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Management and Monitoring of Watershed through Remote Sensing and GIS- A Case Study from Eastern Part of Yavatmal District, Maharashtra

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ABSTRACT: Remote sensing (RS) and geographical information system (GIS) is a powerful tool for the management and planning of watershed. In the present work, we studied the management and monitoring of watershed to restore the ecological balance by harnessing, conserving and developing degraded natural resources such as soil, vegetative cover and water using RS and GIS technique. Ridge to valley concept is adopted for sustainable watershed development of the area. The remote sensing satellite data of IRS-P6 satellite system was used for the present investigations. The thematic maps were interpreted using heads-up interpretation techniques in ArcGIS platform. Based on present studies important water and soil conservation measures are suggested in the action plan map. Present study can help in prevention of soil run-off, regeneration of natural vegetation, rain water harvesting and recharging of the groundwater.

KEYWORDS: Remote Sensing, GIS, Watershed management.

I. INTRODUCTION

Watershed is the hydro-geological unit of an area from which the rain water drains through a single outlet. A Watershed is considered as the ideal unit for integrated management of soil, water and vegetation in a geographical region. Soil and vegetation can also be managed conveniently and efficiently in this unit. Watershed in this sense is the ideal unit for planning, implementation and monitoring of projects pertaining to integrated natural resources management and it is the focal point for rural development. The remote sensing (RS) and geographic information system (GIS) technology is effectively used in mapping and monitoring of natural resources including watershed (Wijesekera et al. [1], Khadari et al. [2], Aher et al. [3], Reddy et al. [4]). The main objectives of the management and monitoring of watershed are to restore the ecological balance by harnessing, conserving and developing degraded natural resources such as soil, vegetative cover and water. The outcome is prevention of soil run-off, regeneration of natural vegetation, rain water harvesting and recharging of the groundwater table.

The main objective of the present work is to create spatial digital database consisting base map, road network, land use / land cover, hydrogeomorphology, slope, physiography, soil, drainage network, watershed and groundwater prospects map using RS and GIS. This will help to extract and understand the topographic characteristics of the study area for effective management and future development of land and water resources.

II. STUDY AREA

The study area comprises of 1770 sq. km of Wani tahsil and its surrounding areas of Yavatmal district of Maharashtra. It spans from longitude 79°8'59" E and latitude 19°53'48" N to longitude 78°38'17" E and latitude 20°12' 16" N covering the entire Wani tehsil and part of Maregaon, Ralegaon and Zari Zamni talukas of Yavatmal district (Fig.1)

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The proposed study area comprises of 8 watersheds viz., WRN-1, WRN-2, from Wardha and Nirguda rivers, WR-6A, WR-7A, WR-8A from Wardha River and PGV-1, PGV-2, PGV-3 from lower Penganga and Vaidarbha, and PG-12 from Penganga. The area is included in Survey of India toposheet numbers 55L/11, 55L/12, 55L/15, 55L16, 56 I/9, 56 I/13, 56 M/1 and 56P/4.

Geologically most of the area is covered with basaltic lava flows of Deccan Volcanic Province. They are mostly exposed along northwestern part of the study area. The oldest rock units are exposed in the southeastern part of the study area and are represented by Neoproterozoic Penganga limestones and shales, which are followed upward by lower Gondwana rocks represented by sandstone, shale and coal of Barakar Formation and sandstones of Kamthi Formation. Gondwanas are overlain by buff and purple coloured shales and cherty limestones of Lameta Formation, which in turn overlain by Deccan basalts and alluvium.

