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Integrated Approach for Sustainable Management of Natural Resources for Rural Development

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Abstract: ***Land and forest resources are limited and their wide utilization is imperative, especially for countries like India. All over the world these resources are dynamic and always affected by anthropogenic activities. In developing countries due to the high rate of urbanization, fringe areas are developing spontaneously in unplanned manner. This uncontrolled, haphazard growth and poor management may prove very costly to resolve process of sustainable development. Urbanization is unavoidable process which converts productive rural lands into urban use and it left serious impact on natural resources utilization. Here, an attempt has been made to provide information on the natural resource of rural area to support their sustainable use and implement an integrated innovative approach and mechanism on micro watershed level. In India, many rural development programs considered watershed as a planning unit for overall sustainable management and development of natural resources. Information on existing land cover and changes through time is prime pre requisites for sustainable management and such information can be generated from remotely sensed data. In the present research work, IRS LISS III multi temporal satellite data of 23.5 meter spatial resolution has been used and obtained results shows that there is loss in quality of land and forest cover of the study area. It is anticipated that such changes may affect the natural ecosystem of the watershed hence spatial planning is required for the reclamation of natural resources of the study area.***
Key words- Fringe, watershed, sustainable management, LISS III, resolution, spatial planning

I. INTRODUCTION

Watershed is natural hydrological entity from which surface run-off flows to a define stream or a river at a particular direction. Watershed management, although is essentially relates particularly soil and water conservation, the role of forest in this regards cannot be neglected. Watershed management practices have been defined as rational utilization of land, water and forest resources for the optimum and sustained production with minimum hazards to natural resources. Watershed deterioration is common phenomenon in most parts of the India. Among various causes, most common among them are improper and unwise utilization of watershed resources without any proper vision. In order to combat and address these problems, sustainable development is no doubt the appropriate policy strategy (S.Srinivasa Vittala, S Govindaiah, H Honne Gowda 2008). In many rural development programmes, catchments and sub-catchments or watersheds are now considered as the fundamental units of managements of land, water and forest resources. While considering watershed conservation work, it is not feasible to take the whole area at once. Thus the whole area is divided into several smaller units as watersheds or sub-watershed by considering its drainage system (S.Srinivasa Vittala, S Govindaiah, H Honne Gowda 2008).

Pune city is located towards the eastern flanks of Western Ghats. Since last two decades, western regions of the Pune city has grown up rapidly in uncontrolled and in haphazard manner and its impacts can be seen in fringe areas which have altered the land cover pattern of the regions. Number of new housing projects, construction activities came up which has put huge pressure on natural resources particularly water, soil and forest. Deforestation and soil erosion on steep slopes is now common phenomena which has caused the progressive destruction of storehouse of trees. Along with this most of the tourist destinations like Khadakwasala backwater, *chaupati*, Sinhagad fort, Panshet and Warasgaon reservoirs etc are located in this region. In monsoon season numbers of visitor increases significantly, which has increased the interference of population in nature. In many parts hills are being cut in an unscientifically which are resulting in loosening of soil and further in landslides. The road widening work is being blamed for making the area prone to 'unprecedented' landslides and frequent landslides are now common on the route. In this region, ghat sections are very steep and heavy downpour makes the soil more prone to landslides. Deforestation, rise in wastelands and construction activities have substantially altered the landscape of the region. Such disturbances of the land can affect important ecosystem processes which can have long term consequences over the region. Important ecosystem services provided by soil and

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forest will reduce if they are converted into other land cover classes. Keeping in view the drastic changes observed in entire region and the significance of the land and forest studies on watershed scale, the present investigation as a case study is undertaken in Donje micro watershed located towards the western part of Pune.

II. OVERVIEW OF THE STUDY AREA

A watershed is all the land area on which rainwater falls and runs/drains off to a common point through streams. It can be a small unit comprising of a small stream encompassed by few hectares or thousands of square kilometers. For the present research work, 'Donje' watershed has been selected as a case study which is located towards the western part of Haveli tahsil in Pune district **(Fig-** This watershed is one of the important watersheds of Khadakwasala catchment area. opography of this watershed is undulating in nature except the northern section. Drainage network shows dendritic pattern and is non-perennial in nature. The geographical coordinates of the watershed are $18^0$21'39" to $18^0$25'38" N and $73^0$45'01" to $73^0$48'13" E longitude. Geographical area of the watershed is around 19.75 sq km (1975.56 hector)**.** It falls under heavy rainfall zone which ranges from 250cm to 300cm. Watershed is covered by three basaltic flows commonly known as 'aa' and compound pahoehoe basaltic lava flows (50-220 m), 10-15 'aa' and simple basaltic lava flows (50-350m) and 'aa' and simple basaltic lava flows (100-300m). Soils are black, dark brown or reddish in color. The largest area is occupied by the black soils. The mean daily maximum temperature and the mean daily minimum temperature in the study area is 41.90^0 C to 21.4^0 C respectively. Vegetation types belong to evergreen, deciduous, and scrub types. Entire watershed comprises parts of small settlements like Golewadi, Askarwadi, Gorhe bk and Gorhe kh and Donje which covers around 4900 population according to census 2011. Most of the people of these settlements are marginal farmers.

