

Original Research Article

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Preparation of Thematic Maps and Farming Situation Characterisation of Distributary Command Area using RS and GIS Techniques

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ABSTRACT

This paper reflects the use of newer technologies Remote Sensing (RS) and Geographical Information System (GIS) which play important role in monitoring canal water distribution and its management, cropping pattern identification and geomorphology characterisation of command area. The conjunctive use of surface and groundwater resources aims to harness maximum quantity of water to achieve optimal utilization of total water resources in a canal command area for maximum agricultural productivity. The command area of distributary no.21 is situated in Arang block of Raipur district and located between 21°00'00" and 21°15'00" N latitudes and 81°45'00" and 82°00'00" E longitudes with 311 m to 262 m above mean sea level. False colour composite (FCC) of IRS-P6 LISS IV geocoded data and survey of India (SOI) toposheet on (1:50000) scale were studied in conjunction to extract various information of the distributary command area. Existing land use/land cover, slope, relief aspect, and physiography for characterization and soil texture map was prepared using the data collected and interaction with farmers of study area. Based on the preparation and overlaying of various thematic maps, along with analysis of Agrometeorological, Hydrological & Geomorphological data, four farming situation, as per the local names of soil texture type viz. *Bhata, Matasi, Dorsa, Kanhar* were identified, characterized and mapped based on the soil sampling analysis and peoples participating research interaction of the village. It was found that command area is drained by network of two main streams, *Sakti Nala* and *Shangari Nala*; and paddy was cultivated on 98% area of command area.

Keywords

GIS, LISS IV,
Command Area,
DEM, FCC

Article Info

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Introduction

Water is elixir for life and the most precious gift of nature. Over utilization of surface water of the canal commands, have given rise to deleterious effects, such as (1) water logging, (2) salinization /alkalinization of the soils

causing land degradation and decline in crop productivity and (3) deficit water supply at the tail ends of the command area. In the canal command areas, the available water is not sufficient to meet the requirement for all purpose. GIS is a collection of computer hardware and software, data and skilled

personnel for managing and analyzing geographic data (Maguire *et al.*, 1991). GIS has the capability to manage many layers, integrate and analyze spatial data from different sources, with diverse formats, structures, projections and helps in spatial modeling (Goodchild, 1992).

Naidu and Giridhar (2011) employed GIS for Geo-Spatial Database Creation for Wazirabad Canal Command Area. GIS based system can help to analyze the spatial information about its engineers and farmers to improve planning, management and supply of water resources in command area.

Therefore, high resolution remotely sensed data provides valuable and up-to-date spatial information on natural resources and physical terrain parameters. Geographical Information System (GIS) with its capability of integration and analysis of spatial, aspatial, multi-layered information obtained in a wide variety of formats both from remote sensing and other conventional sources has proved to be an effective tool in planning for canal command development programmes.

Materials and Methods

Description of study area

The study area is a part of command area of Distributary No. 21 of Rudri Barrage Left Main Canal (Mahanadi Main Canal) and its geographic location lies between $81^{\circ} 45' 00''$ to $82^{\circ} 00' 30''$ E longitude and $21^{\circ} 00' 00''$ to $21^{\circ} 15' 00''$ N latitude in Raipur district of Chhattisgarh as shown in Fig. 3.1. Gross commanded area (GCA) of Distributary No.21 was 4863.15ha and culturable command area(CCA) was 3208 ha.

The Distributary no. 21 which serves the study area originates from Mahanadi Main canal. It flows through the nine villages of

Arang block namely Lakholi, Rasni, Kukra, Baihar, Orka, Arang, Ghumrabhata, Kalai and Borid. The general elevation of the area ranges from 262 to 311 m above mean sea level (MSL). It falls in SOI topographical map no. F44 P16 on scale- 1: 50,000. The annual average rainfall of the area is 1317.36 mm (2007-2016).