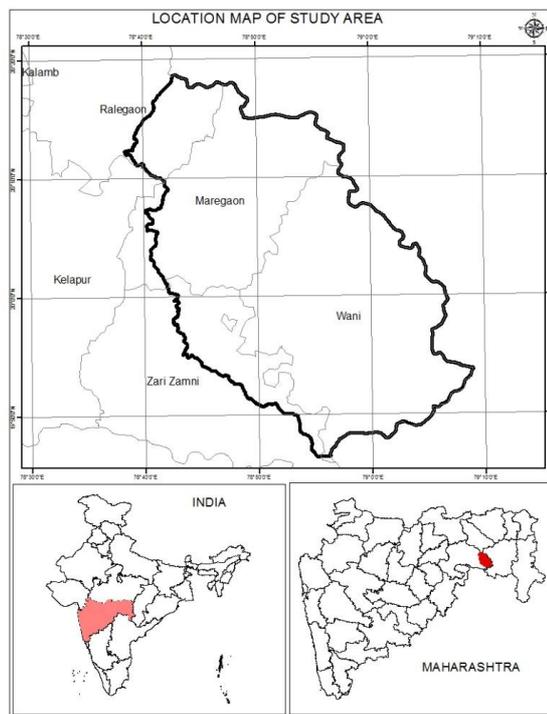


Fig. 1. Location map of study area

III. SATELLITE DATA USED

The remote sensing satellite images used for the interpretation of various thematic maps is given in table 1.

Table 1: Details of satellites data used

Year	Path Row - 100-58/ 99/58 Satellite/Sensor	Date
2005-06	IRS IC – sensor – LISS III	4 November 2005, 15 January 2006, 21 April 2006
2011-12	IRS P6 – sensor - LISS III	November 2011, January 2012, April 2012
2015-16	Resourcesat2	November 2015, January 2016, May 2016

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IV. THEMATIC MAPS

In Watershed Management, four thematic maps namely geomorphology, land use/land cover, slope and soil land capability were prepared along with land and water resources development for the study area. These thematic maps are the main inputs for the scientific planning of watershed.

1. Geomorphology

The geomorphology of the area is interpreted from the satellite images (Fig.2). The analysis of the geomorphological map reveals that the area is hilly towards north western side with all drainage originated from the hill ranges. The gentle undulating topography is present towards the southeastern side of the basin. In the study area, there are three regions viz. Wardha River (WR), Wardha and Niguda River (WRN) and Penganga Vaidharba (PGV) region of watershed. The hilly area situated at the northwestern side of the study area, is underlain by Deccan Trap and the landforms associated with them are butte, escarpment, moderately dissected plateau, slightly dissected plateau, plateau undissected and weathered plateau. The Penganga rocks are present in the central portion of the study area. Landforms associated with them are pediment (PD), pediplain shallow (PPS), pediplain moderate (PPM) and structural hills (SH). Landforms associated with recent formations are alluvium, older alluvium (AYM) and flood plains which are mainly situated along the bank of Wardha River and acts as storage zone.

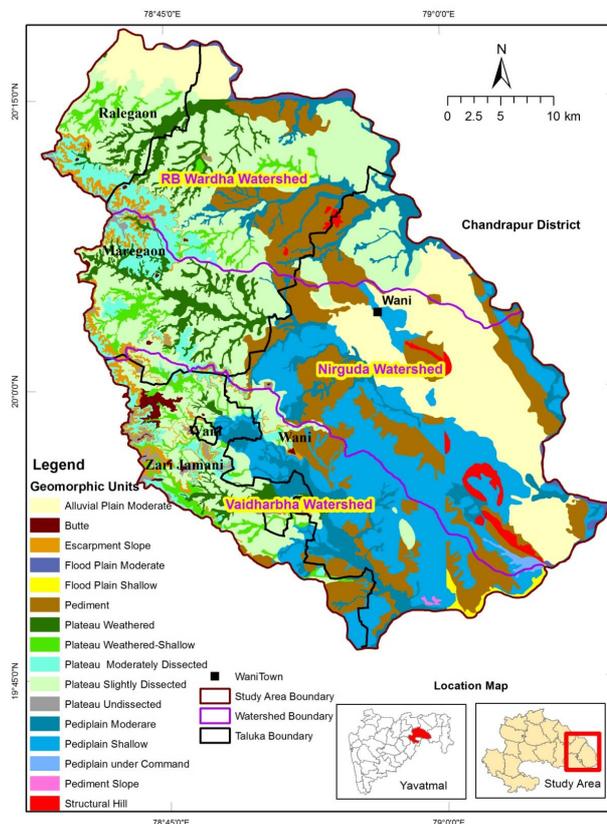


Fig. 2. Geomorphological map of study area

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2. Land use land cover

Major land use land cover category in the study area is Kharif crop. Forest is mainly situated in the Wani and Maregaon talukas of study area (Fig.3). Here the dominant category is open forest and scrub forest. Dense forest is mainly present in the hilly region of Zari Zamni taluka. Scrub land is mainly dominating in the foothill slope of the study area and major mining areas are confined along Wardha valley.

