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An Integrated Approach for Land Resource Management through Remote Sensing and GIS - A Case Study of Keolari Block, Seoni District (Madhya Pradesh), India

Sheetal Kumari¹, Utpal Biswas², Mobin Ahmad³, Sandeep Kumar⁴

^{1, 4}Centre for Land Resource Management, Central University of Jharkhand

² Project Assistant, ³ Scientist, Department of Natural Resource Modelling and Environment Management, CSIR Central Institute of Mining & Fuel Research, Dhanbad, Jharkhand, India.

Abstract: Land resource play a very vital role for the prosperity of any region and its relevant development and management is a matter of extreme concern to the people. Inappropriate use of the land has created so many problems like land degradation, soil erosion, wastes, deteriorate in productivity and so on. Therefore, proper utilisation of land and land resources to fulfil the requirements and increasing demand of growing population is very necessary. This paper focuses on the conceptual integration of land resource management with reference to an action research program for different type of agriculture practices of Keolari Block, Seoni District (Madhya Pradesh). Sentinel 2A, Cartosat DEM, SOI topographical map and relevant secondary data were used for the study area. Various factors including geomorphology, lithology, Ground Water Potential (GWP), soil texture, slope, LULC and land capability were used for the preparation of action plan for the artful management, and planning of land resources of the study area with integration of Thematic maps. GIS and Remote sensing prove as a beneficial tool for the development of user friendly for the study of land resources and Land resource management. The action plan map suggests suitable land site for various type of agriculture including double cropping, agroforestry, agro-horticulture and dryland horticulture. The entire study was classified into five categories very highly suitable, highly suitable, moderately suitable, least suitable and not suitable. Area statistics has been generated for different types of agriculture practices. Implementation of the suggested action plan will lead to sustainable development of the land resources.

Keywords: Land Resource Management, Multi Criteria Analysis, Remote Sensing & GIS.

I. INTRODUCTION

Earth is the only planet in our solar system which has favourable conditions for the growth and development of all kind of living organisms. Anything on the earth that satisfies human needs is called a resource. Among all of the resources land is one of the most prominent resource. Land resources are used to fulfil human needs and demands like food, fodder, fuelwood, fibres etc. But now-a-days land resources are not used in a proper way and hence there is an imbalance. When land is utilised beyond its capability, it may results in the deterioration of land (Mekuriaw 2017). Therefore, proper utilisation of land and land resources to fulfil the requirements and increasing demand of growing population is very necessary. Hence, we need land resource management. It is linked to sustainable development of land. Sustainable land resource management and development depends on proper planning, implementation, operation and management (Hiese et al. n.d.). Geoinformatics plays a very vital role in this. Geographic information system (GIS) and multi criteria decision analysis (MCDA) have been rapidly used to amend the land management (Ahmadi et al. 2016).

The main objective of this present research work is: recommendation of future work and provide guidelines for Land Resource Management in Keolari block, Seoni district, Madhya Pradesh using GIS and Remote sensing and multi criteria analysis. This will include: preparation of various thematic map such as LULC, geomorphology, lithology, GWP, slope, soil texture, land capability, spatial multi-criteria analysis for all the thematic layers, action suggested for various farming practices, and preparation of suitability map for various farming practices.

Multi Criteria Decision analysis (MCDA) has been used in many researches such as Land resource management (Manna et al. 2017), solid waste management (SURAJIT, MOBIN, and PREET 2018), sustainable energy planning (Pohekar and Ramachandran 2004), land suitability (Bagherzadeh and Mansouri Daneshvar 2014).

II. STUDY AREA AND DATASETS

A. Study Area

The study area selected for this case study is Keolari Block (a block situated in Seoni district, Madhya Pradesh).

The total geographical area is 1101 Sq. km. The area is included in SOI toposheets f44h15, f44i4, f44i3, f44i2, f44h16, and f44h11. It is located at 22.37°N, 79.90°E. It is 60 km towards East from district headquarters Seoni and 330 KM from state capital Bhopal towards west. Keolari consist of 182 Villages and 78 Panchayat. It has an average elevation of 447 metres (1466 feet). It is located at the absolute centre of the country. The confluence of the Wainganga and Sagar rivers are located at Keolari. The city has the typical hot and dry temperature of the Great Indian Plateau. Keolari is hot during summers with temperatures up to 44 degrees Celsius but the winters are quite comfortable.

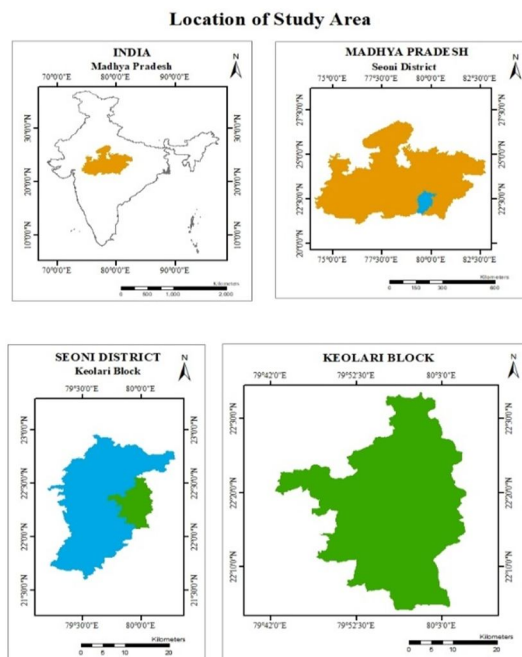


Figure 1: Location Map

B. Datasets

Data used for the present study comprises of six SOI toposheet of scale 1:50000, Sentinel 2A of spatial resolution 30m, Cartosat DEM version-2 R1 of spatial resolution 30m. Geomorphology, lithology and ground water potential map is obtained from District Resource Map, Seoni district, Madhya Pradesh. Soil data is obtained from National Bureau of Soil Survey and Land Use Planning. Land capability is obtained from Madhya Pradesh council of science and technology (MPCST).