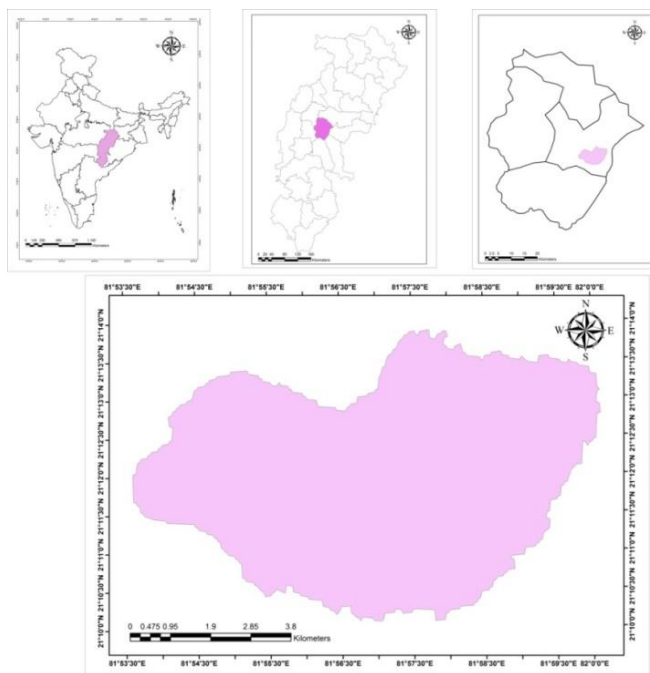


Figure.1 Location of study area

Data collection

Distributary No. 21 command area is covered by topographic map No. F44 P16 (64G/16) of 1:50,000 scale having 10 m contour interval, were collected from Survey of India, Raipur, Chhattisgarh.

The cloud free digital data of the study area were obtained from National Remote Sensing Centre (NRSC), Hyderabad in Compact Disc (CD). The satellite data were in four electromagnetic spectral bands (band 2: 0.45-0.52 μm , band 3: 0.52-0.59 μm , band 4: 0.62-0.68 μm and band 5: 0.77-0.86 μm). Its sensor provided the data of 5.8 m x 5.8 m spatial resolution.

Table.1 Details of satellite image used in the study

Topo sheet	Satellite	Sensor	Resolution (m)	Path	Row	Date of pass
F44 P16	IRSP6	LISS IV	5.8	102	58	23/10/2016

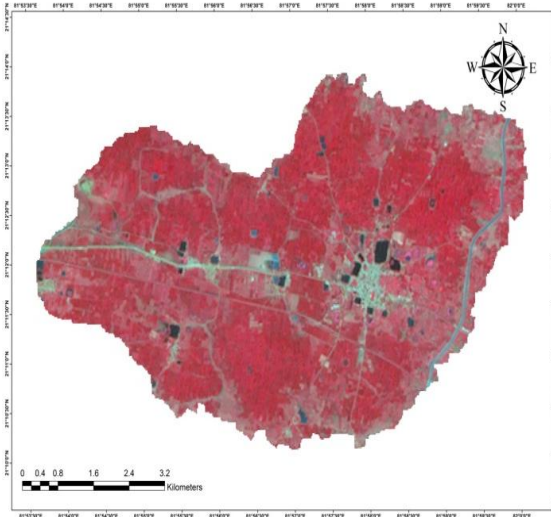


Figure.2 Standard FCC image of study area

Soil texture map of the distributary command area was prepared using Participatory Rural Appraisal (PRA) technique of soil survey and soil data from RAE0.

The area is characterized under Chhattisgarh plains Agro climatic zone .The data on crops acquired from the office of RAE0, Arang block and were processed to find out the existing land use and cropping pattern in the study area.

Data processing

All the required software were available in the Geo-Informatics lab of Soil and Water Engineering Department, IGKV, Raipur, such as ArcGIS 10.4 for digital data analysis and ERDAS IMAGINE 11 for image processing.