A. Major objectives

1) To protect and conserve the land and forest in the watershed for more efficient and sustained use

2) To check the soil erosion and to suggest measures to shelter sediment yield on the watershed

III. MATERIALS AND METHODS

For the present research work multi temporal satellite data has been used, which is obtained from National Remote sensing Centre (NRSC), Hyderabad (India). The Indian Remote Sensing Satellites (IRS) - 1C, and Resourcessat-2 LISS III (Linear Imaging Self Scanning Sensor) MSS (Multi Spectral Scanner) with 23.5 m spatial resolution data of 1997 and 2012 respectively has been used. Toposheet 47/F/15 on 1:50000 scale is obtained from Survey of India and drainage pattern, roads and contours are digitized. Soil erosion data is acquired from soil survey department Pune. Toposheet is rectified in Global Mapper software 11.03. The satellite data is geometrically corrected with the help of Erdas imagine 9.2 image processing software using AOI of the watershed obtained from toposheet. Image Classification is the most widely used technique in remote sensing applications for extraction of target thematic information. To obtain the land use land cover data, satellite data is processed (Fig 2a & 2b) in Erdas imagine 9.2 and using unsupervised classification method, statistics (Table 1) has been generated. The present research work tries to highlight the change in land use land cover of a specific time point and assess its impact on watersheds. In this context remote sensing technology along with GIS play key role.