III. METHODOLOGY

The methodology of the present study is shown in the Figure 2. The boundary of the study area was prepared with the help of Survey of India topographical map on 1:50000 scale. LULC map was prepared with the help of Sentinel 2A geocoded with UTM projection. Thematic map like Geomorphology, Lithology, Ground Water Potential map was prepared, based on District Resource Map (scale 1:50000). The Soil map was prepared, based on National Bureau of Soil Survey and Land Use Planning. Land capability map was prepared, based on MPCST. Slope map was prepared from CARTOSAT DEM data of resolution 30m using ArcGIS spatial analyst tool.

All the map was converted into Raster then reclassified according to the rank of parameter in all layer according to the knowledge base ranking from 1 to 9 according to their suitability. The maximum value is given to the feature with highest potentiality and minimum being to the lowest potential feature. For land management all the thematic map is overlaid by weighted overlay method using spatial analyst tool in ArcGIS 10.4. for different purposes including Double cropping, Agro-horticulture, Agroforestry, Dryland horticulture. During weighted overlay analysis, the ranking was given to all the individual parameter of thematic map, and weights were assigned according to multi-influencing factor for different purposes.

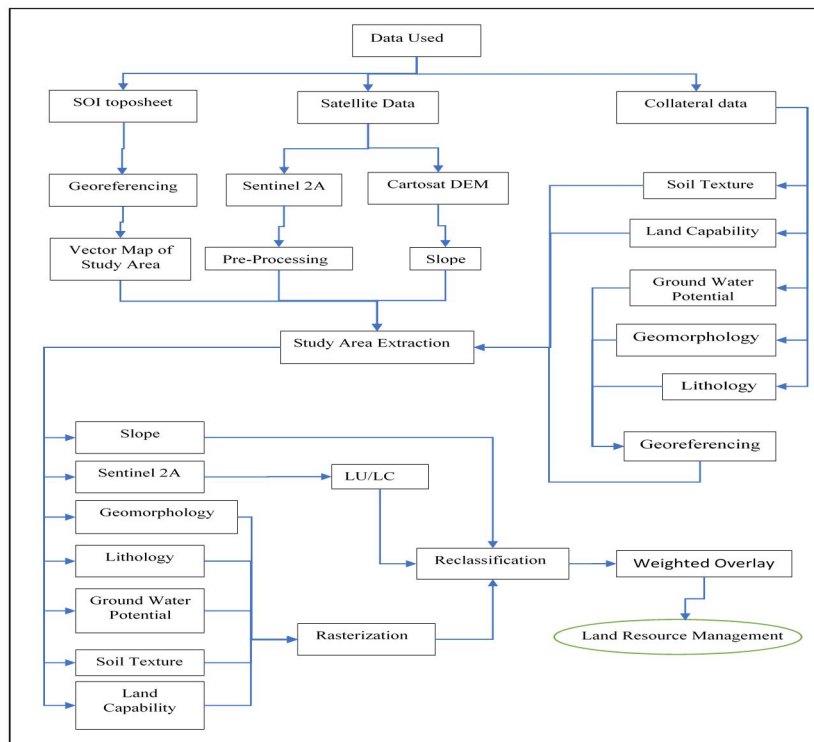


Figure 2: Flow Chart

IV. THEMATIC MAPS

A. LULC Map

LULC map was prepared under the study. The Satellite Data from Sentinel 2A is used for classification. Supervised classification was performed to obtain the land use/ land cover information classes into nine classes after clipping the study area. Data available for Land use/ Land cover map help us to provide critical input for decision making of the management and planning of the future. Rank assigned for each class was according to the potential for certain type of agriculture practice (double cropping, agroforestry, agro-horticulture, dryland horticulture). The statistics of the LULC classes are Table 1. The map of LULC is shown in Figure 3.

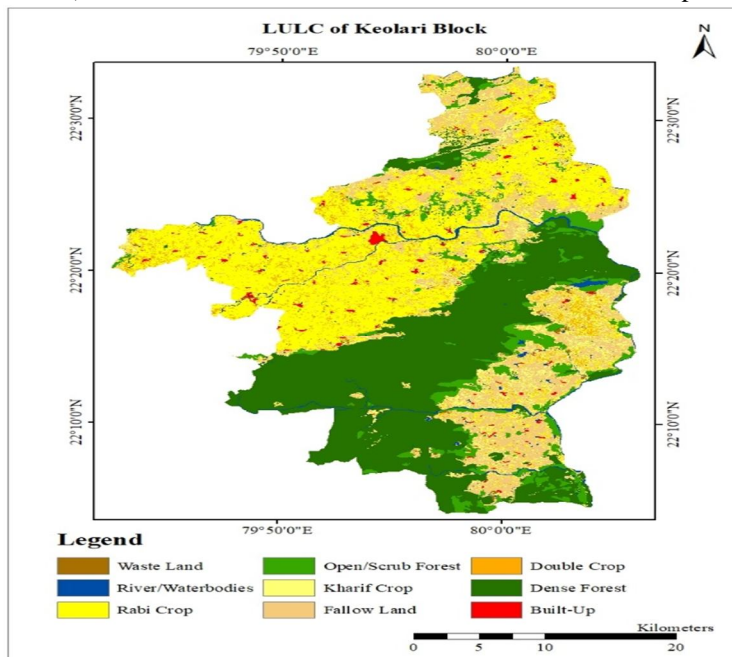


Figure 3: LULC Map

Table 1: Distribution of land under various LULC classes

Class name	Area (sq. km)	% Area
Dense Forest	360.271	32.399
Rabi Crop	333.235	29.968
Fallow Land	190.093	17.095
Open/Scrub Forest	78.324	7.043
Kharif Crop	67.868	6.104
Double Crop	48.683	4.378
River/Waterbody	19.386	1.743
Built up land	11.798	1.061
Waste Land	2.297	0.206

