Groundwater Regime of the WGK5 Sub-Watershed of Waingangā River Basin Around Saoner Region, Nagpur District, Maharashtra Using Remote Sensing and GIS Techniques for Sustainable Development

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ABSTRACT - Resource management using watersheds as an organizing unit has proven to be an effective scale for natural resource management. Remote sensing and its image processing technology provide access to spatial and temporal information on watershed, regional, continental and global scales. GIS and remote sensing applications have proved to be indispensable tools in decision making in the case of problem involving watershed conservation because of the enormity of spatial data involved. The land forms along with slope gradient and relief intensity are other parameters to determine the type of water harvesting and water conservation structures.In this present study, an attempt has been made to understand the groundwater regime of the WGK5 subwaterhed of Waingangā River basin around Saoner region, Nagpur District, Maharashtra using an integrated approach of remote sensing and GIS techniques with Arc GIS Desktop 9.3 and ERDAS Imagine 9.2 software for the sustainable watershed management. The remote sensing data combined with field survey details has provided a unique and hybrid database for the optimal planning and management of the watershed. The water and land resource development action plan is prepared using various thematic layers like slope, land use/ land cover, drainage, soil texture, soil depth, soil erosion and land capability and weight age and rank were assigned to the thematic according to their importance and these layers are overlaid using union operation and suggested suitable zonation for the water conservation structures like check dam, percolation tank, earthen nala bund, form pond, graded bunding, sunkan pond, roof rain water harvesting, and loose boulder structure and for soil conservation land resources development activities suggested are social forestry plantation with continuous contour trenches, check dam, afforestation with continuous contour trenches, canal command, conservation of forest, dry land agro-horticulture with farm pond, horticulture plantation, intensive agriculture with farm bund, irrigated agro-horticulture with farm bund, and pasture development etc. The conservation zonation structures were suggested to reduce soil erosion and conserve the water as natural resource for the sustainable watershed management. In the action plan for water conservation cement nala bund and canal command structures were suggested as >60% of the watershed is having slope of 1-3%. Roof rain water harvesting is suggested for the study area for the collecting and storing the rain water and also to improve ground water level. Check dams are suggested near to the water reservoir to reduce the siltation of the reservoir from the transported sediment of the river or stream. Loose boulder structures and continuous contour trenches were suggested in the high elevation and where slope of the area is steep to reduce the runoff rate and soil erosion. The land resources development plan was suggested for the utilization of soil resources for the economic and social development of the watershed. In the action plan for soil conservation, irrigated agro-horticulture with form bund and canal command which covers 70% watershed with 1-3% slope and for rest of watershed forest conservation and dry land horticulture were suggested.

Keywords: Groundwater regime, georefrencing, remote sensing and GIS, zonation structures, sustainable *watershed management*

1.0 Introduction:

Water is a valuable and essential resource which forms the basis of all economic activities ranging from agriculture to industry. The importance of conservation of water and land assumes special significance in countries like India where the main stay of people is agriculture. Water resources development is a continuous process which has to be resorted on account of ever-increasing demands. Optimal utilization of land and water resources is essential for sustainable development. In view of uneven temporal and spatial distribution of rainfall, agriculture suffers in areas where irrigation facilities are inadequate or non-existent. For a large part of the country, failure of monsoons in any year means

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severe drought and scarcity conditions and abundance of rainfall in some areas causes floods. The crisis about water resources development and management thus arises because most of the water is not available for use and secondly it is characterized by its highly uneven spatial distribution. Accordingly, the importance of water has been recognized and greater emphasis is being laid on its economic use and better management.

Water resources development calls for addressing the key issues of storage, conversation and subsequently utilization. The main objectives of the study are to collect ancillary data and generate different thematic maps from satellite data and to prepare implementable water and land resources development action plan supported by various thematic maps like, base map, drainage map, geological map, geomorphologic map, and land use/land cover map. Water resources development is a continuous process which has to be resorted on account of ever-increasing demands. Physical development will improve the economic situation significantly and lay a foundation for the support of improvement in living standards of the beneficiaries by the added income. In the present work an attempt is made to create water and land resource development plan for the watershed management in selected watershed.