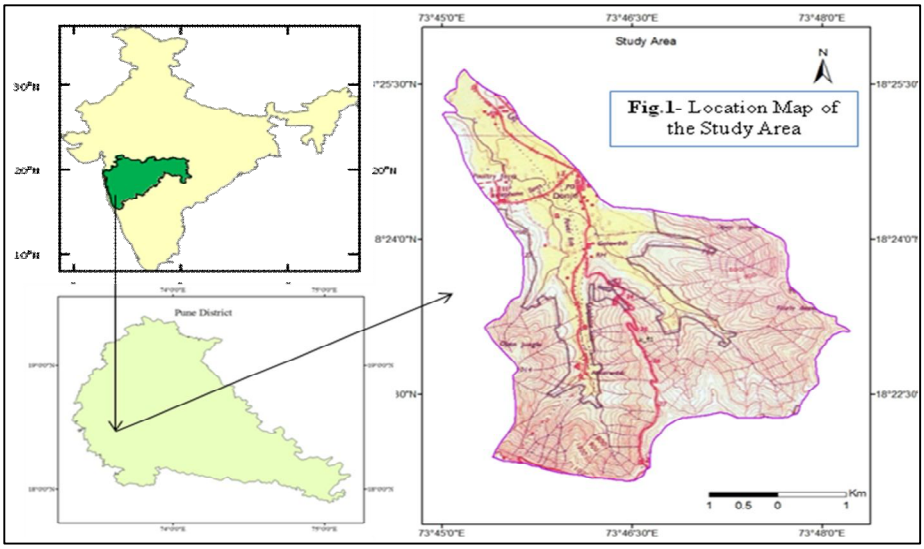


Fig.1- Location Map of the Study Area

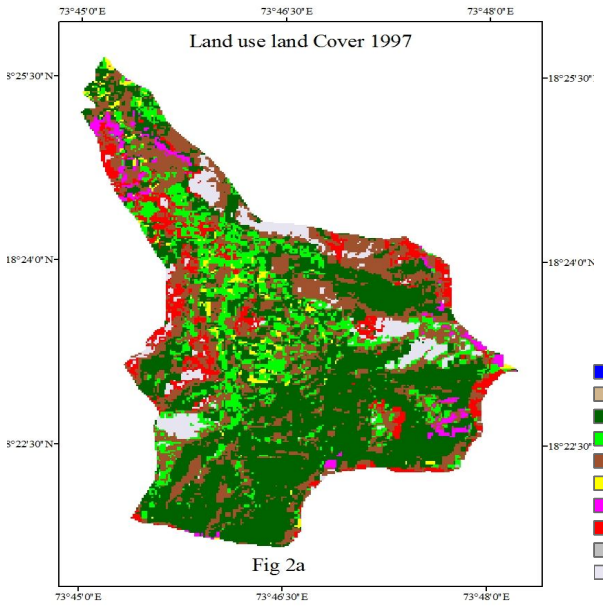


Fig 2a

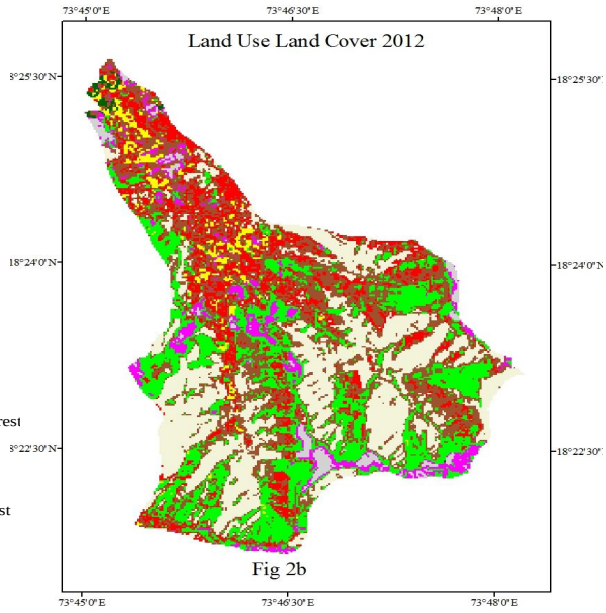


Fig 2b

IV. RESULTS AND DISCUSSION

The present study gives more emphasis on land and forest resources on sustainable basis. For this purpose in land resource category, along with cultivated and fallow lands, wasteland category is also studied. Forest classes of three categories, viz, moderately dense, open forest and scrub or degraded forest are considered. All the estimations about the land cover classes are derived using satellite data at 23.5 m ground resolution and have been summarized in Table 1. There might have been different or may be better estimations at more fine spatial resolution satellite data. An attempt has been made to identity relevant factors negatively impacting the quality of forest and land resources in the watershed. Highest rate of growth in the level of natural resources vulnerability was observed in the southernmost parts of watershed, where most of the area under moderately dense forest has been vanished.

No	Land Use Land Cover (LULC) Class	Year 1997		Year 2012		Change in
		Area		Area		1997 to 2012
		(Ha)	(%)	(Ha)	(%)	Area (Ha)
1	Reservoir & Rivers	0	0	0	0	0
2	Dry River bed	1.2	0.06	0	0	-1.2
3	Cultivated Land	32.43	1.64	53.97	2.73	21.54
4	Agricultural Fallow	527.79	26.72	550.54	27.87	22.75
5	Moderately Dense Forest	858.24	43.44	8.12	0.41	-850.12
6	Open Forest	258.97	13.11	435.92	22.07	176.95
7	Scrub/Degraded Forest	41.93	2.12	97.46	4.93	55.53
8	Barren Land	0.40	0.02	41.64	2.11	41.24
9	Rocky Waste Land	114.85	5.81	512.58	25.95	397.73
10	Built up	139.74	7.07	275.33	13.94	135.59
TOTAL		1975.56	100.00	1975.56	100	

Table 1- LULC data of the study area

It is clear from the Fig 2a & 2b, that the LULC classes under consideration shows significant change within the specific time span. As far as change in land use is concern among all the classes, land and forest shows significant and negative change.

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Land is one of the major factors of production and essential input for built up and food production in the rural areas. In the entire parts of the study area cultivated and agricultural fallow land does not show any remarkable changes and remained almost same. Along with the cultivated and agricultural fallow lands, wasteland category is also taken into consideration which includes barren and rocky wasteland. Increase in barren land is a serious concern as it shows around 41.24 ha increase. Most of barren land came under cultivation in rainy season. Rocky waste lands also increased drastically by 397.73 ha. The degradation of land is clearly associated with soil erosion in the study area. Soil erosion map is acquired from soil survey department, Pune (Fig 3). Entire study area is characterized by high elevation and steep slope (Fig 4). Slope is one of the major controlling factors in the development and formation of different landforms. Soil erosion depends upon land slope and intensity of rainfall. The high velocity water takes away more soil with it. In the present watershed maximum slope is observed towards the southern parts. During the heavy rainfall, due to absence of sufficient forest cover these soils are washed out rapidly leaving behind the open rocky surfaces (Gaikwad S 2009). Figure 3 shows drainage pattern and soil erosion in the study area. It was observed that about 14.062 sq km area (71.20%) is severely eroded (Fig 3). Slope and contour map has been prepared to understand the natural landscape of the study area (Fig 4). The eroded area is mainly noticed towards the upper reaches of the study area where more than 20^0 slope is observed. Severity of soil erosion increases on the surface regions where more than 30^0 slope is observed (Fig 4).