B. Geomorphology Map

The prepared geomorphology map is shown in Figure 4. Several landforms and structural features can be identified and characterized using geomorphological mapping. Many of these features are favourable for the occurrence of ground water and surface water. Geomorphological units found in the study area are Denudational Plateau, Denudational slope on deccan trap, pediplain and region of middle level plateau.

It is depicted that the pediplain may be accomplishment of the landform growth, the final result of the process of erosion. So, it is best suitable for agricultural land. It is best suited for double cropping, agro-forestry, agro-horticulture, dryland horticulture. The statistics for various classes of geomorphology found in the study area is given in Table 2.

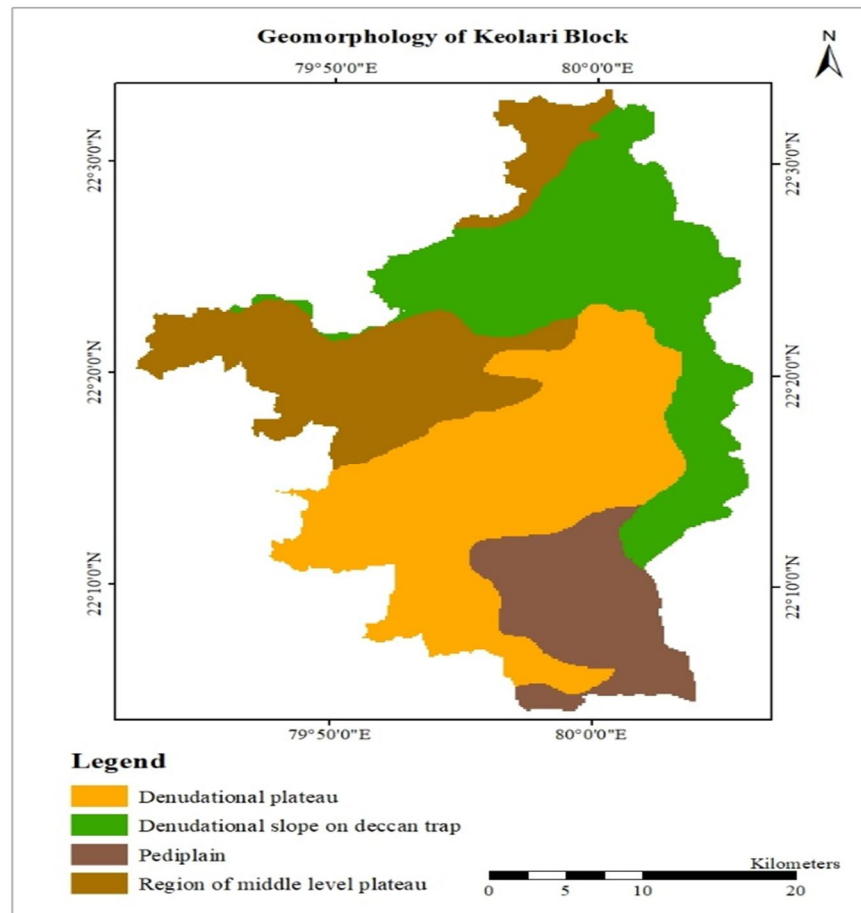


Figure 4: Geomorphology Map

Table 2: Distribution of land under various Geomorphological types

Class	Area (sq.km)	% Area
Region of middle level plateau	247.385	22.247
Denudational slope on deccan trap	328.355	29.529
Pediplain	145.287	13.066
Denudational plateau	390.929	35.157

C. Lithology Map

The prepared lithology map is shown Figure 5. The term lithology refers to the study of landforms, structures, and the subsurface to be conscious of the physical processes that create and modify the Earth’s crust. To acknowledge about the quality of land surface structure, composition or subsurface along with other data sources that provide equivalent measurement, remote sensing is used. The different lithological units present in the study area are Vesicular Basalt, Granite, Compact Basalt and gneiss. Lithology plays important role to recharge the ground water level and land resources management. The statistics for various classes of lithology is shown in Table 3.

Table 3: Distribution of land under various Lithology types

Classes	Area (sq. km)	% Area
Vesicular Basalt	507.726	45.6605
Granite	75.808	6.817
Gneiss	497.495	44.740
Compact Basalt	30.927	2.781

