltration rate plays an important role in determining the contamination risks of groundwater. The infiltration map (Figure) is prepared based on primary and secondary permeability of the lithological terrain. Depending on the infiltration rate the study area is divided into high, medium, and low zones as per Central Pollution Control Board (CPCB) guidelines. It is interpreted based on soil types and its thickness and weathering status. The maximum study area comes under moderate infiltration class (63%). Infiltration is low in impermeable, compact and sheet rock areas observed in some portion of the study area (22. 13%), nil infiltration rate is observed in hilly area (2. 7%), high infiltration rate is observed near coastal region (11. 2%). It is observed that infiltration rate is influenced by urbanization.

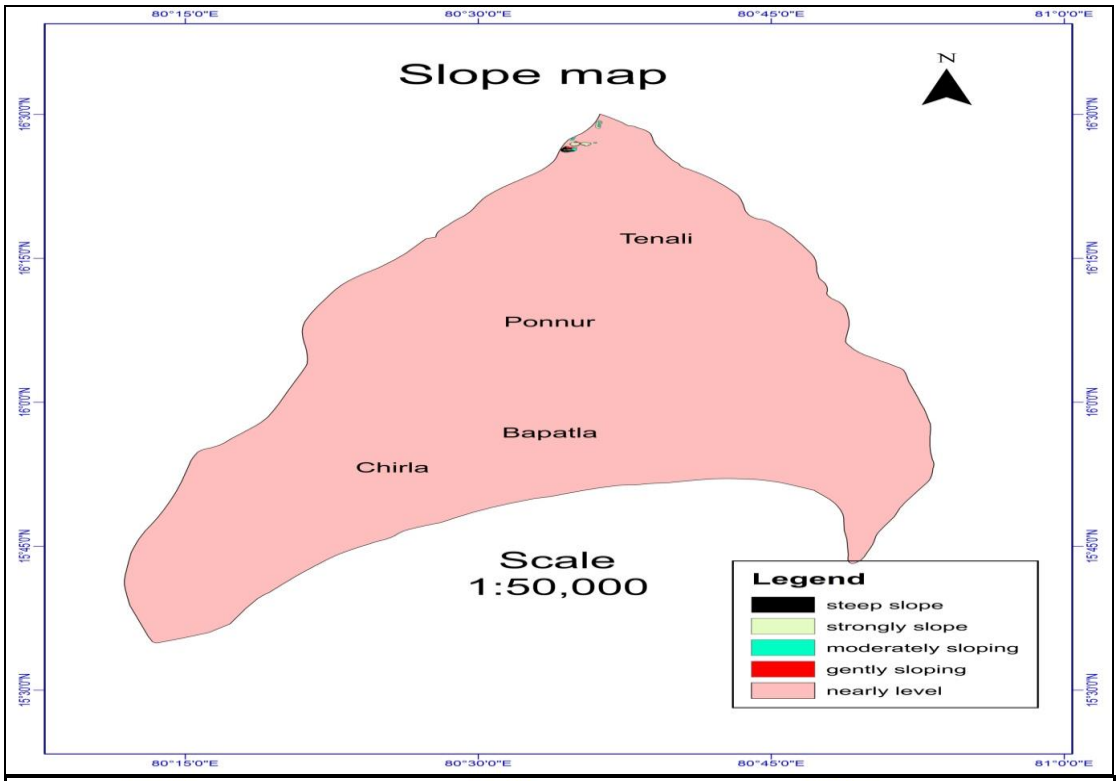
Groundwater table map :
This map (Figure) is prepared based on Central Pollution Control Board (CPCB) guidelines and information obtained from the Central and State Groundwater Departments, using satellite data and toposheet information and besides necessary ground checks. During fieldwork, information about the depths of water levels are obtained from the residents and used in preparation of this map. The maximum study area comes under moderate ground water table class (62. 5%), some areas are coming from high (11. 1%), low (22%) and Nil ground water table class (2%).