2.0 Study Area:

The WGK-5 sub-watershed of Wainganga river basin in Maharashtra is located between 21°23′9″ N latitude and 78°55′12″ E longitude and has a drainage area of 348 Sq.km covering 55 K/15 toposheet (Fig 1). The WGK-5 sub-watershed of Wainganga river basin located in Saoner taluk of Nagpur district of Maharashtra state. Nearly 70 villages are covered by the WGK-5 sub-watershed. The physiography of the study area derived from the SRTM DEM well to analysis elevation, it various from western to east hilly ranges is marked. The major part of the basin is a gently undulating topography sloping towards east.

2.1 Drainage analysis

The drainage is digitized from the SOI toposheet using GIS technique and stream ordered using Strahler method (1964). The WGK-5 Sub-watershed having stream order up to 5th order (Fig. 2). The bifurcation ratio can also show which parts of a drainage basin is more likely to flood. The bifurcation ratio is not same from one to another due to irregularities in the topographic feature of the drainage basin. The average bifurcation ratio of WGK-5 sub-watershed is 4.92.Drainage density is the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin. Drainage density depends upon both climate and physical characteristics of the drainage basin. High drainage densities also mean a high bifurcation ratio. The drainage density of WGK-5 sub-watershed is 1.86 km/km^2.

3.0 Geomorphology:

The geomorphic features found in the study area are pediment, pediplain, plateau, hills, valley fill, flood plain, escarpment, denuded slope. These features are developed by erosion and deposition process of the river. On the basis of interpretation of satellite image, toposheet, and field visits, it is clear that geomorphology of the area comprises of plateau, eroded land denudation hills, residual hills, and younger alluvium. Plateau is the table like land. It is broad, elevated, and almost level. It covers southern part of the watershed along the watershed divide. This landform is easily identifiable in the satellite data due to flat top, occupying the higher altitude. The geomorphology of the watershed is having landforms features area moderate dissected plateau, denudational slope and alluvial pain in the lower part of the WR-6 sub-watershed of Wardha River. The WGK-5 is sub-watershed of Wainganga River in Godavari river basin. Wainganga River which originates about 12 km from Mundara village of Seoni district of MP and flows south through MP & Maharashtra in a very winding course of approximately 360 miles. After joining the Wardha, the united stream, known as the Pranahita, ultimately falls into the River Godavari. The area shows dendritic drainage pattern.

Land use in the study area can be divided into five categories; agricultural land, forest land, waste land, built up and water body. More than 70 per cent of the land area in the watershed is covered by the agricultural land. The storage capacity and the transmissivity of the basalt flows are not uniform. It changes from place to place and flow to flow. The lateral flow continues for considerable distance while the weathered mantle is thick. In the Deccan trap area the primary porosity is due to presence of interconnected vesicles when it is not filled by secondary material while secondary porosity is developed due to weathering and cooling of flows. In alluvial area the sandy zone becomes a good aquifer having good porosity and permeability. The ground water is tapped by the tube wells in the area.

The soil depth of the study area is ranges from more than 100 cm (very deep) to less than 25 cm (very shallow). More than 70% area's soil deepness is very deep (>100 cm). The rate of infiltration of the water depends upon the soil depth. Soil depth varies from area to area because geology and geomorphology differ from area to area. Hard rock areas having very low soil depth and less infiltration rate of water and high runoff (Fig.3). Soil land capability classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time (FAO Soil Bulletin 39). Capability class is the broadest category in the land capability classification system. Class codes I (1), II (2), III (3), IV (4), V (5), VI (6), VII (7), and VIII (8) are used to represent both irrigated and non-irrigated land capability classes. Capability is viewed by some as the inherent capacity of land to perform at a given level for a general use, and suitability as a statement of the adaptability of a given area for a specific kind of land use; others see capability as a classification of land primarily in relation to degradation hazards, whilst some regard the terms "suitability" and "capability" as interchangeable. The analysis reveals that Class II, III, IV, VI and VII are present in the study region. Out of that Class II which is much suitable for agriculture accounts 70 per cent. The Class VI is most susceptible to land degradation which accounts for 10 per cent and remaining area was covered by the class III, IV and VII (Fig.4).