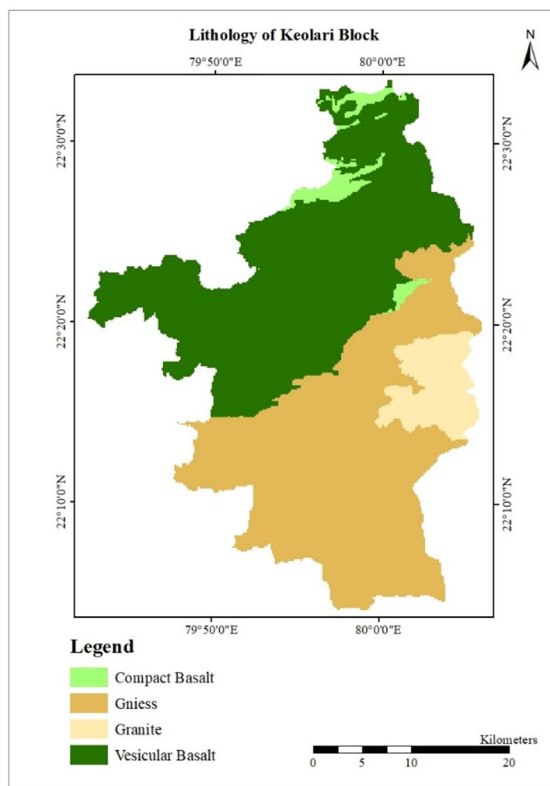


Figure 5: Lithology Map

D. Ground Water Potential Map

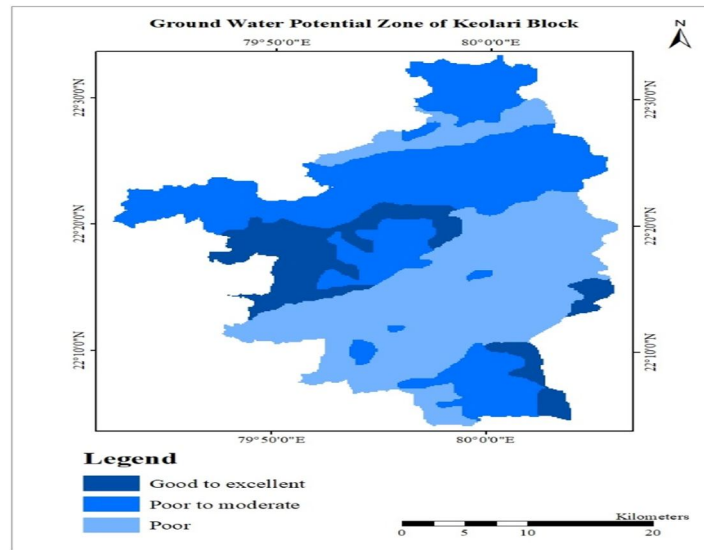


Figure 6: Ground Water Potential Map

The prepared map is shown Figure 6. Ground water is the water that accumulate below the surface of the earth due to the rain and the flow of river between the voids of the rock. The location of ground water can be found using remote sensing data that depends on indirect analysis of geological structure, geomorphology and their hydrological characteristics. Ground water potential zone of study area was divided in three zone: good to excellent, poor, poor to moderate. The statistics of these zone is given in Table 4.

Table 4: Distribution of land under various GWP zone

Classes	Area (sq. km)	% Area
Poor	476.635	42.864
Poor to moderate	480.329	43.196
Good to excellent	154.993	13.938

E. Soil Texture Map

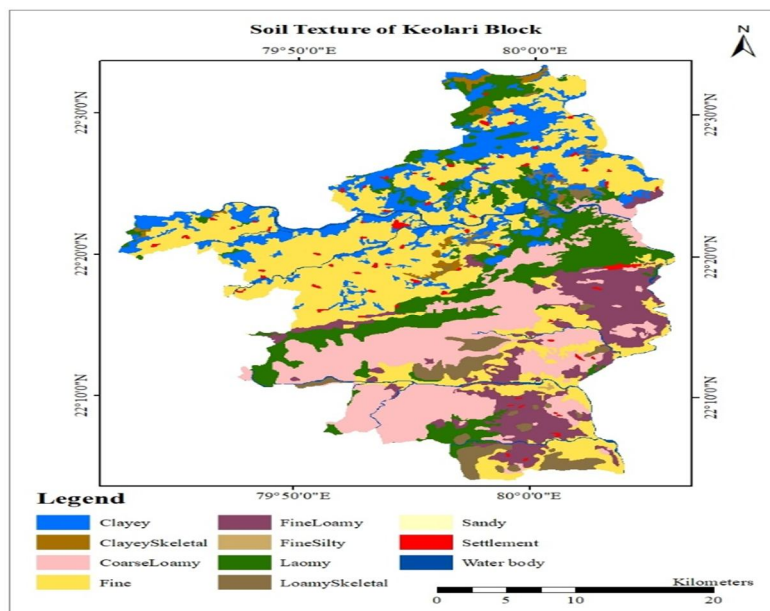


Figure 7: Soil Texture Map

Soil is the basically the foundation of the Earth surface. It is the basic criteria on which the whole agriculture system rests. Its important feature is its water holding capacity, variation in porosity with depth. The relative size of the particles of soil (sand, silt and clay) is identified by its texture. Soil texture is used as a qualitative tool in a fast, simple and effective way to assess soil physical's characteristics. Remote Sensing along with GIS helps to determine which soil is best for certain type of soil. It has become the most powerful tool for the detection of soils characteristics. Soil texture found in Keolari block are fine, loamy, clayey, clayey skeletal, loamy skeletal, fine loamy, coarse loamy, sandy, and fine silty. Soil which is best for different type of agriculture in study area are mainly fine, fine loamy and coarse loamy so they have given more weightage in all. Soil texture map is shown in Figure 7 and statistics is shown in Table 5.