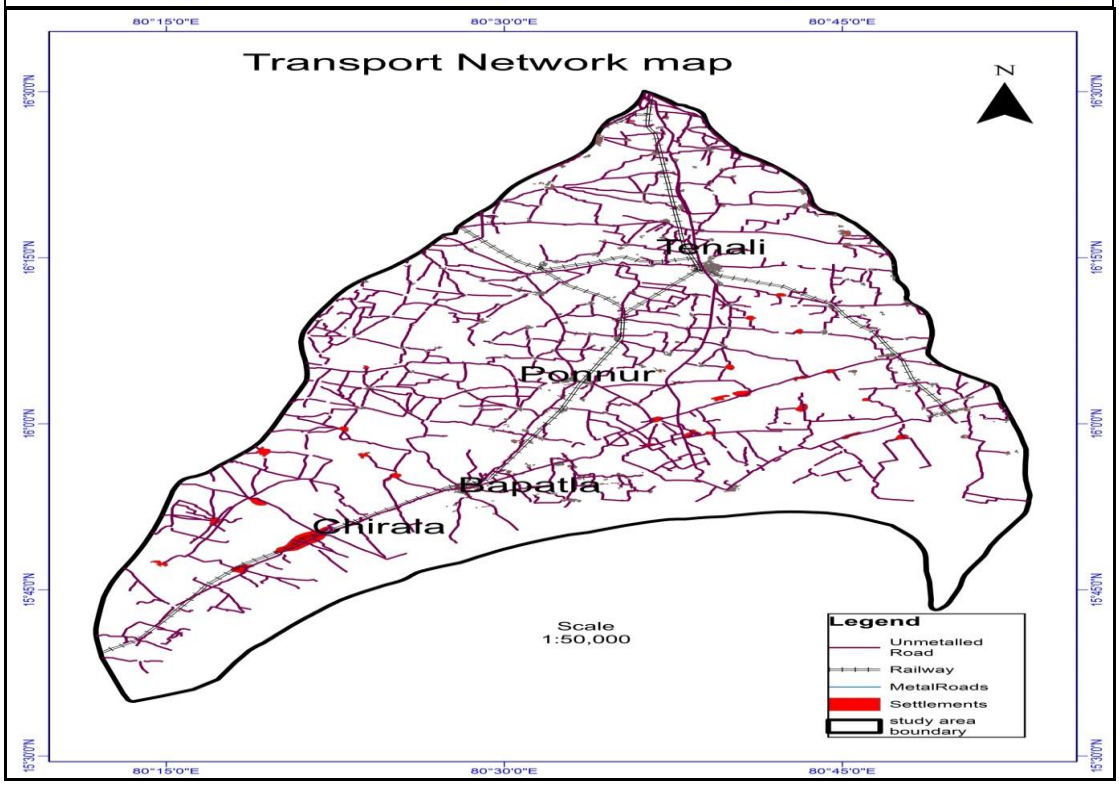
Groundwater potential map :
The groundwater potential map (Figure) is prepared based on the analysis of various themes such as geomorphology, land use / land cover, lineament,, drainage pattern, lithological evidences by using converging evidence concept, besides the collateral data obtained from State Groundwater Board with necessary field checks. The groundwater potential map reveals the available quantum of groundwater and is delineated into zones showing excellent (11%), good to moderate (62. 8%), moderate to poor (22%) and nil (2. 7%) groundwater potential areas.