Topographic maps F44 P16 with the scale of 1:50000 was scanned and scanned map was registered with respect to grid base using ERDAS IMAGINE 11 software in order to

have real world coordinates through Georeferencing process.

Various maps such as contour map, soil map and command area boundary were digitized in ArcGIS 10 and information available with each map was entered as an attribute value in GIS to prepare the database of a particular thematic map.

Preparation of thematic maps

Boundary of distributary command area

The boundary of distributary command area is prepared manually using topographic map having 10 m contour map, drainage network of the study area and the distributary map obtained from CGWRD on the ArcGIS platform.

Preparation of drainage map

Drainage map comprises of various streams that are flowing in the area. Drainage patterns and textures are key signatures and very important terrain recognition elements, used as criteria for identification of geological and geomorphological phenomena.

Generation of DEM

A DEM is a numerical representation of landscape topography. DEM is the digital representation of the topographic surface. DEM was prepared using contour lines and elevation points extracted from SOI toposheets and additional attributes observed from GPS.

Generation of contour map

The contour map of the study area was drawn with the help of the toposheets and DEM. The contours were drawn at 10 meter intervals.

Generation of slope map

The slope map was prepared from DEM and contour map. 3D analyst tool is then used to convert digitized contours into Triangulated Irregular Network (TIN) model and then to DEM. From this DEM, slope map was generated using this process: Arc GIS 3D Analyst tool Surface analysis Slope Percentage function.

Soil texture map

The soil texture was the only physical property that was analyzed in laboratory. The soil texture of the study area was calculated by using International Pipette method; map was prepared using Arc GIS 10.

Land use/land cover classification

The ERDAS IMAGINE 11 software has been used for land use/cover classification in this study. Most common land use classification method “supervised classification” also known as pixel based classification was used in this study.

Maximum Likelihood Classifier (MLC) module was used for classifying the land uses. The False Colour Composite of the year 2016 is used for land use/cover classification in this study.

Results and Discussion

Generation of base map

A Base map is the frame to which all ancillary data will be registered. The base map is

prepared using Survey of India Toposheet F44 P16 on 1:50000 scale. The map, thus, drawn is scanned and digitized to get a digital output. Command area of Distributary No. 21 was used for this study.

Preparation of thematic map

On the basis of standard methodologies described in materials and methods, following given maps have been prepared.

Boundary of distributary no. 21

The geographical area of the Distributary No. 21 is 4863.15 ha. The boundaries were digitized as described previously. The maps of Boundary of Distributary No. 21 are shown in Figure 3.

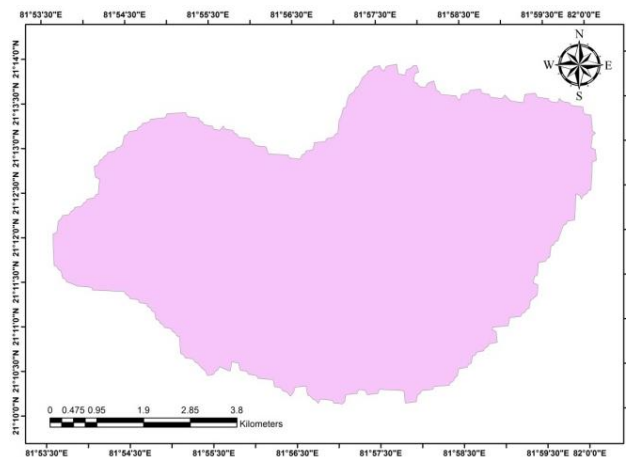


Figure.3 Boundary of Distributary No. 21

Distributary network map

The Distributary No. 21 consists of 6 minor namely Borid minor, Rasni-Kukra minor, Arang minor 1, Arang minor 2, Odka-Baihar minor and Rasni Baihar minor.

Each minor is named after the village it irrigates. The Distributary Network Map the command area is shown in Figure 4.