In the process of soil erosion, nutrients rich top fertile soil is lost and it also causes environmental problems due to siltation of lakes, reservoirs and rivers. Various factors are responsible for the soil erosion those are slope, soil depth, rock structure, rainfall intensity and runoff, and vegetation cover etc. in the present study soil erosion is categorized into four categories such as severe to very severe, moderate to severe, slight to moderate and slight. In the study area slight soil erosion covers 80 percent area and nearly 10 percent having severe to very severe erosion problem (Fig.5). The slope of the study area ranges from 1-3% to 15 -35%. The most of study area is having slope between 1 -3 % which covered by lower part of the study area. The upper area is having slope between 3 to 5%. The runoff rate and soil erosion controlled by the slope of the area. Steep slope area is more prone to soil erosion and high runoff than gentle slope (Fig.6).

3.1 Water resource management

Water resource development action plan was developed for the water and soil conservation in the watershed. The weighted overlay method used for the analysis and preparation of the water harvesting using various conservation structures and zonation map was prepared. The weight age and rank are assigned according to the importance of the thematic layer for the zonation of conservation structures. In the action plan water and soil conservation structures suggested were check dam, cement nala bund, earthen nala bund, percolation tank, farm pond, sunkan pond, and loose boulder structure using various thematic layers (Fig.7). The water and land resource development action plan is prepared to conserve the water and soil resources from the depletion using remote sensing and GIS techniques. The conservation zonation structures were suggested to reduce soil erosion and conserve the water and land as natural resource for the sustainable watershed management (Fig.8).

4.0 Conclusions:

This study has demonstrated that water resource management plan for the sustainable development of the micro-watersheds can be effectively prepared using remote sensing and GIS techniques with an integrated approach through Arc GIS Desktop 9.3 and ERDAS Imagine 9.2 software for the sustainable watershed management. The remote sensing data combined with field survey details has provided a unique and hybrid database for the optimal planning and management of the watershed. The water and land resource development action plan is prepared using various thematic layers like slope, land use/ land cover, drainage, soil texture, soil depth, soil erosion and land capability and weight age and rank were assigned to the thematic according to their importance and these layers are overlaid using union operation and suggested suitable zonation for the water conservation structures like check dam, percolation tank, earthen nala bund, form pond, graded bunding, sunkan pond, roof rain water harvesting, and loose boulder structure and for soil conservation land resources development activities suggested are social forestry plantation with continuous contour trenches, check dam, afforestation with continuous contour trenches, canal command, conservation of forest, dry land agro-horticulture with farm pond, horticulture plantation, intensive agriculture with farm bund, irrigated agro-horticulture with farm bund, and pasture development etc. The conservation zonation structures were suggested to reduce soil erosion and conserve the water as natural resource for the sustainable watershed management. In the action plan for water conservation cement nala bund and canal command structures were suggested as >60% of the watershed is having slope of 1-3%. Roof rain water harvesting is suggested for the study area for the collecting and storing the rain water and also to improve groundwater level thereby assuring the sustainable water resource development of the region.

References

[1] Reddy, M. Anji, "Textbook of Remote Sensing and Geographical Information Systems" BS Publication, 2008

[2] T. M. Lillesand & R. W. Kiefer, “Remote Sensing & Image Interpretation”, Wiley, 1987.