Table 5: Distribution of land under various soil classes

Classes	Area (sq. km)	% Area
Water body	18.525	1.666
Fine	378.545	34.043
Loamy	164.802	14.820
Clayey	137.196	12.338
Clayey Skeletal	10.667	0.959
Loamy Skeletal	47.484	4.270
Settlement	12.203	1.097
Fine Loamy	120.127	10.803
Coarse Loamy	221.782	19.945
Sandy	0.208	0.018
Fine Silty	0.416	0.037

F. Land Capability

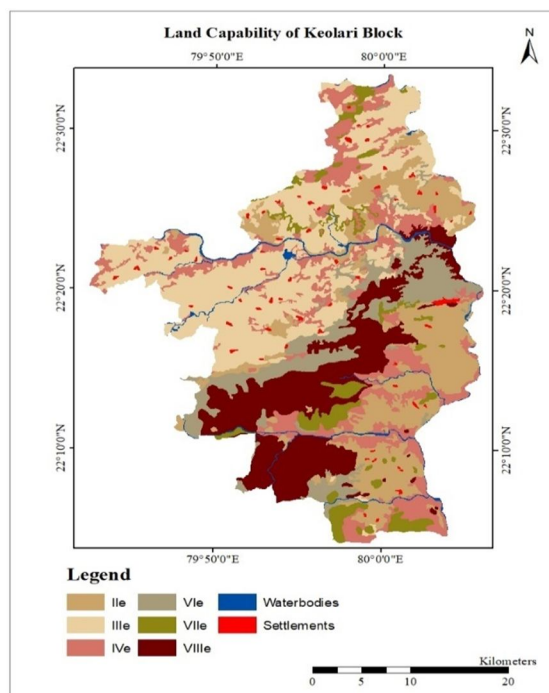


Figure 8: Land Capability Map

Land capability is the ability of the land to sustain a type of land use permanently. Land capability map of the study area based on the data of soil survey of India and provided by MPCST, Bhopal, Madhya Pradesh shows that the land in the Keolari block is subject to the risk of soil erosion. In spite of this limitation, nearly three-fourth of the geographical area of this block in class II and Class III is capable of high level of sustained agriculture.

The statistics of land capability classes is shown in Table 6 and the map is shown in Figure 8.

Table 6: Distribution of land under various land capability

Classes	Area (sq. km)	% Area
I _{le}	221.938	19.959
III _{le}	311.676	28.029
IV _{le}	183.665	16.517
VI _{le}	117.265	10.545
VII _{le}	60.259	5.419
VIII _{le}	186.423	16.765
Waterbody	20.060	1.804
Settlement	10.667	0.959

G. Slope Map

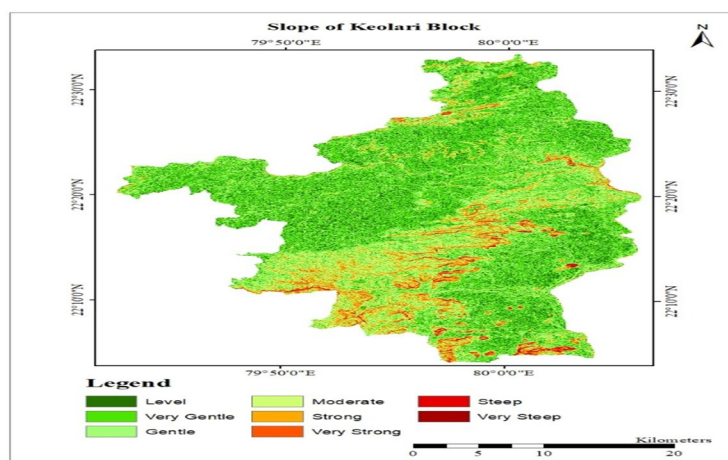


Figure 9: Slope Map

Slope is the most important feature of the Earth Surface. Slope map is created with the help of Digital Elevation Model using ArcGIS 10.4 software. DEM is the basic unit for generation of Slope map. The study area falls in eight categories. These are level (0-2%), Very gentle (2-5%), gentle (5-10%), moderate (10-15%), strong (15-30%), very strong (30-45%), steep (45-70%), very steep (70-100%).

The slope category: level, very gentle slope extends over those areas where slope ranges from 0-2% and 2-5 %, this area is suitable for double cropping. Agroforestry requires steeper slope having densely populated area. In the study area this criterion is fulfilled by the slope category very gentle and gentle slope. Dryland horticulture and agro horticulture also requires level to gentle slope for higher production. The slope map of the study area is shown in Figure 9 and along with its statistics in

Table 7.

Table 7: Distribution of land for various classes of slope

Classes	% Slope	Area (sq. km)	% Area
Level	0-2	168.335	15.138
Very gentle slope	2-5	423.396	38.076
Gentle	5-10	278.693	25.063
Moderate	10-15	122.457	11.012
Strong	15-30	87.145	7.837
Very strong	30-45	21.806	1.961
Steep	45-70	9.174	0.825

Very steep	70-100	0.948	0.0853
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V. RESULTS AND DISCUSSIONS

This chapter cover the aspect of agriculture land management. An approach has been adopted to appraise lands for promotion of a suitable land use management practice. Capability of GIS is put into use with overlay weightage and multicriteria approach for integration of thematic information and generation of land resource management plan. Geomorphology, lithology, Ground water potential, soil, slope, land use land cover and land capability have been considered for Land resource management.

The practices taken for agriculture land management are:

A. Double Cropping

Planting two different crops in the same field with in a season is termed as double cropping. This is accomplished by means of companion crops and successive crops. In double cropping, second crop should be rooted after the first crop's growing season come to an end or second crop should be rooted in amidst of harvesting period of first crop. Harvesting wheat crop in early summer and then planting of corn or soya beans is an example of double cropping (Dale et al. 2010). Double cropping has many benefits. It protects soils against wind and water, enhances soil fertility, reduces reliance on agriculture chemicals, increases net profit, etc.