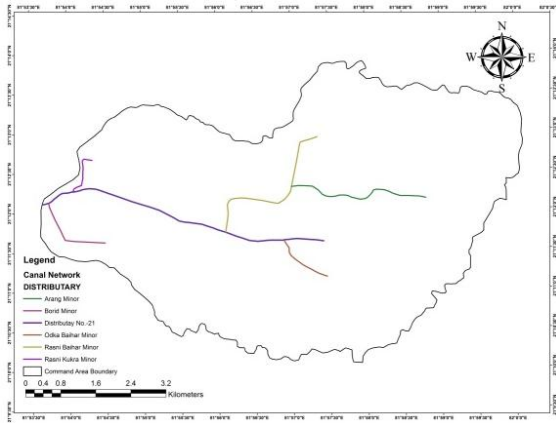


Figure.4 Distributary Network map

Drainage map of distributary command area

Drainage map was prepared by using Survey of India Topographic maps on 1:50,000 followed by further modification in ArcGIS using Spatial Analyst Tools. All the streams existing in this command area and their order are marked in Figure5. The entire area of the command area is drained by two main streams, Sakti Nala and Sanghari Nala.

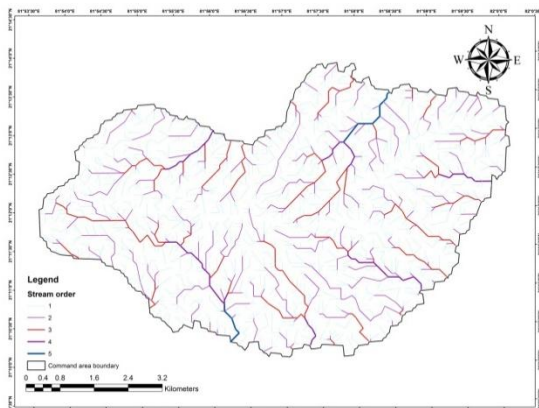


Figure.5 Drainage map distributary command area

DEM of distributary command area

DEM is the digital representation of the topographic surface. DEM was prepared using contour lines and elevation points extracted from SOI toposheets and additional attributes observed from GPS in the study

watershed. Figure6 shows the DEM of the study area. Different colours give different zones of interpolation. The accuracy of results obtained from a DEM depends on the recent topography or contours and resolution. The DEM was prepared from the contours traced from the topographic sheet.

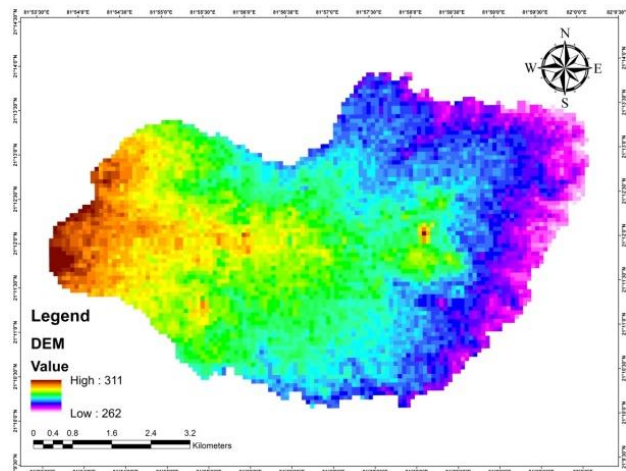


Figure.6 DEM of distributary command area

Contour map of distributary command area

The Contour Map was generated through GIS Digital Elevation Model (DEM) of 30 m by 30 m resolution of the study area. Figure7 shows the Contour Map of the study area.