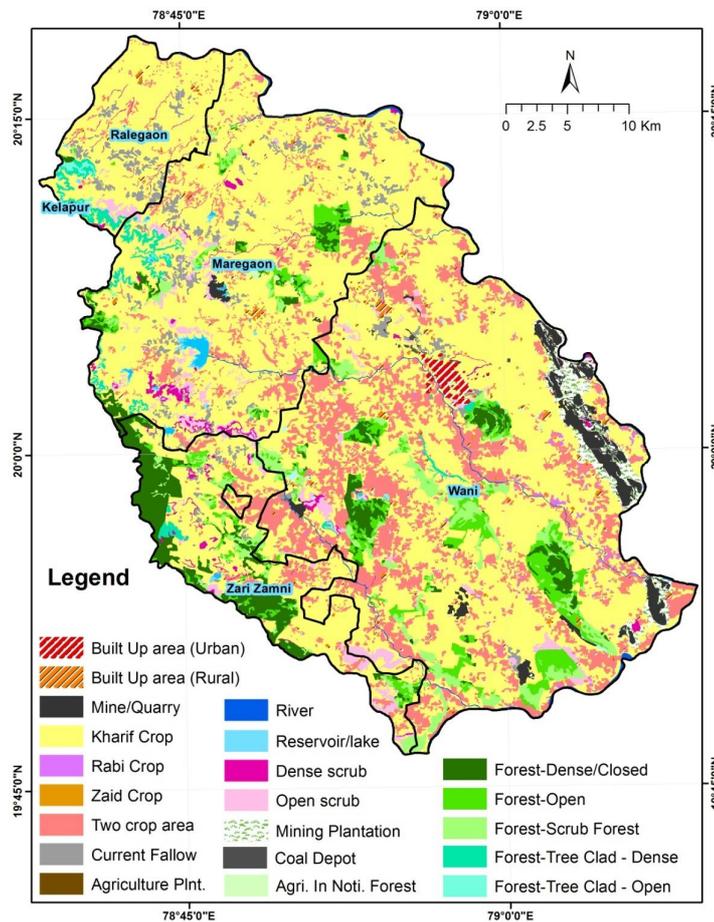


Fig. 3. Land use- land cover map of study area

3. Slope map

Slope map is an important input in the preparation of land resources development plan and water resources development plan, since it controls the factors of soil formation, the type of land utilization and recharge to groundwater (MRSAC [5]). The taluka wise area under various slope categories is given in table 2.

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Table 2: Taluka wise area under various slope categories

Sr No.	Slope Category	Slope %	Taluka wise area in km ²					Total area
			Wani	Maregaon	Ralegaon	Zari Zamani	Kelapur	
1	Very Gentle Slope (2)	1 to 3	766.81	320.76	93.15	81.18	NP	1261.9
2	Gently Sloping (3)	3 to 5	93.92	158.32	24.37	74.04	0.01	350.66
3	Moderately Sloping (4)	5 to 10	11.81	19.68	7.28	27.16	NP	65.93
4	Strongly Sloping (5)	10 to 15	2.80	6.81	2.89	3.49	0.05	16.04
5	Moderately Steep to Steep (6)	15 to 35	6.78	5.95	5.25	11.54	NP	29.52
			882.12	511.52	132.94	197.41	0.06	1724.05

Above table indicates that about 73.19% of the geographical area has very gentle slope and mostly present in the south-eastern side of the area. The area under higher slope (Slope more than 3 %) accounts for 26.80% of the study area and which is situated in the western and north western side (Fig.4)