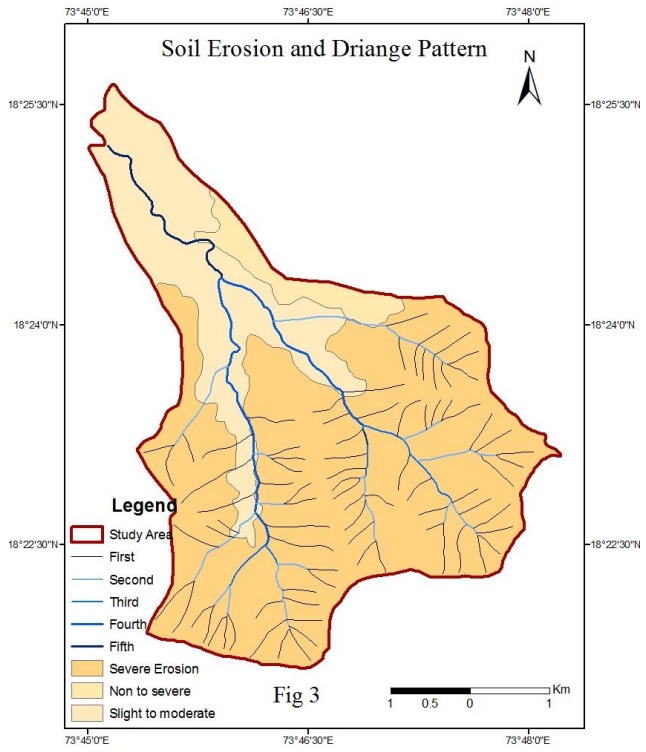


Fig 3

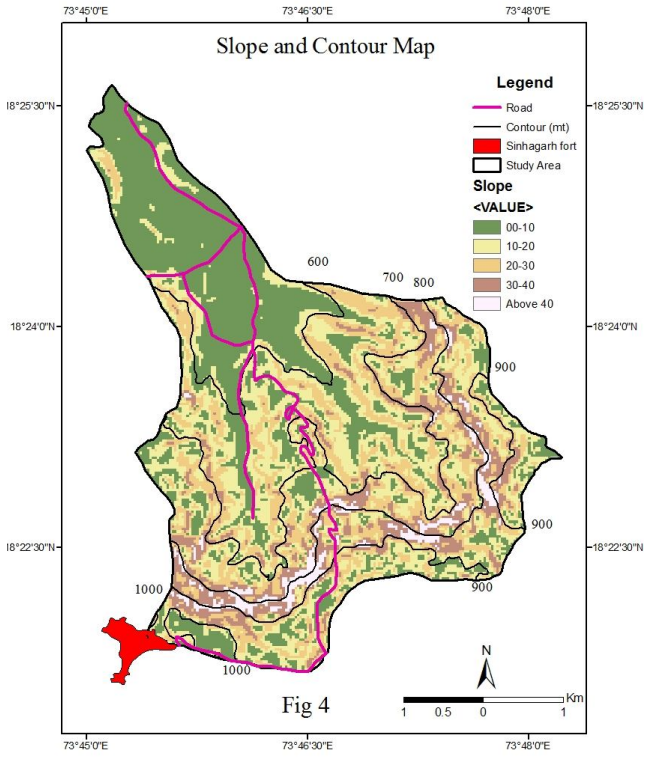


Fig 4

As far as degradation of forest is concern, all the forest cover classes taken into consideration shows disastrous change. Moderately dense forest is severely affected and need urgent attention (Fig 2b) as it is vanished over the 850 ha area. This watershed has extremely rich flora and fauna including some rare endangered species (Ingalhalikar S. 2005). Common plant species observed during the field visit in the study area are shown in the table 2. Most of the parts showing increase in open forests were previously densely forested and now due to the encroachment, the area under moderately dense forests is decreasing and shows around 176 ha growth in open forest. Scrub or degraded forest also shows increase by 55.53 ha.