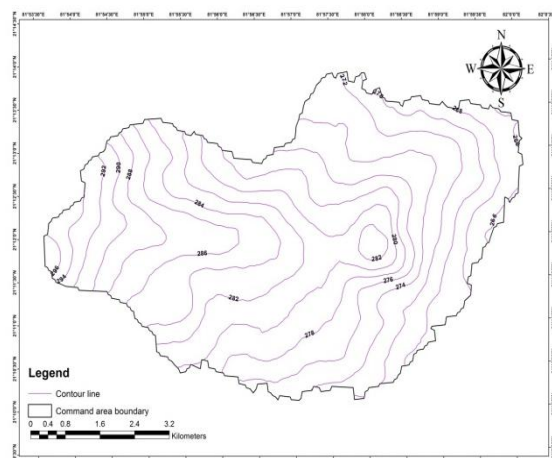


Figure.7 Contour Map of distributary command area

Table.2 Slope categories

Class	Percentage (%)	Slope Category
I	0-1	Nearly level
II	1-2	Very gentle sloping
III	2-5	Gently sloping
IV	5-10	Moderately sloping
V	10-12	Strongly sloping

Slope map of distributary command area

The slope values can be measured either in percentage or degrees. The slope map (Figure8) was prepared using the contour information of survey of India topographical maps on 1:50000 scales with 10-meter contour interval and further worked in ArcGIS to generate the slope map. The different classes of slopes corresponding to their percentages were categorized in Table 2.

The slope information is useful in understanding the topography, geomorphology soil types and their erodibility, surface drainage. Slope is a vital for land capability assessment, formulating soil and water conservation measure.

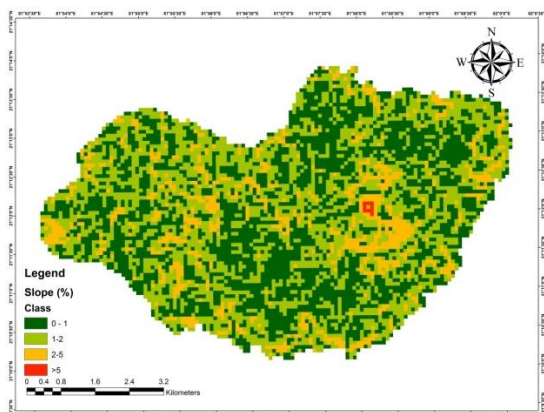


Figure.8 Slope map of distributary command area

Land use/cover map of the distributary command area

The NRSC Data Centre, Hyderabad provided the cloud free geocoded digital data of IRS-R2 (LISS-IV) in CD ROM. The imagery, which covers the distributary command area, was used in the study. Pixel based classification technique was used to classify the land under Five Class.

Area under different land use classes obtained after classification are given in the Table No. 3 and Fig. 9. The results showed that there were 5 land use classes in the watershed with major part of the study area is dominated by Lowland Paddy (1557.48 ha) which is 32.03% of the total area.

This is followed by current fallow (1232.27ha) which is 25.34% and Midland Paddy (1138.59 ha) which is 23.41% of the total area. Settlement occupies 780.13 ha which is 16.04% of the total area.

Water body contributes 3.18% of the total area. Distributary command area is mainly single cropped and paddy is the major crop during *kharif* season.

Table.3 Land Resources use pattern of small watershed

Value	Land use	Area (ha)	Area in Percent(%)
1	Water Body	154.67	3.18
2	Current Fallow	1232.27	25.34
3	Lowland paddy	1557.48	32.03
4	Midland paddy	1138.59	23.41
5	Settlement	780.13	16.04
	Total	4863.15	100.00

Table.4 Area under different soil texture

Village Name	Type Of Soil			
	Bhata(ha)	Matasi(ha)	Dorsa(ha)	Kanhar(ha)
Arang	202	216	229	1251
Baihar	0	27.88	83.64	167.28
Borid	0	0	0	560.3
Ghumrabhata	0	0	56.4	84.6
Kalai	0	9.6	44.8	120.78
Kukra	0	155.6	99.3	191.5
Lakholi	10	169	105	185
Orka	0	0	0	174.4
Rasni	0	72.01	216.02	432.04
Total	212	650.09	834.16	3166.9
Percentage (%)	4.35	13.37	17.17	65.12

Farming situation (soil texture)

The soil texture was the only physical property that was analysed in laboratory. Four farming situation, as per the local names of soil texture type viz. *Bhata, Matasi, Dorsa, Kanhar* were identified, characterized and mapped based on the soil sampling analysis and peoples participating research interaction of the village.

