Full Length Research Article

CARAS

Research Journal of Agricultural Sciences
Volume 15; Issue 04 (Jul–Aug 2024); pp 992–997

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Remote Sensing and GIS Based Integrated Land Resources Management of Ghagara Watershed

Ranjit Kumar Behera*[1] and Krushna Shankar Pattanaik[2]

[1] Centre for Environment and Development, Bhubaneswar - 751 003, Odisha, India
[2] Odisha Space Applications Centre (ORSAC), Bhubaneswar - 751 023, Odisha, India

Received: 31 May 2024; Revised accepted: 26 Jul 2024

Abstract

Land resources are the prime anchors required for the sustained quality of human life and the foundation of agricultural development. Land use and land cover (LU/LC) mapping serves as a kind of basic information for land resources inventory. Detecting and analyzing the quantitative changes of the land surface has become necessary and advantageous, because it can result in proper planning, which would ultimately result in improvement in sustainable land resources. Integration of Remote Sensing and GIS is helpful in planning and management of land resources for adoption of location specific technologies. The socio-economic growth of an area depends primarily on continuing preservation and effective utilization of its natural resources. Therefore, an attempt has been made to develop integrated land resources management of watersheds by applying Remote Sensing and GIS technologies. Ghagara watershed in Baleswar district of Odisha, India has been identified as the present study. In the context, an action research method adopted, where land resources were planned for management in an effective way to control land degradation and enhance the long-term sustainability of agricultural land and rural communities through locality-based land use planning and its management at the watershed level.

Key words**:** GIS, Remote Sensing, Land use, Land Cover, watershed, Land Resources

Land is a valuable source of natural resources and an important factor of food production. The needs of population for food, drinking water, domestic and socio-economic requirements due to which there is a great need to conserve the natural resources [1]. The introduction of sustainable development has an impact on land use/ land cover, playing a vital role in natural resource management [2]. Since the beginning of human existence, they have directed their activities with reference to the earth resources and they know how to use these resources for their benefits. The proper utilization and management of land is a matter of utmost concern of the people because improper use of land resources creates many problems like land degradation, soil erosion that results decline in productivity of land [3]. The use of satellite remote sensing data has proved to be quite useful in mapping present LU/LC patterns. Remote sensing and GIS provide vital tools, which can be applied at macro and micro level planning of natural resources. Remote sensing provides synoptic view and multi- temporal land use/ land cover data [4]. Satellite remote sensing data comprise essentially a faithful record of the reflected or emitted electromagnetic radiation from a given segment of earth's surface [5]. The main objective of the study is to develop a sustainable land resource management plan at watershed level and to develop a local specific micro watershed action plan considering land and forest resources for optimal utilization. Land resource planning based on land resource evaluation and spatial orientation of planning as part of GIS may ensures appropriate land allocation in order to achieve sustainable agriculture [6].

MATERIALS AND METHODS

Study area

The study area is located near Nilagiri town in Baleswar district. This is a part of Nilagiri block of Baleswar district which is in the northern part of Odisha state, India. The study area covering an area of 4272.83 ha. It is located between longitudes 86°40'19.44"E to 86°44'43.69"E and latitudes 21°29'34.92"N to 21°25'14.95"N. It comes under SOI toposheet No.73K11. The area is well connected with the adjoining townships and district headquarter with a good network of roads. The nearest railhead is Baleswar town, located about 27 km from the study area. The study area has been experiencing remarkable land cover changes due to urban expansion, population pressure and various economic activities in the recent years.

Methodology

The satellite image PAN+LISS-III image were used for this study. LISS-III satellite images were downloaded from Bhuvan portal developed by NRSC, ISRO, Govt. of India. The study area was delineated from the SOI topographic maps numbered 73K-15, downloaded from the Survey of India portal. The base map and drainage maps of Ghagara watershed were

***Correspondence to:** Ranjit Kumar Behera, E-mail: rkumarbbsr24@gmail.com; Tel: +91 7978721203

Citation: Behera RK, Pattanaik KS. 2024. Remote sensing and GIS based integrated land resources management of Ghagara watershed. *Res. Jr. Agril. Sci*. 15(4): 992-997.