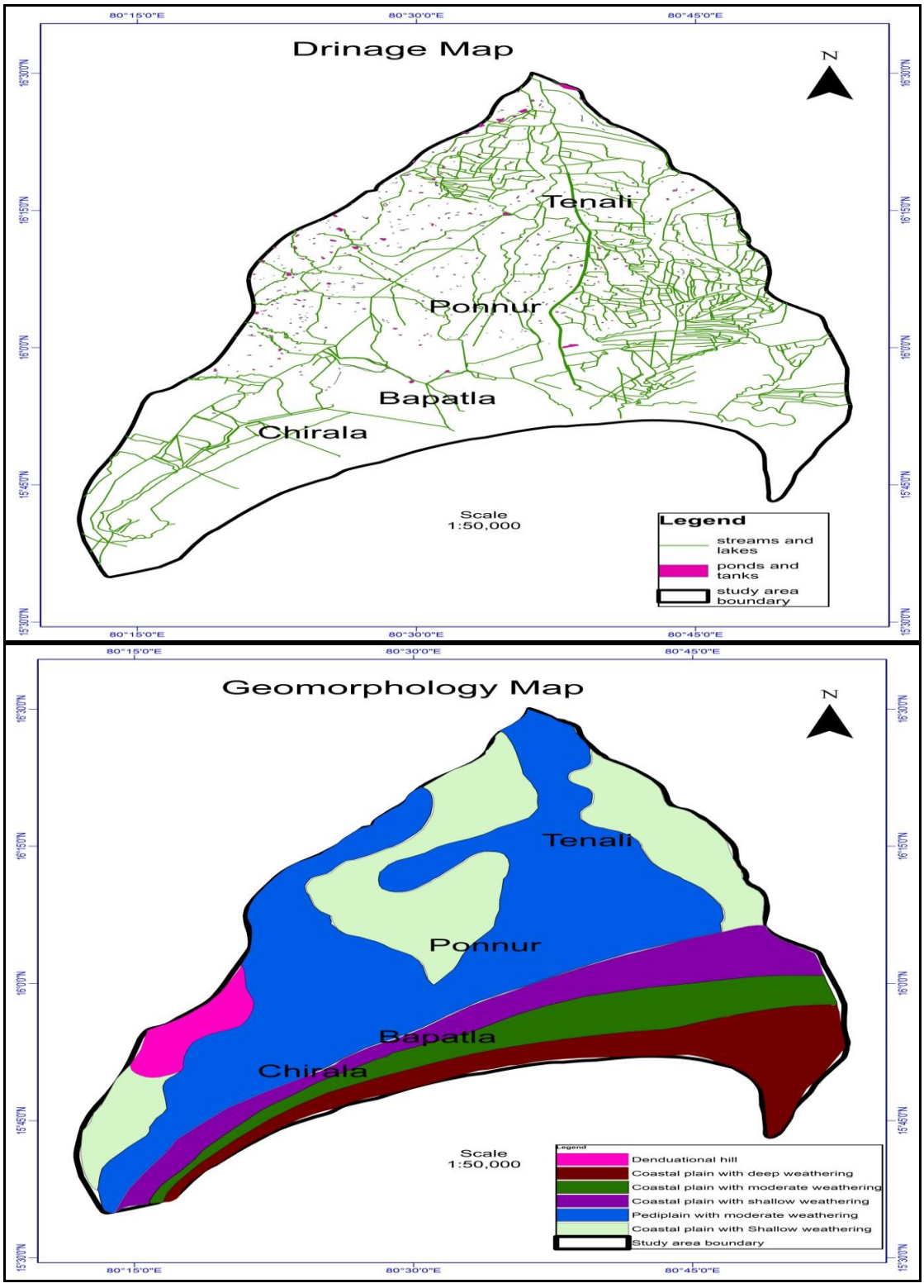
Conclusions

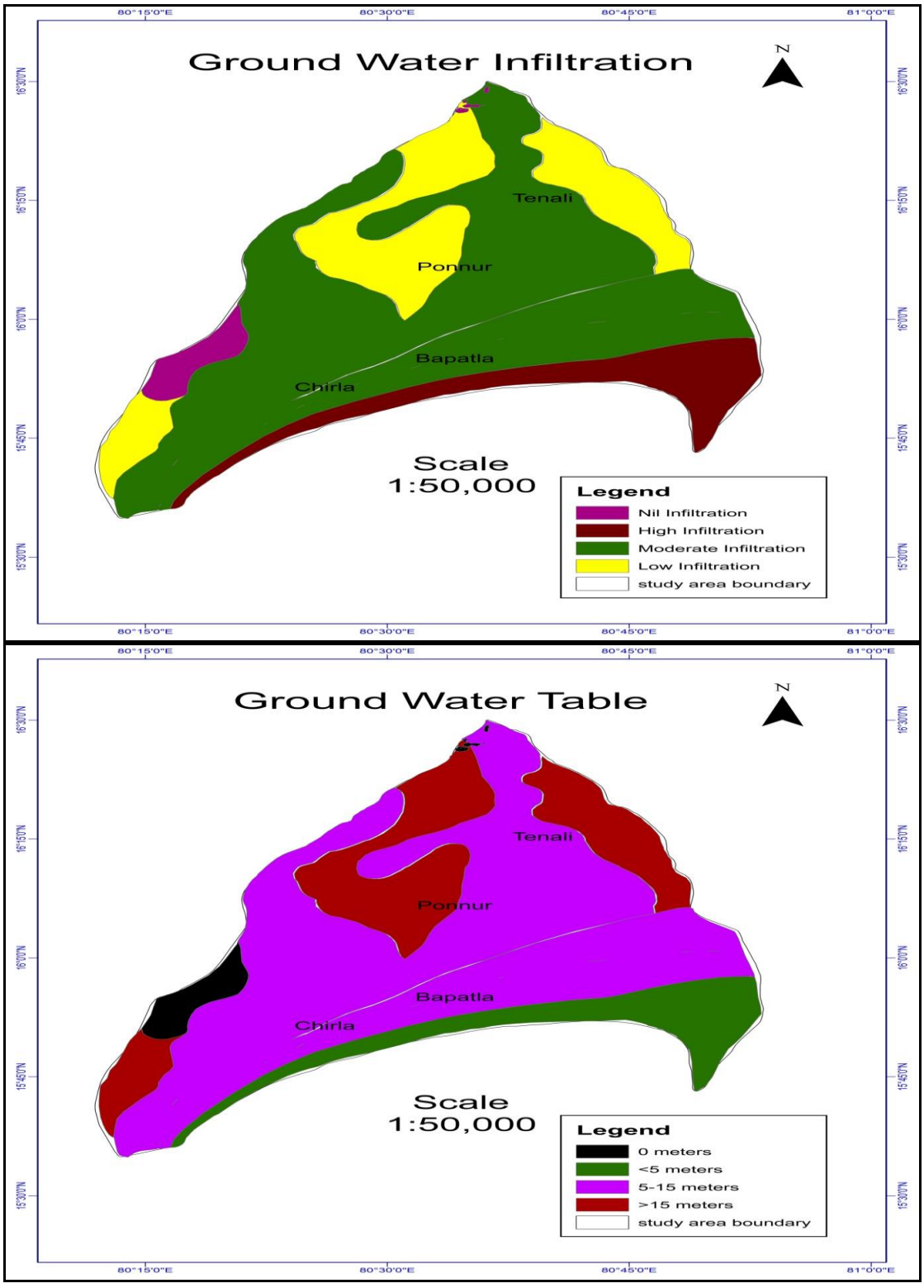
This study obtain the full details of the study area as it is useful for a Decision support of micro planning of Irrigation Management. We can get all details like the Drainage data, demographic (v, details of transportation. The type of study is useful in updating viewing report and hence for making decisions for the end user, any user who is not having any prior knowledge about this study area can also easily find out all the details at one place. This kind of study is useful to apply for any study area for quick and detailed information purpose.