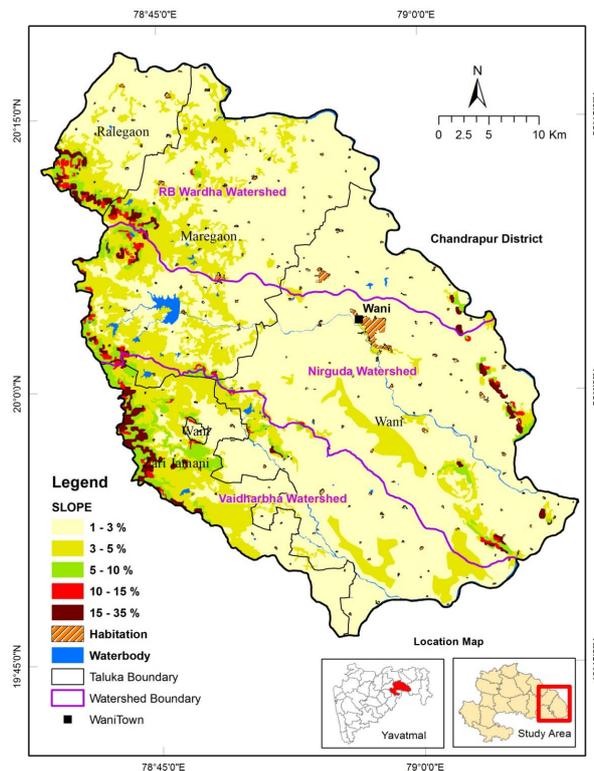


Fig. 4. Slope map of study area

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4. Soil map (Land capability)

The land capability classification places all the soil in eight capability classes. The risk of soil damage or limitation in the use becomes progressively greater from class I to Class VIII. Soil in the I to IV class is under good management and capable of producing deep rooted crops, such as forest trees, commonly cultivated field crops and pastures. Soils in class V, VI, VII and VIII are suited for the use of adopted native plants. Out of the 714 km² of study area, 36% of the geographical area is occupied by land capability class II and 433.84 km² areas (21.86% to geographical area) is occupied by land capability class III (Fig.5). The maximum soil limitation is present in the Penganga and Vaidharbha River watershed (PGV-1, PGV-2, PGV-3) i.e. 37.15% to geographical area of watershed followed by Wardha and Nirguda River (WRN-1, WRN-2) i.e. 30% to geographical area of watershed.