prepared using SOI toposheet and updated with satellite image. The land use/ land cover map was prepared using SOI toposheet and satellite imagery to know the various uses of land. Land use and land cover mapping carried out by the standard methods by analyzing remote sensed data as per NRSC standard. The contour data were generated from the SRTM DEM of 30 m resolution. Spatial analysis and three-dimensional analyst tools used to prepare the slope map. The spatial data pertaining to geology been derived from Geological Survey of India (GSI). Slope map was prepared from DEM of SRTM data. For soil map, Odisha Sampad portal developed by ORSAC, Bhubaneswar was referred. These thematic maps were integrated under the GIS domain to explore their inter relationships. Esther Shekinah *et al*. [7] opined that land capability and soil site characteristics can be assessed and mapped in a GIS environment for the suitability of a land to be put for particular kind of land use considering those variable which affects its use, because either they restrict, or their presence determine the conditions for its development. Information on the existing land use/ land cover pattern and its distribution is a pre-requisite for better understanding of land aspects and plays a vital role in developmental planning. With the advent of Remote Sensing techniques (both aerial and satellite), it has been possible to prepare land use maps at various levels showing categories of land under different uses both in spatial and statistical form.

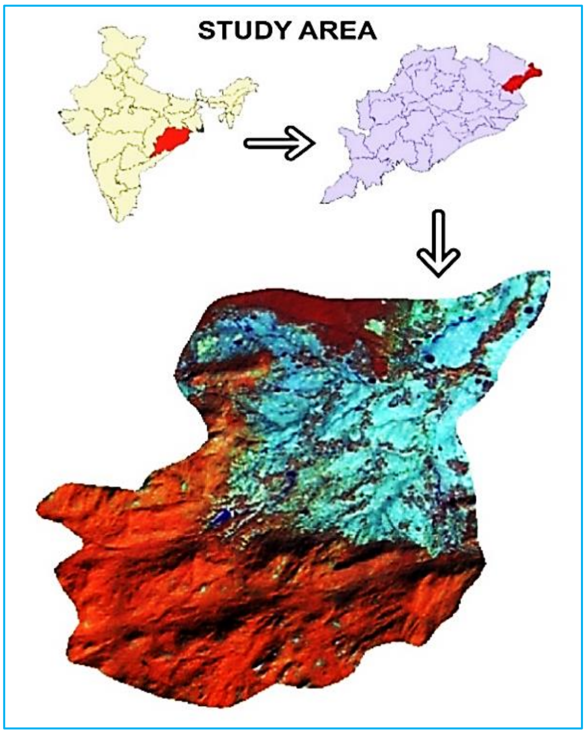

Fig 1 Showing the study area

RESULTS AND DISCUSSION

In the present study, an integrated approach has been adopted to evaluate every part of land for adoption of a suitable land use practice. Capability of GIS is utilized adopting with scientific criteria approach, for integration of various thematic maps and generation of land resource management plan. Lithology, geomorphology, land use/ land cover, soil, slope, land capability and groundwater potential have been considered for land resource management. The land resources management plan was prepared integrating lithology, geomorphology, land use/ land cover, soil, slope, land capability, and groundwater potential by over-laying principles in GIS environment.

Base map

Base map of Ghagara watershed area prepared by digitizing the road networks falling under study area and the settlement area were delineated from the Survey of India (SOI) toposheet and satellite image. The base map is shown in (Fig 2).