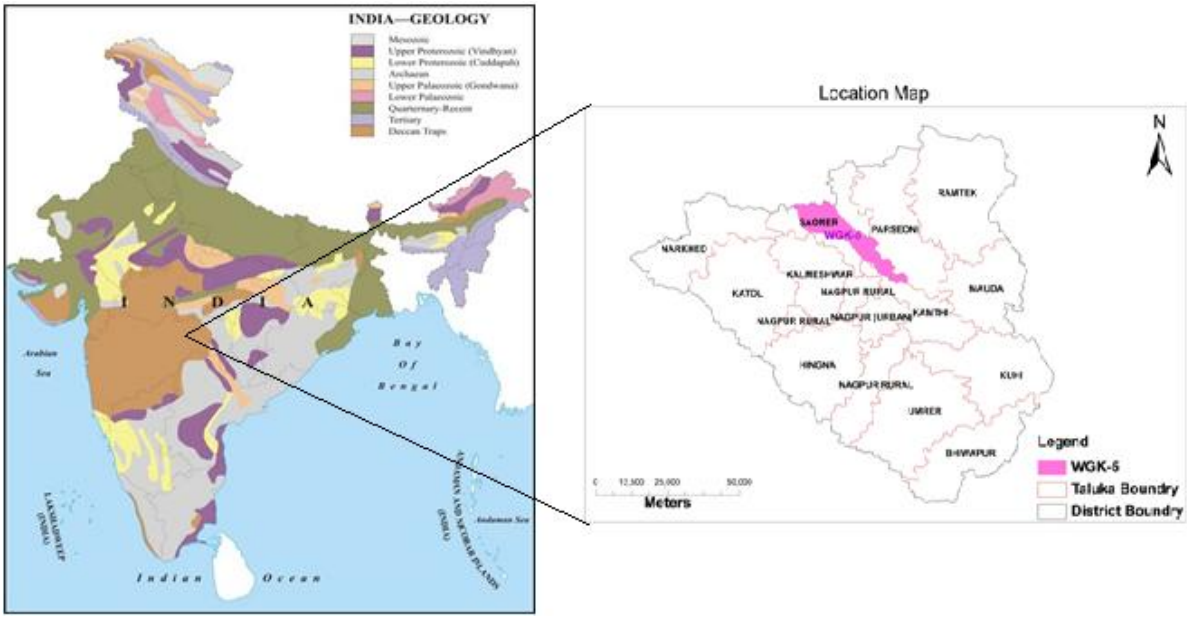

Fig. 1. Location map of the study area

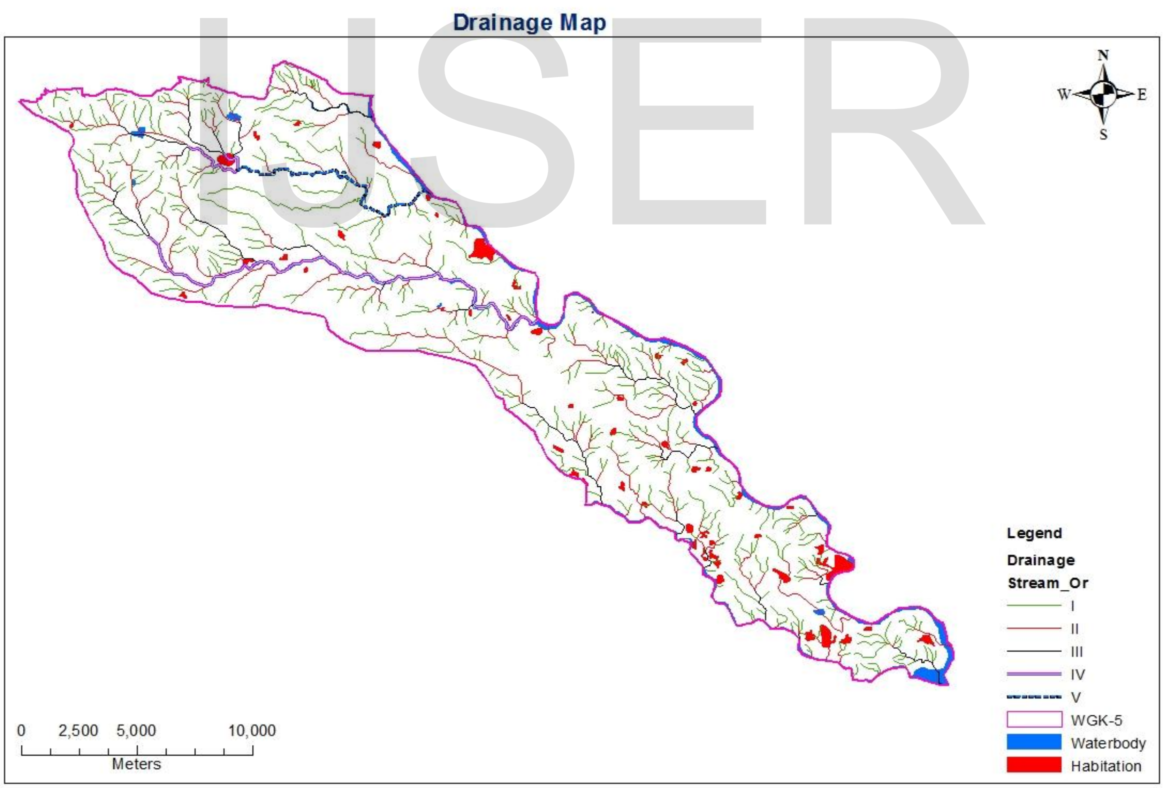

Fig. 2. Drainage map of the study area