During the field visits, it was observed that watershed is characterized by various types of trees, shrubs and grasses, which particularly belong to evergreen and semi evergreen types of forest. Verities in tree species are observed mainly in 700 to 900 meter altitudinal zone. Economical as well as ecological significance of these plant species is immense for native population. In entire parts of western Maharashtra, forest are subject to many demands like food, fodder, fuel, fiber, timber, ornamental, manure, tanning, religious, spices or flavor, perfume and folk medicines.

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Large scale deforestation had been noticed in the foothills around the Sinhagad fort. The change in the forests cover is due to the human induced activities. Positive aspect in this region is that the barren hill slope are now have good plantations made by the forests department mainly around the Sinhagad valley. The forest at lower level is also dominated by plantations made by the forests department, which includes prominent species like *Teak, Australian Acacia and Eucalyptus.*

No	Type	Table 2 -Botanical and local names of common plant species observed in the Study Area
1	Trees	Tectona grandis (Teak), Acacia catechu (Khair), Adina cordifolia (Hedu), Aegle marmelos (Bel), Albizia lebbeck (Shirish), Albizia procera (Kinhai), Anogeissus latifolia (Dhavda), Mangifera indica (Mango), Anthocephalus cadamba Roxb (Kadamb), Bauhinia racemosa (Apta), Butea monosperma (Palas), Dalbergia latifolia (Shisam), Eucalyptus camaldulensis (Nilgiri), Flacourtia latifolia (Tambat), Olea dioica (Parjambhul), Terminalia alata (Ain), Terminalia chebula (Hirda)
2	Shrubs	Lantana camara (Tantani), Lasiosiphon eriocephalus (Rametha), Euphorbia antiquorum (Nivdung), Calotropis procera (Rui), Carissa congesta (Karvand), Carvia callosa (Karvi) Vitex negundo (Nirgudi)
3	Herbs	Solanum anguivi (Chichandri), Parthenium hysterophorus (Gajargavat), Impatiens balsamina (Terda), Euphorbia rothiana (Dudhi),
4	Grasses	Cynadon dactylon marli (Marli), Dendrocalamus structus (Bamboo)

Apart from the destruction to forest, thinning process of forests is noticed, i.e. the forests are altered which makes change in forests type from dense to open or scrub/ degraded. Native tracts of forests are separated into patches due to the increasing anthropogenic activities. The region is rich in biodiversity of both flora and fauna, but excessive tourism and now spread of exotic weeds is posing a threat to the diversity and wildlife. Because of intrusion of outsiders with commercial intensions in this region reckless construction activities and stress on land and forest resources are increasingly became common. This is threatening the ecosystem of watersheds causing widespread deforestation, soil erosion and siltation of streams.

V. SUGGESTIONS

Watershed planning for the rural development is now involves in utilization, conservation and management of catchment precipitation, soil and forest resources. The rural development programme in general and watershed programme in particular should be comprehensive one covering varied areas like land reclamation, checking soil erosion, scientific water management and afforestation programmes. It also aims at employment generation through allied agricultural activities and tourism by improvement in basic infrastructure, roads, agricultural inputs etc. Hence integrated approach to conserve both soil and forest is more fruitful as they are closely associated with each other. Considering the slope of the study area, it was observed that contour trenches are useful to increase soil moisture by impounding the run-off flowing over the slopes. It also reduces land erosion by entrapping the run-off from sloping grounds. Stone pitching and gully plugging prevents land from eroding and down cutting of gully heads. Such soil conservation work carried out for preventing soil erosion also helps in water conservation. To prevent the high velocity of running water from steep slope, adequate vegetative cover is best option. Eroded soil can be trapped in trenches which further helps for development of roots resulting in vigorous growth of trees. Deep rooted native trees like *Tectona grandis* (Teak), *Mangifera indica* (Mango), *Eugenia jambolana,* (Jambhul), *Psidium guajava* (Guava), *Feronia elphantun* (Kavath) planted on steep sloping lands to reduce soil erosion. *Termanilia chebula* (Hirda), *Dalbergia latifolia* (Sesum) ,*Butea monosperma* (Palas) can grow on barren rocky hills. Agro-forestry is a sustainable land management system hence plantation of multipurpose tree species has been recommended for degraded lands in the watershed for improvement of soil fertility. It will also help in fuel and fodder. Wastelands or degraded lands are currently unutilized and they may be deteriorating due to lack of appropriate management or sometimes due to the natural causes. These lands can be brought under native vegetation cover with reasonable efforts.