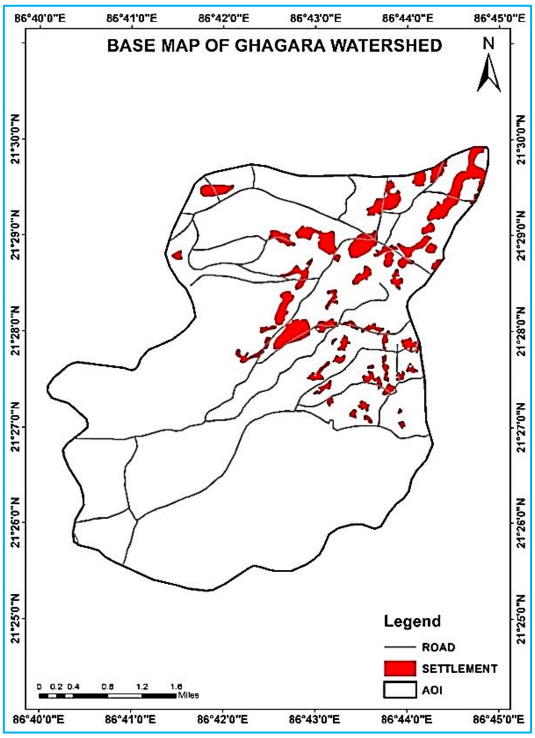

Fig 2 Showing base map

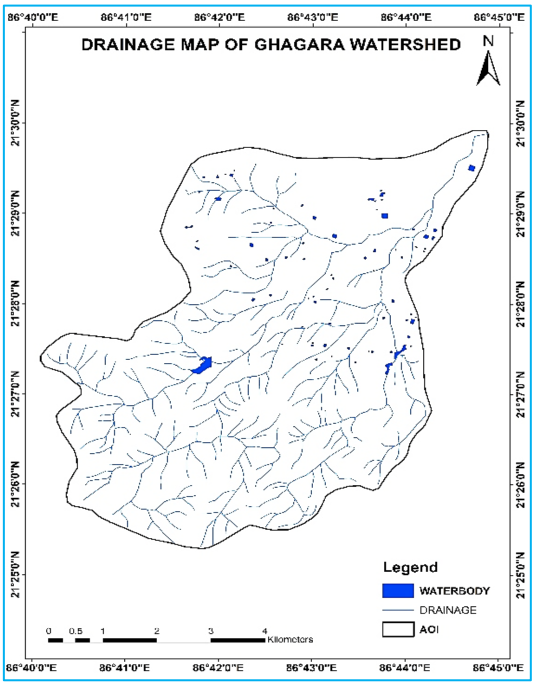

Fig 3 Showing drainage map

Drainage map

The movement of water to a place of disposal, whether by way of the natural characteristics of the ground surface or by artificial means as drainage. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks, and the gradient of the land. Ghagara watershed area drainage pattern is mainly dendritic which looks like the branching pattern of tree roots. All the drainage lines captured from the toposheet, and rest are updated from satellite image which shown in (Fig 3).

Slope map

Spatial distribution of different slope classes was prepared using SRTM DEM data which downloaded from the Bhuvan portal. Slope was divided into seven classes shown in (Fig 4). The dominant slope categories in the Ghagara watershed are Level (0-1%), Nearly level (1-3%), Gently Sloping (3-5%), Moderately sloping (5-10%), strongly sloping (10-15%), moderately steep (15-25%) and steep (25-33%).

Land use/ land cover map

Land use and land covers map were prepared in GIS environment by visual interpretation using satellite image. LU/LC data were classified into settlement, agricultural land, open forest, dense forest, degraded forest, scrub land and water body. The area of different land use and land cover features are agriculture land is 1249.47 ha, degraded forest is 451.62 ha, dense forest is 851.86 ha, open forest is 1300.98 ha, scrub land is 84.89 ha, settlement is 304.69 ha and water body is 29.32 ha [8-12]. The land use/ land cover map is shown in (Fig 5).

Soil map

In this present study three types of soil found and they are Fine loamy fluventic ustochrepts, Fine loamy udic ustochrepts, Loamy skeletal Lithic ustochrepts. Soil types of the Ghagara watershed were derived from the Odisha Sampad portal. Fine loamy fluventic ustochrepts are the immatures soils with irregular organic carbon contents with 18% to 35% clay contents. Fine loamy udic ustochrepts are the immature moist soils with 18% to 35% clay contents. Loamy skeletal Lithic ustochrepts are immature soils with moderate depth and soils have stones and pebbles in the entire profile having less than 18% clay contents [13-17]. Soil map is shown in (Fig 7).