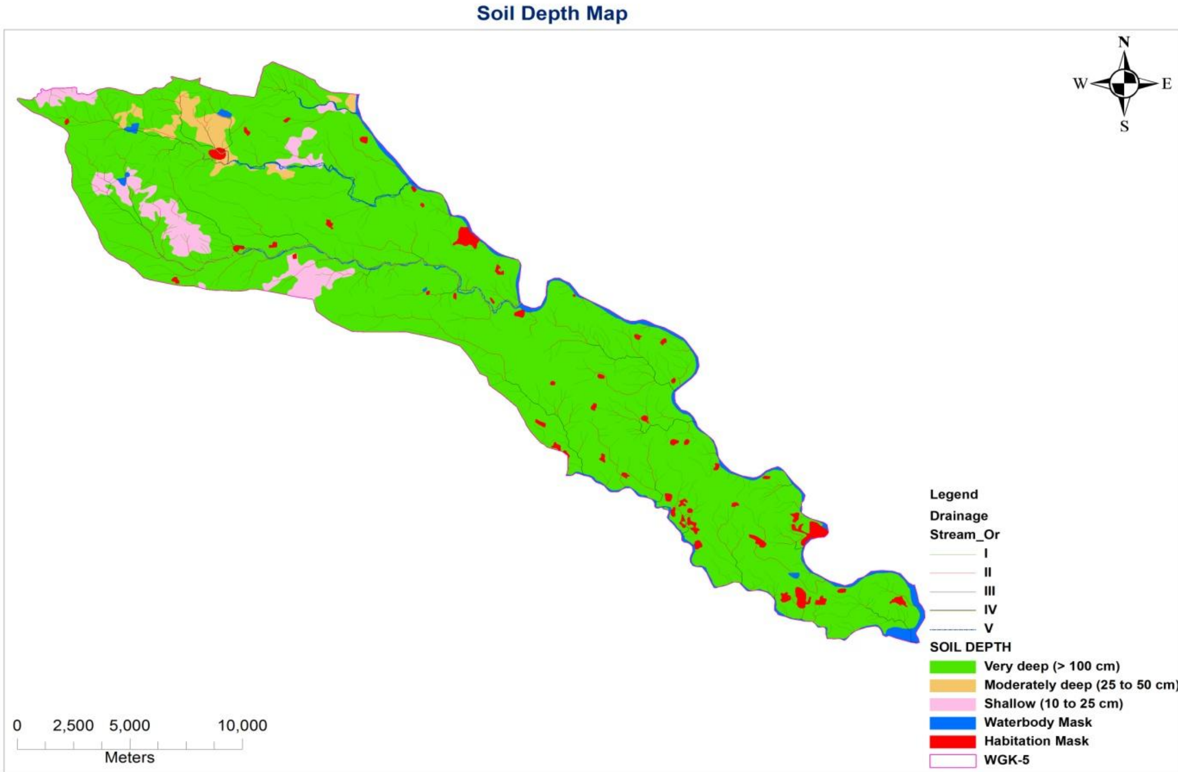

Fig. 3. Soil depth map of the study area

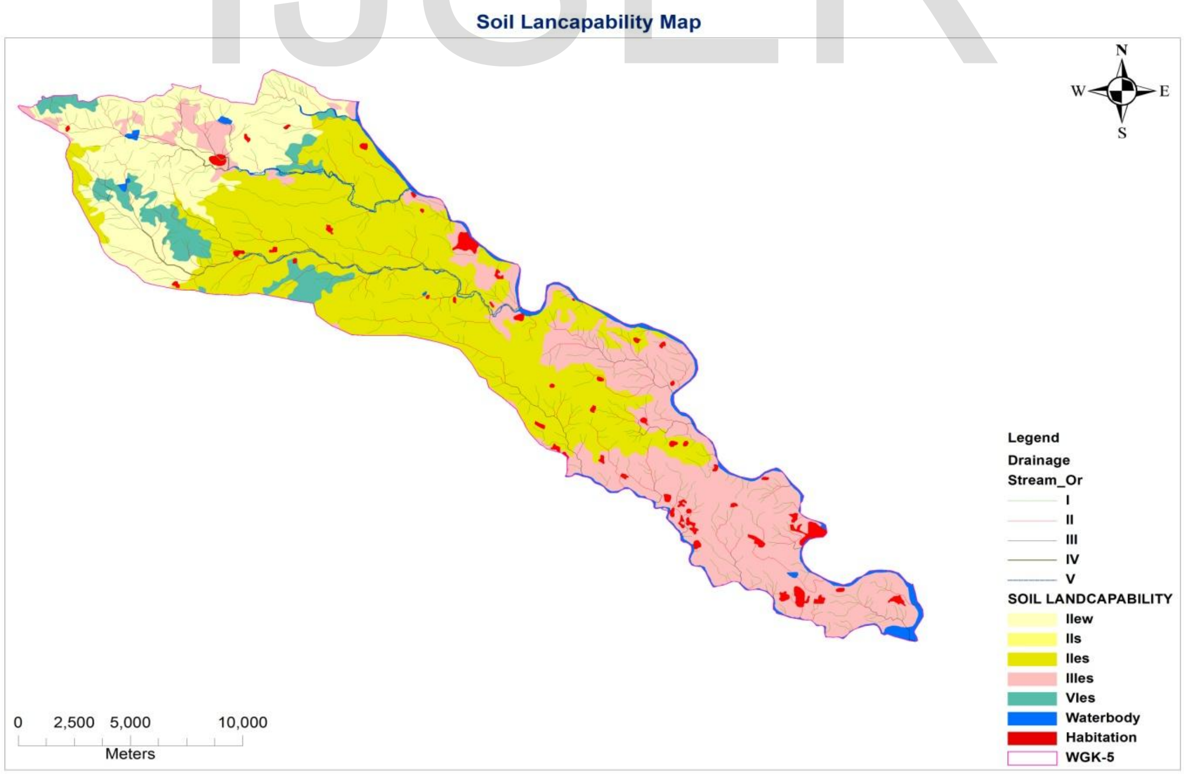