In the study area Keolari block, Double crop is best suggested where the Geomorphology is pediplain, lithology is vesicular basalt, GWP is good to excellent, soil is fine loamy and coarse loamy, slope is level and very gentle, Lulc is Rabi and Kharif crop, and Land capability is class II and Class III. The suitable crop which is practiced in the area are rice, wheat, Gram etc. Suitability map for double crop is shown in Figure 10.

Very highly suitable area for double cropping constitutes 21% and not suitable area constitute 0.75% of the study area. Almost 30% of the area is moderately suitable, 29% is highly suitable and 18.5% is least suitable. According to the map very high suitable area for double crop is mainly located in the western and southern part of the Keolari block and represented by dark green colour in the map.

Action suggested for double cropping is shown in Table 8 and Statistics is shown in Table 9.

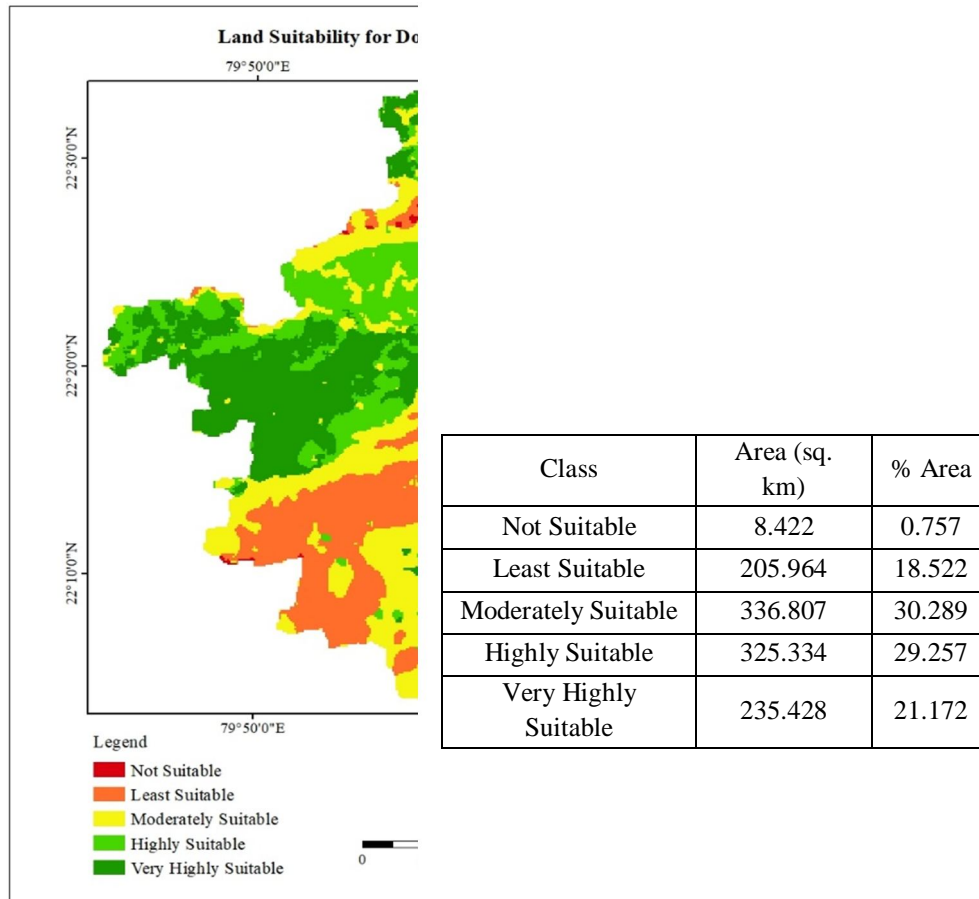


Figure 10: Suitability map for double cropping

Table 8: Action suggested for double crop

Double Crop	
Geomorphology	Pediplain, Region of middle level Plateau
Lithology	Vesicular Basalt
GWP	Good to Excellent
Soil	Fine Loamy, Coarse Loamy
Slope	Level , Very Gentle
LULC	Rabi Crop, Kharif Crop
Land Capability	Ile, IIIe

Table 9: distribution of land for double cropping suitability

B. Agroforestry

Agroforestry can be defined as the management and integration of crops and trees with in a plot of land. This type of farming includes both agriculture and forestry to improve sustainable land use system. Example of agroforestry is citrus along with vegetables. It has many benefits. It improves land drainage, biodiversity and habitat, control runoff and soil erosion, provides source of renewable energy, etc.

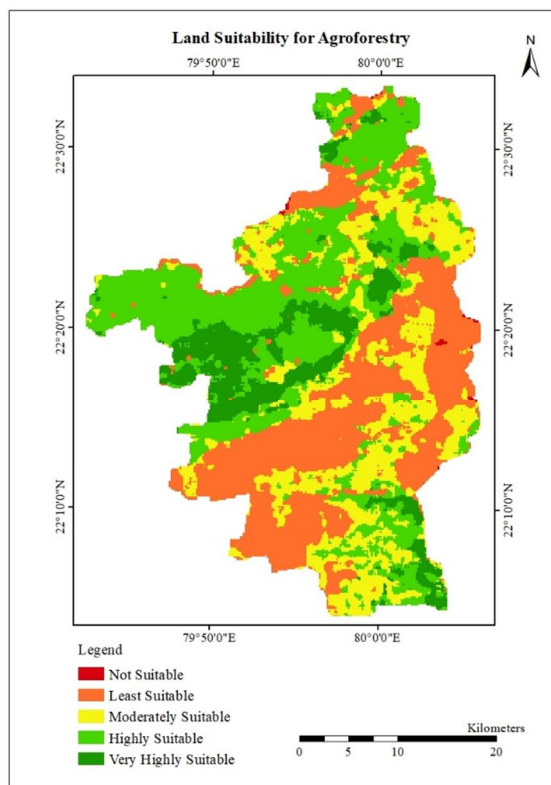


Figure 11: Suitability map for Agro-forestry

Table 10: Action suggested for Agro-forestry

Agroforestry	
Geomorphology	Pediplain, Denudational Plateau
Lithology	Vesicular basalt, Gneiss
GWP	Good to excellent
Soil	Loamy skeletal, Loamy, Fine
Slope	Very Gentle, Gentle, strong
LULC	Rabi crop, Kharif crop, Fallow land
Land Capability	IIIe,, IVe