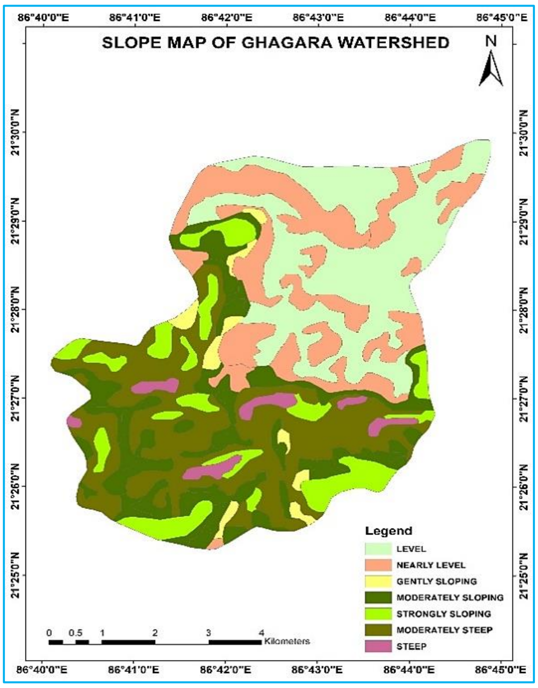

Fig 4 Showing slope map

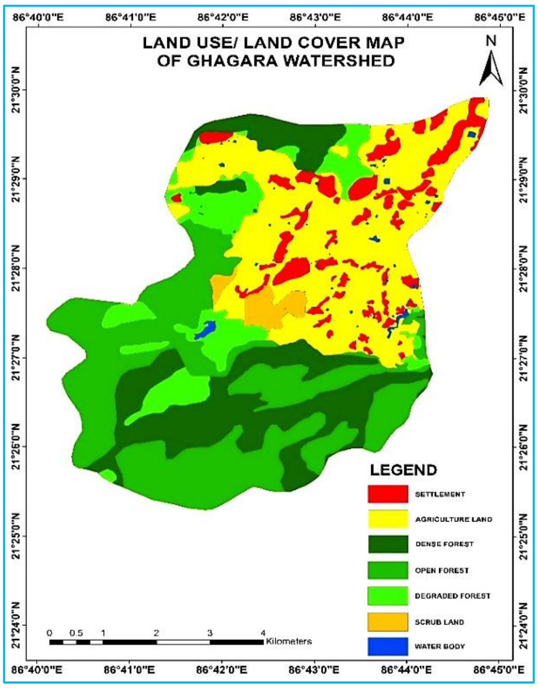

Fig 5 Showing land use / land cover map

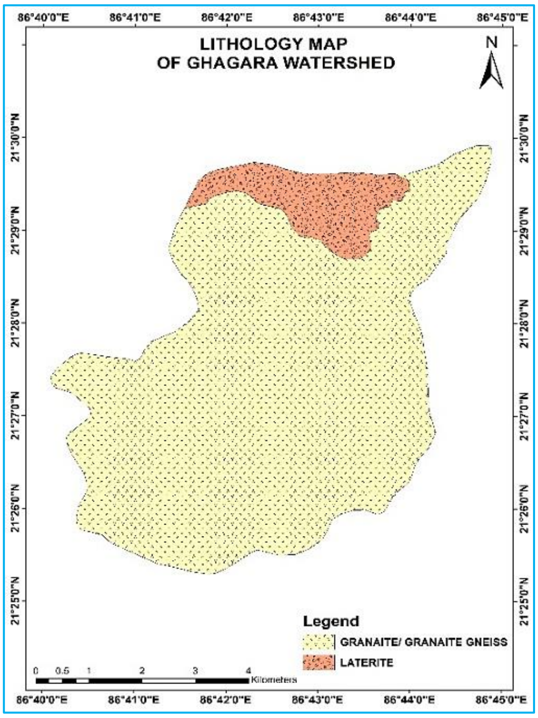

Fig 6 Showing lithology map

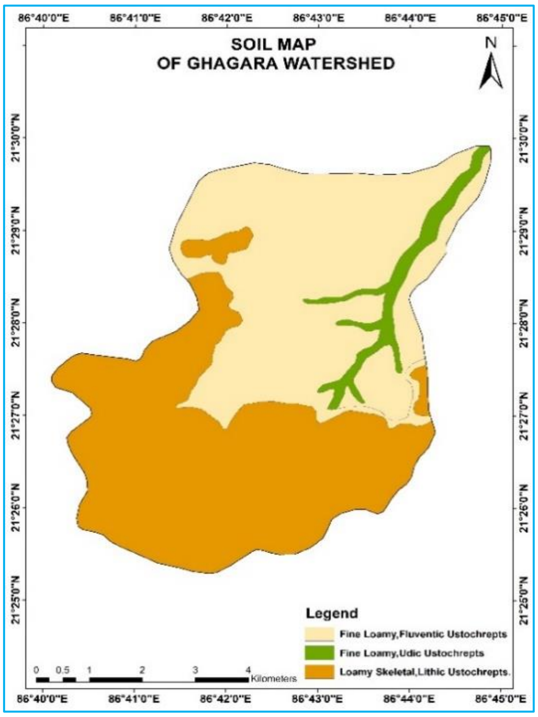

Fig 7 Showing soil map

Geomorphology map

Geomorphological mapping was done using satellite images which shown in (Fig 8). In this study five categorical features obtained, and they are vally fills, pediplain, pediment, denotational hill and structural hill.