Fig. 4. Soil-Land capability map of the study area

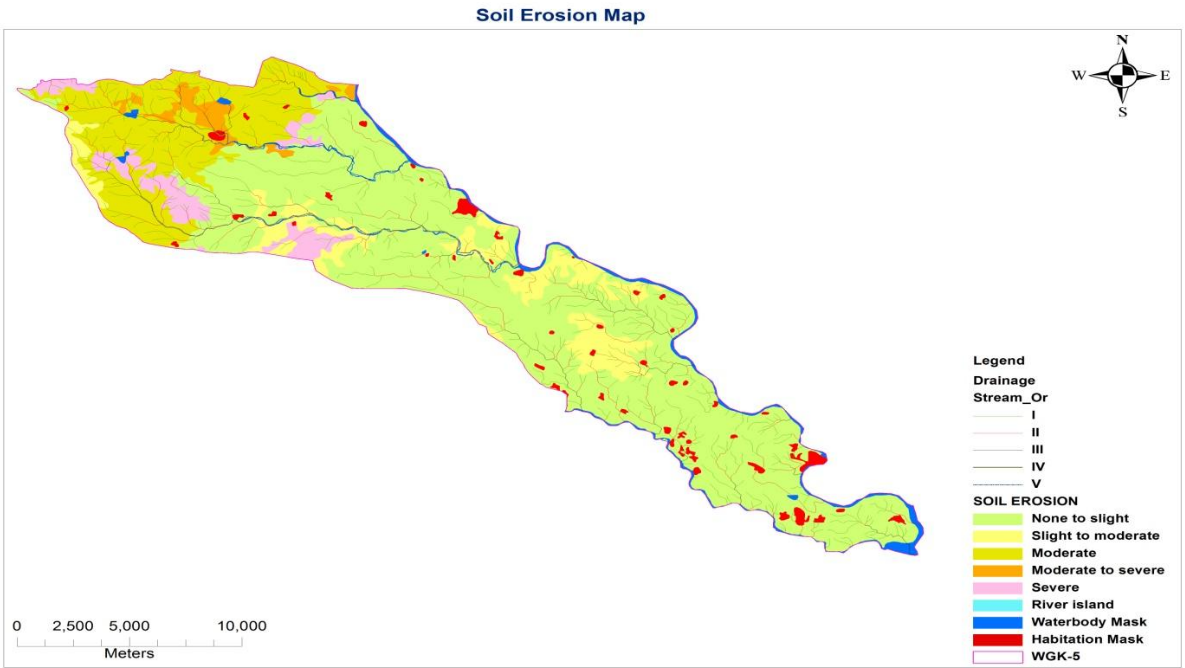

Fig. 5. Soil erosion map of the study area

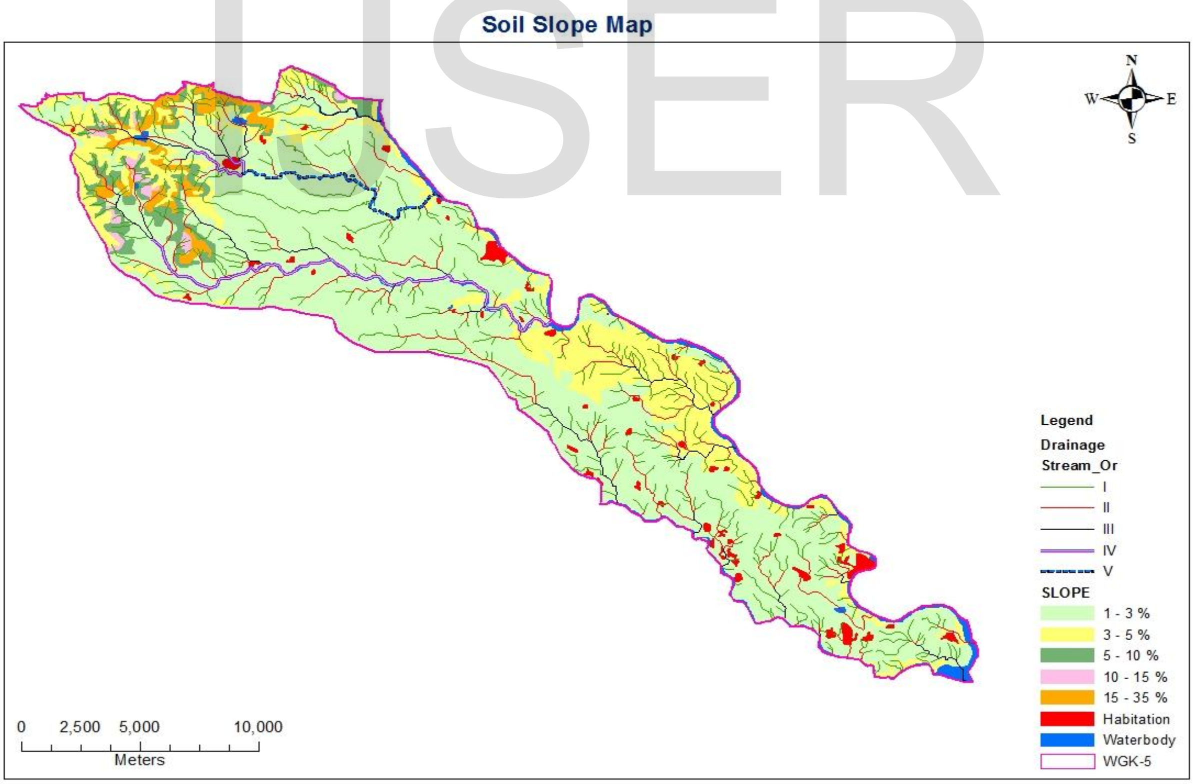