In the study area Keolari Block, agroforestry is best suited where geomorphology is Pediplain, lithology is vesicular basalt, GWP is good to excellent, soil is loamy skeletal and loamy, slope is gentle and very gentle, LULC is fallow land, rabi and kharif crop and land capability is class III and IV. Agroforestry map shown in Figure 11.

Very high suitable area for agroforestry constitutes 13.51% and not suitable constitutes 0.19% of the study area. Almost 32% of the area is least suitable, 30% is highly suitable and 24% is moderately suitable. According to map very high suitable area is located at western to the middle part of the Keolari block including Kandipar, Malhanwara, Dhanagada, Chanwarmara, Lopa, Jhola, Sanwari villages. Also found in the north and southern part part of the Keolari block and represented by dark green colour in map. Action suggested for Agroforestry is shown in

Table 10 and statistics in Table 11.

Table 11: Distribution of Land for

Agroforestry		
Class	Geomorphology	Area (sq. Km)
Not Suitable	Pediplain, Denudational Plateau	2.216
Least Suitable	Vesicular-basalt, Gneiss	357.309
Moderately Suitable	Good to excellent	267.501
Highly Suitable	Loamy, skeletal, Loamy, Fine	334.695
Very Highly Suitable	Very Gentle, Gentle, strong	50.443
LULC	Rabi crop, Kharif crop, Fallow land	315.2
Land Capability	IIIe, IVe	

Agro-forestry suitability

C. Agro-Horticulture

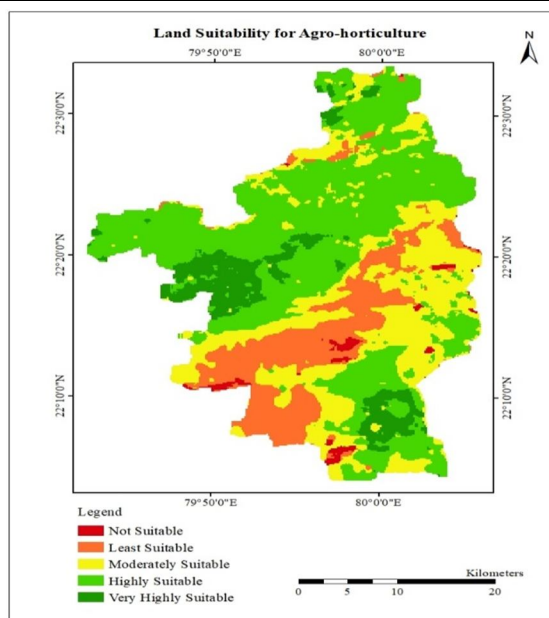


Figure 12: Suitability map for Agro- horticulture

Agro-Horticulture is the science and art of cultivation of garden plants such as fruits, vegetables, flowers, and crops. These crops require relatively less amount of water. This type of farming provides a better alternative to improve the land use efficiency. It is environmental friendly and provides us nutritious foods. In this way, it helps to make higher profitable production.

In the study area, Keolari block agro horticulture is best suited in where geomorphology is pediplain and region of middle level plateau, lithology is vesicular basalt and gneiss, GWP is good to excellent and poor to moderate, soil is fine, fine loamy, slope is gentle and very gentle, LULC is fallow land and rabi crop land capability is class III and IV.

Very high suitable area for agro-horticulture constitutes 8.29% and not suitable constitutes 1.47% of the study area. Almost 46% of the area is highly suitable, 17% is least suitable and 26% is moderately suitable. According to map very high suitable area is located at western and southern part of the Keolari block and represented by dark green colour in map. Action suggested for Agro-horticulture is shown in Table 12 and statistics in

Table 13. Map prepared is shown in Figure 12.

Table 12: Action suggested for Agro-horticulture

Agro Horticulture	
Geomorphology	Pediplain, region of middle level plateau
Lithology	Vesicular basalt, gneiss
GWP	Good to excellent, poor to moderate
Soil	Fine, fine loamy, loamy
Slope	Gentle, very gentle
LULC	Fallow land, rabi crop
Land Capability	Ie, IIIe

Table 13: Distribution of land for Agro- horticulture suitability

Class	Area (sq. km)	% Area
Not Suitable	16.323	1.468
Least Suitable	187.295	16.847
Moderately Suitable	300.146	26.993
Highly Suitable	515.966	46.402
Very Highly Suitable	92.226	8.294

D. Dryland Horticulture

Dryland horticulture is defined as cultivation of crops in the absence of irrigation facilities. These types of crops give optimum production using maximum moisture from low or very often rainfall. Crops are planted in a dispersed manner and in very less number. Examples are apple, guava, amla, ber, etc. Benefits include low capital investment, high employed potential, maximum use of local raw materials and left barren land can be used.