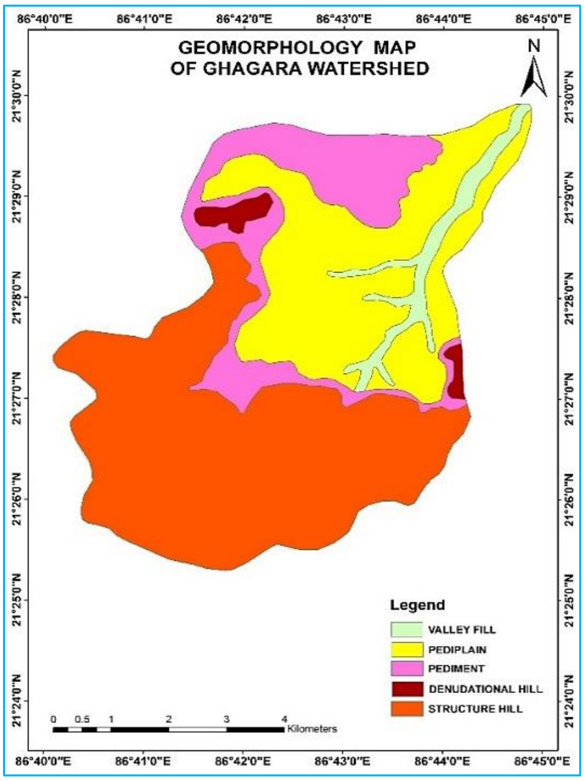

Fig 8 Showing geomorphology map

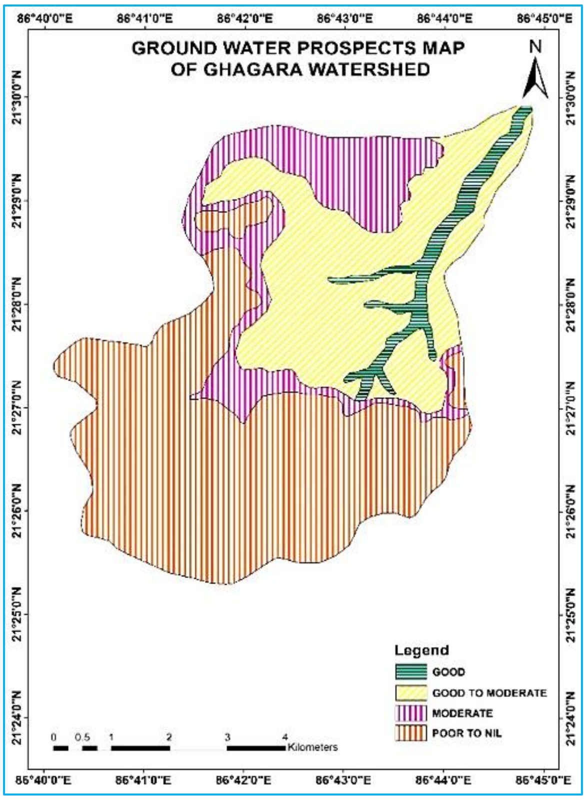

Fig 9 Showing ground water map

Ground water map

In this present study, four categories of ground water prospects were found and they are good, good to moderate, moderate and poor to nil. Maximum area covers by the poor to nil category in Ghagara watershed. Ground water map is shown in (Fig 9).