VI. CONCLUSION

An attempt has been made to identity relevant factors negatively impacting the quality of natural resources in the watershed. Highest rate of growth in the level of natural resources vulnerability was observed in the southern part of watershed. Change detection

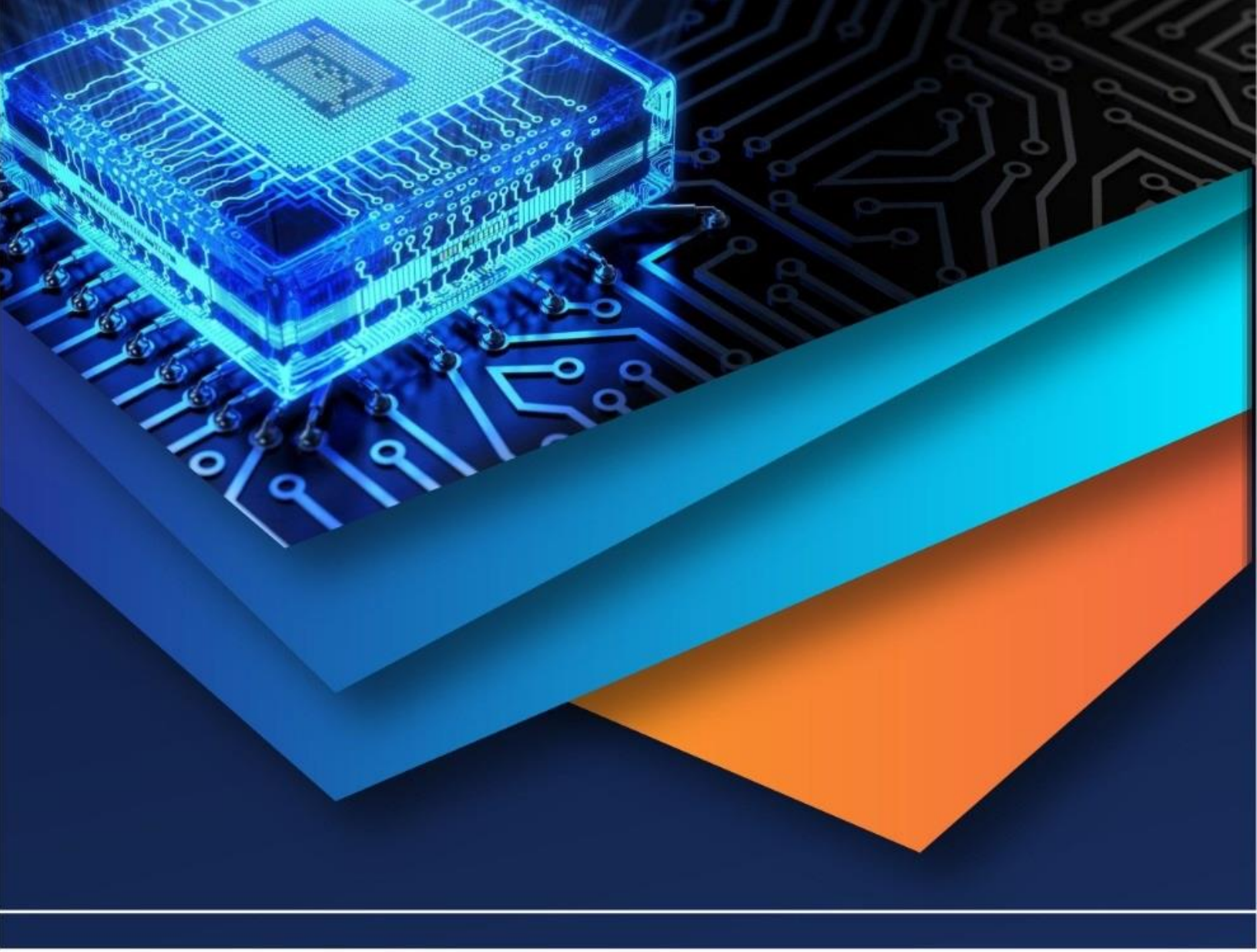
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analysis is found to be useful in monitoring and managing natural resources as it provides quantitative analysis of land use land cover data over a specific time period. At present there is an extreme adequacy of basic data or resources for preparation of scientifically sound watershed development plan. Remote sensing and Geographical Information System (GIS) in this regards play a key role in generation of valid database.

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