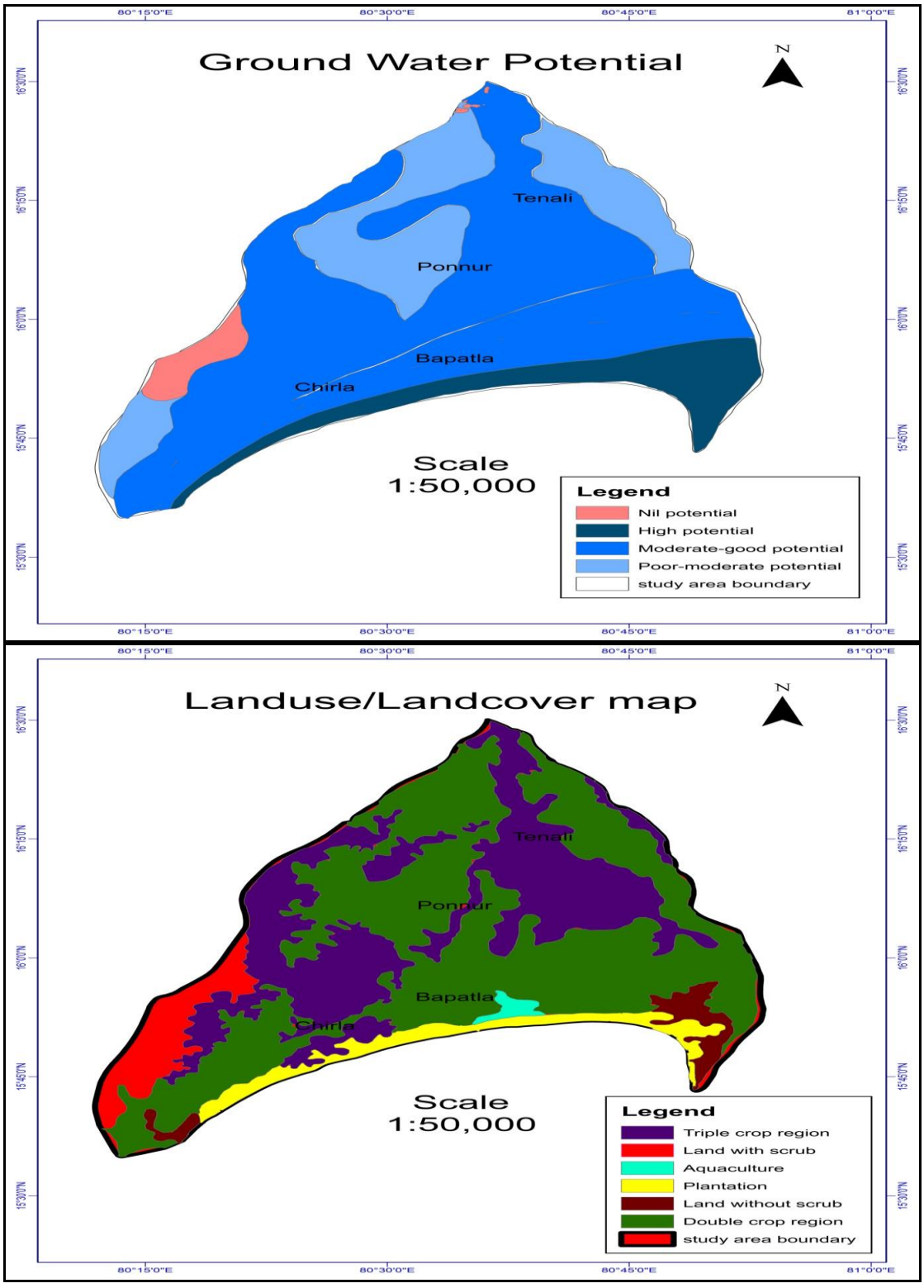


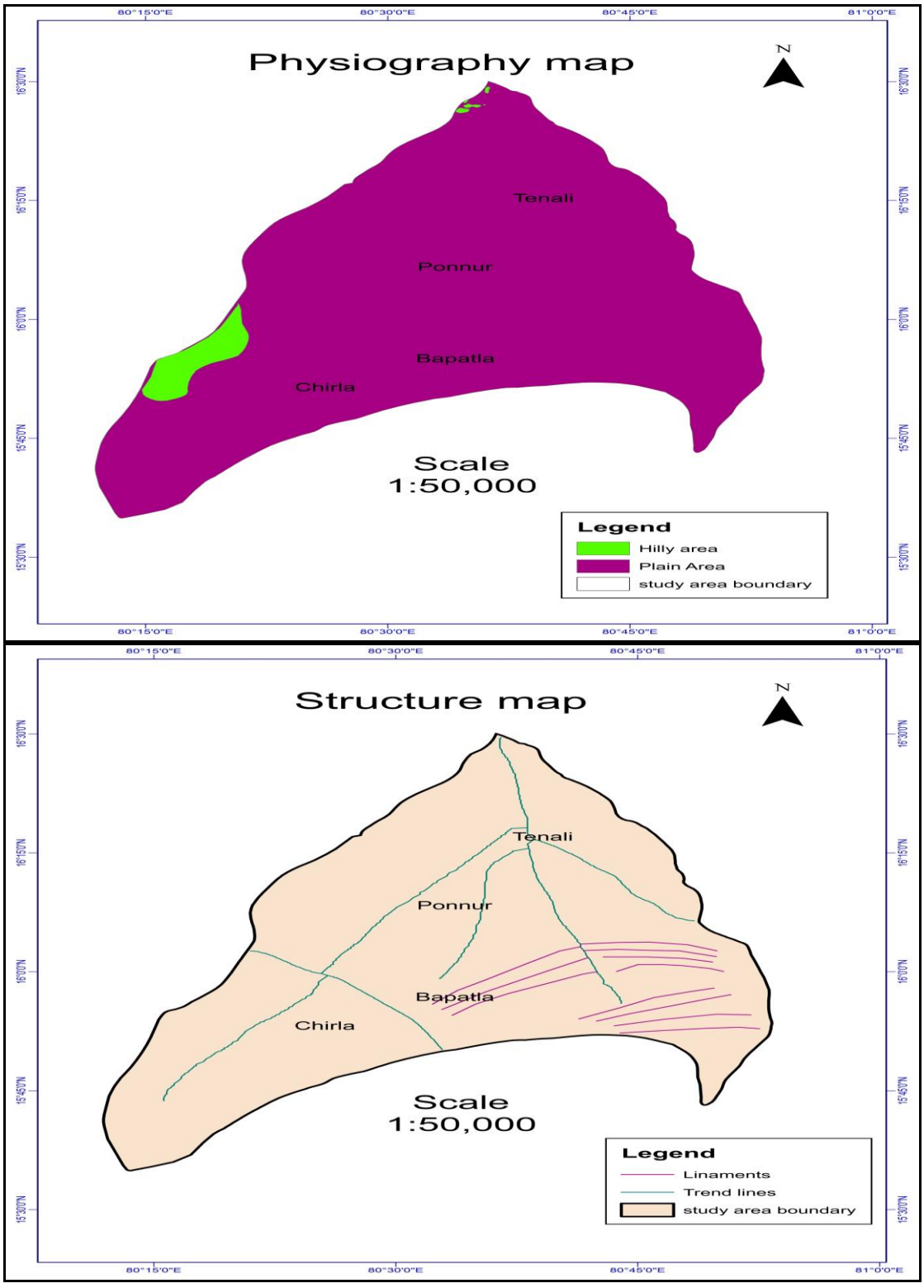

Slope map
N
Tenali
Ponnur
Bapatla
Chirla
Scale
1:50,000
Legend
steep slope
strongly slope
moderately sloping
gently sloping
nearly level


Transport Network map
N
Tenali
Ponnur
Bapatla
Chirala
Scale
1:50,000
Legend
Unmetalled Road
Railway
MetalRoads
Settlements
study area boundary


Drinage Map
N
Tenali
Ponnur
Bapatla
Chirala
Scale
1:50,000
Legend
streams and lakes
ponds and tanks
study area boundary
Geomorphology Map
N
Tenali
Ponnur
Bapatla
Chirala
Scale
1:50,000
Legend
Denduational hill
Coastal plain with deep weathering
Coastal plain with moderate weathering
Coastal plain with shallow weathering
Pediplain with moderate weathering
Coastal plain with Shallow weathering
Study area boundary


Ground Water Infiltration
N
Tenali
Ponnur
Bapatla
Chirla
Scale
1:50,000
Legend
Nil Infiltration
High Infiltration
Moderate Infiltration
Low Infiltration
study area boundary
Ground Water Table
N
Tenali
Ponnur
Bapatla
Chirla
Scale
1:50,000
Legend
0 meters
<5 meters
5-15 meters
>15 meters
study area boundary


Ground Water Potential
N
Tenali
Ponnur
Bapatla
Chirla
Scale
1:50,000
Legend
Nil potential
High potential
Moderate-good potential
Poor-moderate potential
study area boundary
Landuse/Landcover map
N
Tenali
Ponnur
Bapatla
Chirla
Scale
1:50,000
Legend
Triple crop region
Land with scrub
Aquaculture
Plantation
Land without scrub
Double crop region
study area boundary


Physiography map
N
Tenali
Ponnur
Bapatla
Chirla
Scale
1:50,000
Legend
Hilly area
Plain Area
study area boundary
Structure map
N
Tenali
Ponnur
Bapatla
Chirla
Scale
1:50,000
Legend
Linaments
Trend lines
study area boundary

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