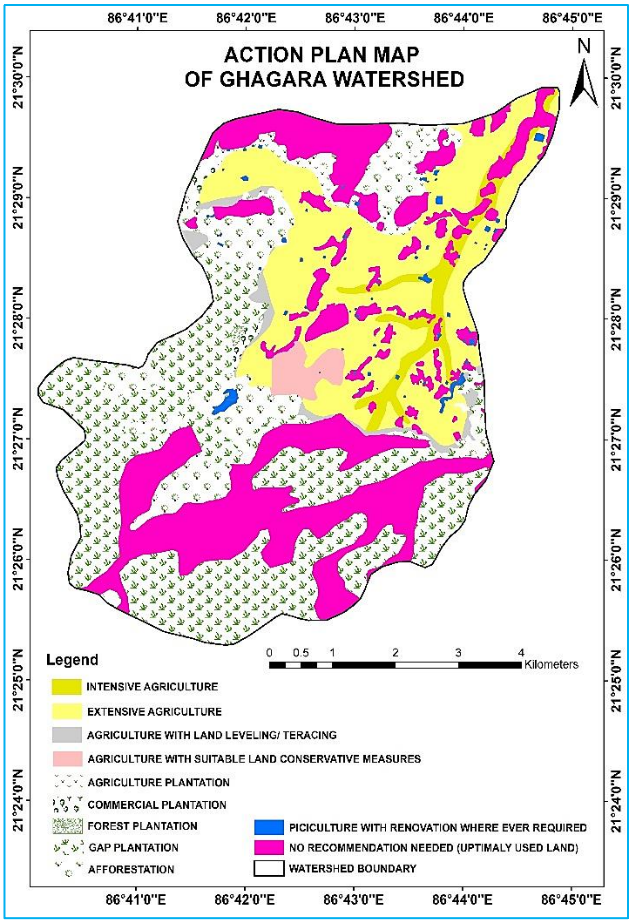

Fig 11 Action plan map

Integrated land resources management plan

The land resources management includes agriculture land management, wasteland management and forest land management. Remote sensing and GIS are powerful tools for understanding of land resources of the terrain and for suggestion of suitable management planning [18-22]. It provides continuous detailed terrain information. Therefore, it is important to land resource management, incorporating information in the data collection stage and in resource management works. The development plan has been proposed for land resources management of the study area based on the study of land use/land cover, soils, rainfall, DEM, slope, groundwater, and geomorphology [23-25]. The total geographical area of Ghagra watershed is 4272.83 ha among which agriculture land is 1249.47 ha, degraded forest is 451.62 ha, dense forest is 851.86 ha, open forest is 1300.98 ha, scrub land is 84.89 ha, settlement is 304.69 ha and water body is 29.32 ha. The land resource management prepared based on the existing lithology, geomorphology, land use/land cover, soil, slope, land capability, and groundwater potential [26]. The scientific criteria for proposed plan is shown in table No.1 and suitable actions have been suggested. The proposed action plan of Ghagra watershed shown in (Fig 11), comprising areas of Afforestation 451.62 ha, Agriculture plantation 87.20 ha, Agriculture with land leveling/ terracing 65.07 ha, Agriculture with suitable land conservative measures 68.55 ha, Commercial plantation 23.48 ha, Extensive agriculture 961.28 ha, Forest plantation 4.51 ha, Gap plantation 1301.68 ha, Intensive agriculture 123.57 ha, no recommendation needed (optimally used land) 1156.56 ha. Pisciculture with renovation wherever required 29.32 ha [27-28].

CONCLUSION

The rising pressure on land resources due to the increasing human population is a big challenge for sustainability. Remote sensing and geographic information system (GIS) can be used to manage these precious limited resources in effective and efficient manner. This study reveals that the Ghagara sub- watershed of Nilagiri block, Baleswar district Odisha, India is extremely under threat due to improper land use practices and anthropogenic activates emphasizing the need for advanced tools like remote sensing and GIS for sustainable land resource management. So, there is a need to adopt new tools, techniques and technologies for proper use and conversation practices for land resource management. In the present study, an integrated approach has been adopted to evaluate different types of land resources and it is proposed for the better development. The data from Bhuvan and Survey of India toposheet was analyzed with the help of collateral and ground data to generate spatial layers of drainage, land use/land cover, contour, DEM, slope and geomorphology. All the above thematic layers were integrated for the generation of an action plan, which is optically suitable for the terrain and the development of local resources so that the level of production is sustained without decline over time. Thus, remote sensing has been found to be very effective and economical tool for resources management. The results of above study, aim for optimum development of land resources and for the human sustainability, thereby improving their socio-economic conditions. The process adopted in this case study can be applied by decision makers, researchers for sustainable development of any given watershed area.