Fig. 6. Soil slope map of the study area

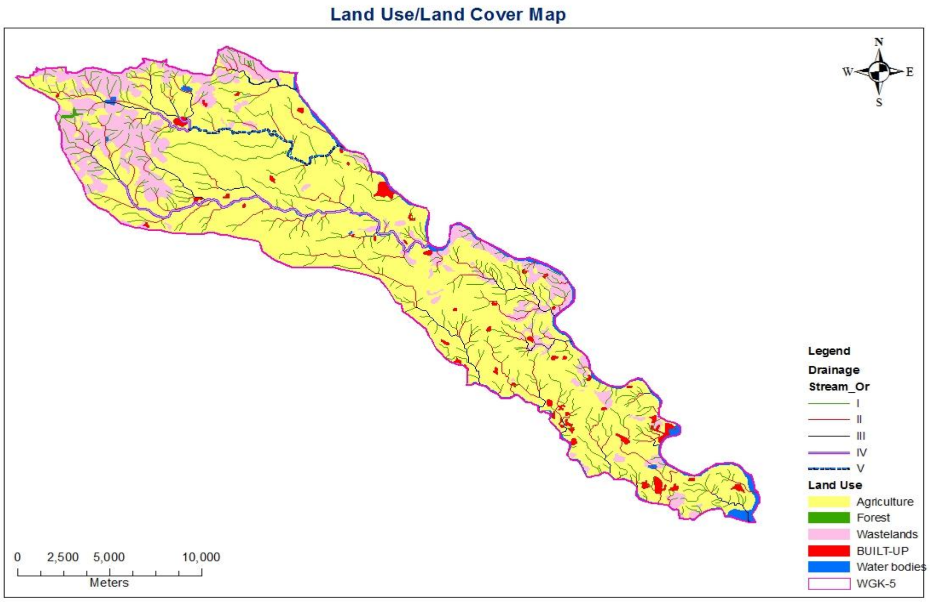

Fig. 7 Land use/Land cover map of the study area