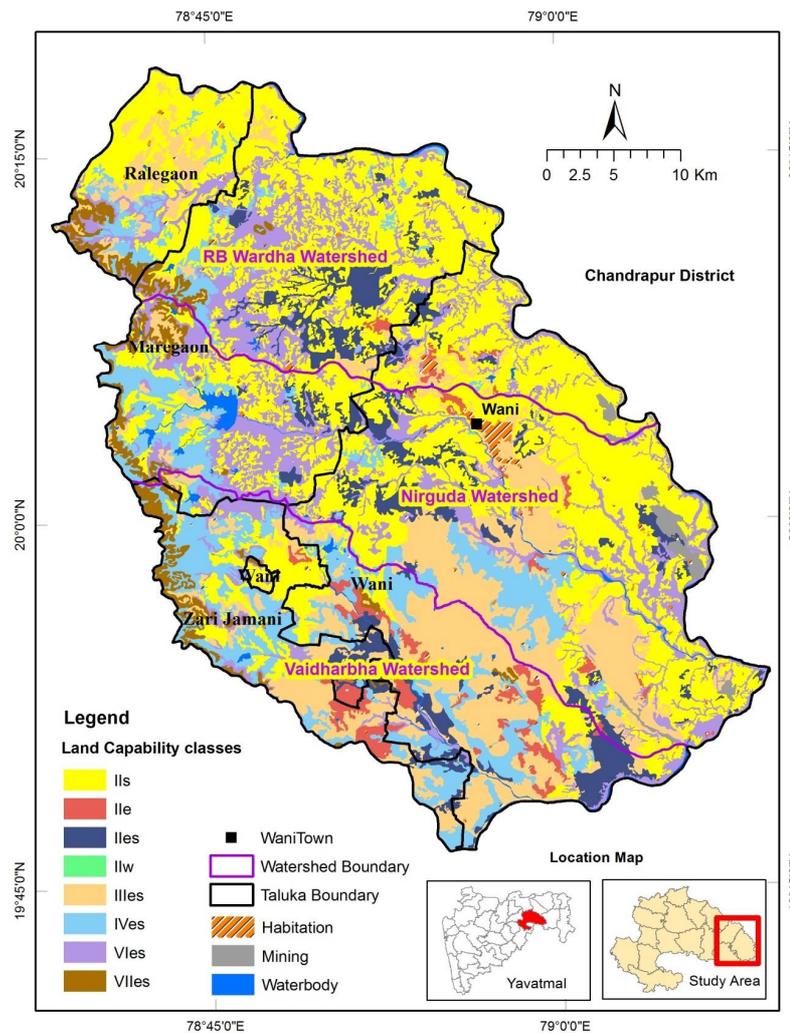


Fig.5. Soil (Land capability) map of study area

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V. WATER AND LAND RESOURCES DEVELOPMENT PLAN

In Water and Land Resources Development Plan, the main objective is to classify the geographical area in to three important hydro-morphological characters like runoff zone, recharge zone and storage zone. The layers are integrated by assigning weightages for individual themes viz. Slope map, Geomorphological map, Soil Land capability map and Land use land cover map (Fig.6). Here internal weights are given according to the ridge-to-valley concept. The weightages are given such that low weight corresponds to runoff while higher weight corresponds to storage zone.

For water conservation, gully plug, looseboulder structures, earthen nalla bund, cement nalla bund, nalla deepening with recharge shaft are suggested as drainage line treatment. For area treatment, dug well flooding, bore well flooding, farm pond and continuous contour trenching (CCT) and artificial rain water harvesting is suggested.

For soil conservation measures, afforestation with CCT, conservation of forest, conservation of forest with WAT and CCT, social forestry plantation with CCT, pasture development with CCT, agro-forestry with farm bund, dry land agro-horticulture with farm pond and farm bund, irrigated agro-horticulture with farm bund, intensive agriculture with farm bund and farm pond, horticulture plantation with contour bund and horticulture plantation are suggested (Fig.7). In canal command area, water harvesting structures like Gabion and Vanrai bandhara is suggested. In urban and rural areas, artificial groundwater recharge is recommended.