Criteria for suggested action plan

Land use	Lithology	Geomorphology	Ground water prospects	Slope	Soil	Action plan
Agriculture land	Granite / granaitegneiss	Valley fill	Very good	Level, nearly level	Fine loamy, udic ustochrepts	Intensive agriculture
Agriculture land	Granite / granaitegneiss	Pediplain	Moderate to good	Level, nearly level, gentle sloping	Fine loamy, fluventic ustochrepts	Extensive agriculture
Agriculture land	Granite / granaitegneiss	Pediment	Moderate	Moderately sloping	Fine loamy, fluventic ustochrepts	Agriculture with land leveling / teracing
Scrub land	Granite / granaitegneiss	Pediplain	Moderate to good	Level, nearly level	Fine loamy, fluventic ustochrepts	Agriculture with suitable land conservative measures
Agriculture land	Laterite	Pediment	Moderate	Level, nearly level	Fine loamy, fluventic ustochrepts	Agriculture plantation
Scrub land	Granite / granaitegneiss	Pediment	Moderate	Moderately sloping	Fine loamy, fluventic ustochrepts	Commercial plantation
Scrub land	Granite / granaitegneiss	Structure hill	Poor to nil	Moderately sloping moderately steep	Loamy skeletal, lithic ustochrepts	Forest plantation
Open forest	-	-	-	-	-	Gap plantation
Degraded forest	-	-	-	-	-	Afforestation
Water body	-	-	-	-	-	Piciculture with renovation where ever required
Built upland, dense forest, river	-	-	-	-	-	No recommendation needed (Uptimaly used land)

LITERATURE CITED

1. Bandyopadhyay S, Jaiswal RK, Hegde VS, Jayaraman V. 2009. Assessment of land suitability potentials for agriculture using a remote sensing and GIS based approach. *Int. Jr. Remote Sensing* 30(4): 879-895.
2. Sarkar D, Gangopadhyayand SK, Sahoo AK. 2006. Soil resource appraisal towards land use planning using satellite remote sensing and GIS a case study in Patiloniala Micro watershed, district Puruliya, West Bengal. *Journal of the Indian Society of Remote Sensing* 34(3): 245-260.
3. Bijalwan A, Swamy SL, Sharma CM, Sharma NK, Tiwari AK. 2010. Land-use, biomass and carbon estimation in dry tropical forest of Chhattisgarh region in India using satellite remote sensing and GIS. *Journal of Forestry Research* 21(2): 161-170.
4. Nigam K. 2000. Application of remote sensing and geographical information system for land use / land cover mapping and change detection in the rural urban fringe area of Enschede City, The Netherlands. *International Archives of Photogrammetry and Remote Sensing* 33, Part B7. Amsterdam 2000.