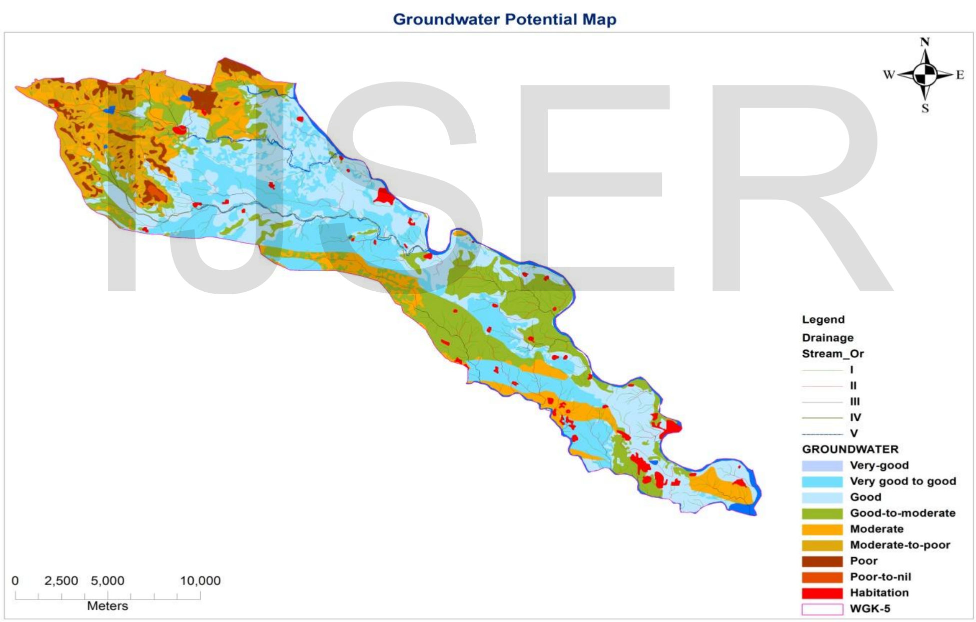

Fig. 8 Groundwater potential map of the study area

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