The predominant textures of the soil profiles in the entire study area were found to be Vertisols (*kanhar*) contribute 9992.178 ha, which is 65.12% of the total area, followed by Alfisol(*dorsa*) 834.16 ha, Inceptisols(*matasi*) 650.09 ha and Entisols(*bhata*) 212 ha as given in Table 4 and Fig. 10. Soil erosion depends much on the infiltration rate of a soil. The properties of soil in study area is given in Table No. 5.

Table.5 Physio-chemical properties of soil of study area

Partiulars	Bhata	Matasi	Dorsa	Kanhar
Soil depth(cm)	5-25	25-75	75-100	>100
Sand (%)	50-75	30-55	20-35	15-30
Silt (%)	15-30	30-55	25-35	20-35
Clay (%)	10-25	20-40	34-50	45-50
Bulk density(g/cc)	1.75-1.85	1.56-1.66	1.36-1.66	1.29-30
pH	5.5-6.5	6.4-7.0	7.0-7.5	7.4-7.7
Infiltration (cm/hr)	4.1-6	0.5-2.9	1.30-1.60	1.3-1.35
Available water(cm/m)	2.2	8.8	17.5	17

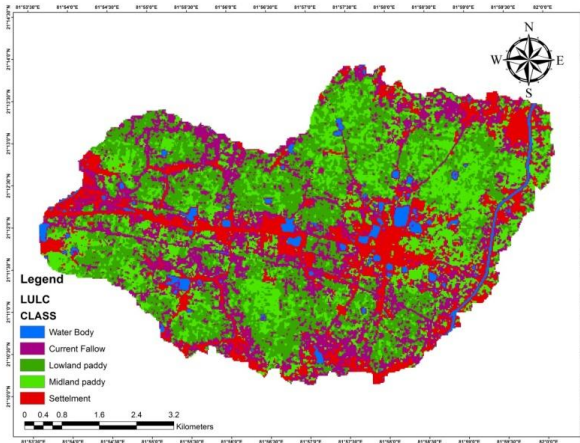


Figure.9 Land use/cover map of distributary command area

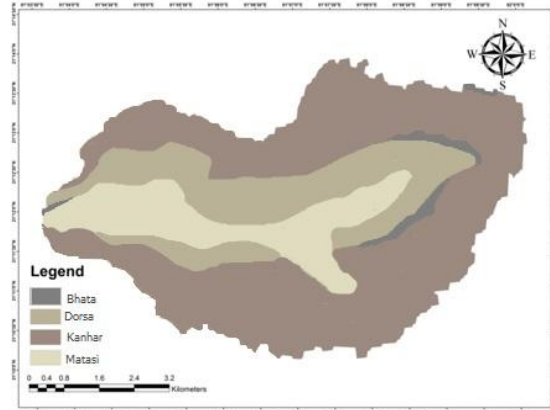


Figure.10 Soil Texture map of distributary command area

In the present study, GIS has been extensively used in determination of geomorphological parameters of the command area. The command area has sufficient potential to meet the ever increasing demand of water if harvest and conserve properly. Statistics on farming situation of the study area has already revealed that a significant portion of the fallow land can be brought under cultivation if proper water and land management practices are performed. In the present study, GIS has been extensively used in determination of geomorphological parameters of the command area. GIS can

handle a large amount of spatial and non-spatial data (Ramkrishnan, *et al.*, 2009). The integration of Remote Sensing and GIS along with field data provides an appropriate approach for solving various resources management problems.

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