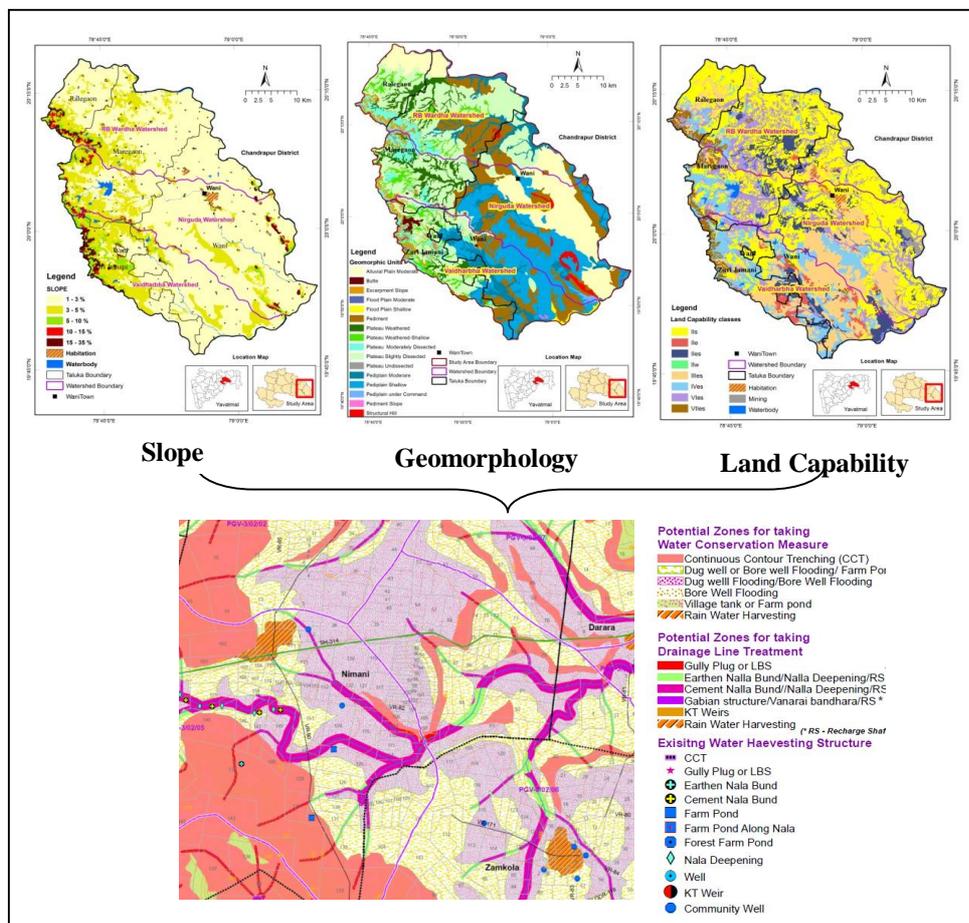


Fig. 6. Integration of Slope, Geomorphology and Land capability to generate the Water Resources Development Plan

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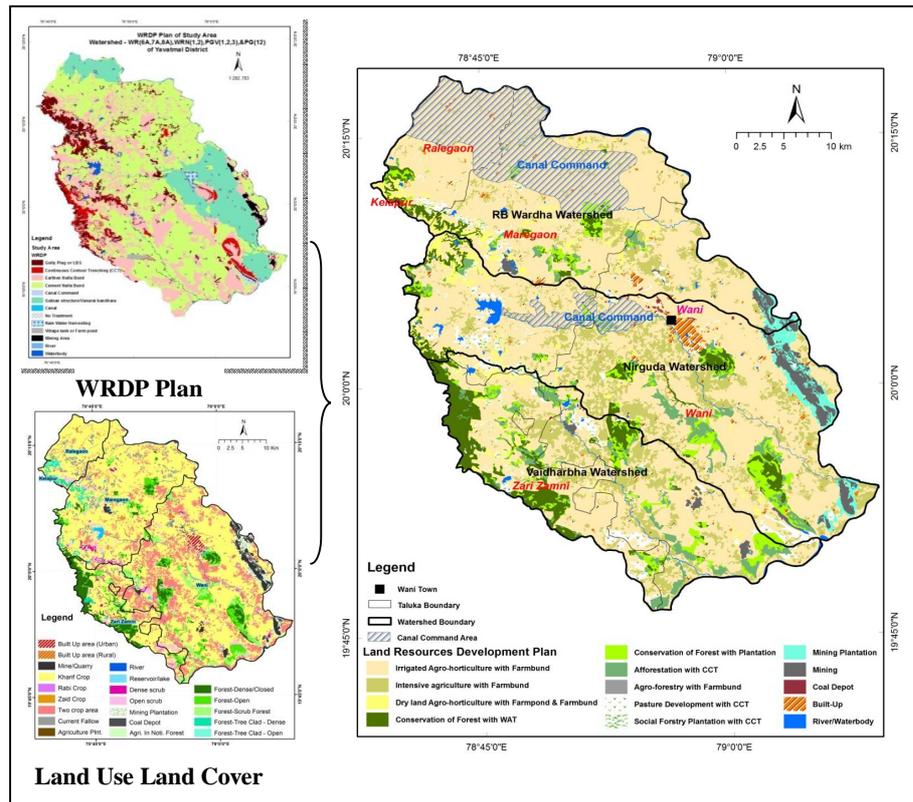


Fig. 7. Integration of WRDP plan and Land use land cover to generate the Land Resources Development Plan

VI. CONCLUSION

This study has showed that the water resource development plan and land resources development plan for the sustainable development of the watershed can be effectively prepared using remote sensing and GIS techniques with an integrated approach. In the water resources development plan (WRDP), the three thematic layers are integrated by assigning weightages for individual themes viz. slope map, geomorphological map and soil land capability map. After integration, the geographical area is classified into three important hydro-morphological zones such as runoff zone, recharge zone and storage zone. Existing water conservation structures are also marked on action plan. Based on present studies important water and soil conservation measures are suggested in the action plan map.

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