5. Rao BRM, Dwivedi RS, Sreenivas K, Khan QI, Ramana KV, Thammappa SS. 1998. An inventory of salt-affected soils and waterlogged areas in the Nagarjunsagar Canal Command Area of Southern India, using space-borne multispectral data. *Land Degradation and Development* 9: 357-367.
6. Bhermana A, Sunarminto BH, Utami SNH, Gunawan T. 2013. The combination of land resource evaluation approach and GIS application to determine prime commodities for agricultural land use planning at developed area – A case study of Central Kalimantan Province, Indonesia. *ARPN Journal of Agricultural and Biological Science* 8(12): 771-784.
7. Esther Shekinah D, Saha SK, Rejaur R. 2004. Land capability evaluation for land use planning using GIS. *Jr. Indian Soc. Soil Science* 52(3): 232-237.
8. Mallupattu PK, Reddy J, Reddy S. 2013. Analysis of land use/land cover changes using remote sensing data and GIS at an urban area, Tirupati, India. *Scientific world Journal Hindawi Publishing Corporation* 02013: 107.
9. Roy PS, Giriraj A. 2008. Land use and land cover analysis in Indian context. *Journal of Applied Science* 8(8): 1346-1353.
10. Weng QH, Lu DS, Schubring J. 2004. Estimation of land surface temperature– Vegetation abundance relationship for urban heat Island studies. *Remote Sens Environ.* 89: 467-483. https://doi:10.1016/j.rse.2003.11.005
11. Mahajan S, Panwar P, Kaundal D. 2001. GIS Application to determine the effect of topography on landuse in Ashwani Khad watershed. *Journal of the Indian Society of Remote Sensing* 29(4): 243-248.
12. Palaniswami C. 2000. GIS and remote sensing techniques for land degradation studies in Dharmapuri district of Tamil Nadu. *Ph. D., Thesis*, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.
13. Pandian M, Rajagopal N, Sakthivel G, Amrutha D. 2014. Land use and land cover change detection using remote sensing and GIS in parts of Coimbatore and Tiruppur districts, Tamil Nadu, India. *International Journal of Remote Sensing and Geoscience* 3(1): 2319-3484.
14. Rahman R, Saha SK. 2008. Multi-resolution segmentation for object-based classification and accuracy assessment of land use/land cover classification using remotely sensed data. *Journal of the Indian Society of Remote Sensing* 36(2): 189-201.
15. Sharma R, Joshi PK. 2016. Mapping environmental impacts of rapid urbanization in the National Capital Region of India using remote sensing inputs. *Urban Climate* 15: 70-82.
16. Halim MA, Shahid A, Chowdhury MSH, Nahar N, Sohel SI, Nuruddin, Jahangir M, Koike M. 2008. Evaluation of land-use pattern change in West Bhanugach Reserved Forest, Bangladesh, using remote sensing and GIS techniques. *Journal of Forestry Research* (Springer) 19(3): 193-198.
17. Mani N, Krishnan R. 2013. Assessment of changes in land use/ land cover in Tamil Nadu state in India using GIS. *African Journal of Science and Research* 2(6): 01-06.
18. Prakash AK, Muralikrishna IV, Mishra PK, Chalam RVRK. 2007. Deciding alternative land use options in a watershed using GIS. *Journal of Irrigation and Drainage Engineering* 133: 162-174.
19. Chowdary VM, Ramakrishnan D, Srivastava YK, Chandran V, Jeyaram A. 2009. Integrated water resource development plan for sustainable management of Mayurakshi watershed, India using Remote Sensing and GIS. *Water Resource Management* 23: 1581-1602.
20. Goyal S. 2002. An integrated approach for watershed management. A case study of Chundi watershed. Department of Geography University of Allahabad, Allahabad, Uttar Pradesh.
21. Chakraborty D, Dutta D, Chandrasekharan H. 2001. Land use indicators of a watershed in arid region, Western Rajasthan using remote sensing and GIS. *Journal of the Indian Society of Remote Sensing* 29(3): 115-128.
22. Kumar R, Singh RD, Sharma KD. 2005. Water resources of India. *Current Science* 89(5): 794-811.
23. Lal M. 2001. Climate change Implications for India's water resources. *Journal of India Water Resources Society* 21: 101-109.
24. Sharma A, Tiwari KN, Bhadoria PBS. 2011. Effect of land use land cover change on soil erosion potential in an agricultural watershed. *Journal of Environ Monit Assess* (springer) 173: 789-801.
25. Lallianthanga RK, Sailo RL. 2013. Land use planning for sustained utilization of resources using remote sensing and GIS techniques: A case study in Mamit district, Mizoram, India. *American Journal of Engineering Research* 2(11): 216-222.
26. Palaniyandi M, Nagarathinam V. 1997. Land use/land cover mapping and change detection using space borne data. *Journal of the Indian Society of Remote Sensing* 25(1): 27-33.
27. Patel NR, Prasad J, Kumar S. 2001. Land capability assessment for land use planning using remote sensing and GIS. *Agropedology* 11(1): 1-18.
28. Mishra A, Kar S, Singh VP. 2007. Prioritizing structural management by quantifying the effect of land use and land cover on watershed runoff and sediment yield. *Journal of Water Resource Management* (Springer) 21: 1899-1913.