In the study area, Keolari block Dryland horticulture is best suited in where geomorphology is Denudational slope on deccan trap and pediplain, lithology is vesicular basalt and granite, GWP is poor and poor to moderate, soil is fine loamy, coarse loamy, loamy, slope is level, gentle and very gentle, LULC is fallow land, kharif crop, and rabi crop land capability is class II, III and IV.

Very high suitable area for Dryland-horticulture constitutes 17.28% and not suitable constitutes 0.28% of the study area. Almost 34% of the area is highly suitable, 28% is least suitable and 19% is moderately suitable. According to map very high suitable area is located at north, north west, eastern and southern part of the Keolari block and represented by dark green colour in map. Action suggested for Agro-horticulture is shown in Table 14 and statistics in Table 15. Prepared map is shown in Figure 13.

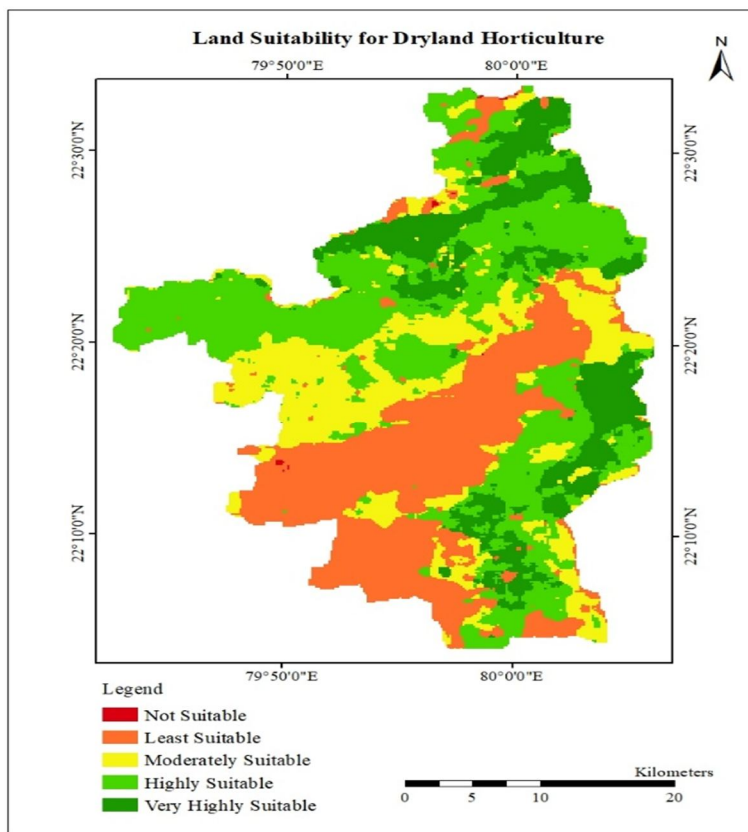


Figure 13: Suitability map for Dryland horticulture

Table 14: Action suggested for dryland horticulture

Dryland Horticulture	
Geomorphology	Denudational slope on deccan trap, pediplain
Lithology	Vesicular basalt, granite
GWP	poor, poor to moderate
Soil	Fine loamy, coarse loamy, loamy
Slope	Gentle, very gentle
LULC	Fallow land, rabi crop
Land Capability	I _{II} e, III _e , IV _e

Table 15: Distribution of land dryland horticulture

Class	Area (sq. km)	% Area
Not Suitable	2.842	0.255
Least Suitable	320.328	28.807
Moderately Suitable	215.716	19.399
Highly Suitable	380.873	34.253
Very Highly Suitable	192.196	17.285

VI. CONCLUSIONS

Land Resource Management is defined as “the actual practice of the use(s) of the land by local human population, which should be sustainable”. The study of the Land Resource management using GIS and Remote Sensing proves as very beneficial tool. Using GIS tool, it is easy to recognise, analyse, understand and relationships between different parameter used in this study. The main approach to using GIS is to suggest action plan to manage agriculture land.

- A. There are nine LULC classes rabi crop, kharif crop, double crop, fallow land, dense forest, open/scrub forest, waste land, river /waterbody, and built-up. In this, rabi and kharif are best for the double cropping, fallow land is best for the agro-forestry, agro-horticulture. For dryland horticulture, suitable LULC classes are fallow land and rabi crop.
- B. There are four classes in geomorphology and lithology in which pediplain and vesicular basalt is most suitable.
- C. There are three classes of ground water potential (GWP) in which good to excellent is suitable for double cropping, agroforestry, agro-horticulture and poor, poor to moderate is suitable for dryland horticulture.
- D. There are eleven classes of soil in which loamy, fine loamy, fine, coarse loamy is best for agriculture.
- E. There are eight classes of slope in which level, gentle, very gentle is suitable for double cropping, agro horticulture, dryland horticulture, and gentle, level, strong is suitable for agroforestry.
- F. There are eight classes of land capability in which class II, III, IV is suitable for agriculture.
- G. The final result prepared by analysing different parameter namely land use/land cover, geomorphology, lithology, GWP, slope, soil texture, and land capability using Weightage overlay method in ArcGIS 10.4. The result is indicated in five zones i.e., very highly suitable, highly suitable, moderately suitable, least suitable, not suitable.
- H. About 235 sq. km, 150 sq. km, 92 sq. km and 192 sq. km of study area is suggested for double cropping, agro-forestry, agro-horticulture, and dryland horticulture respectively.
- I. Very highly suitable land constitutes 21.172%, 13.512%, 8.294%, 17.285% of study area for double cropping, agroforestry, agro-horticulture, and dryland horticulture respectively.
- J. The study is very useful for land management of agriculture in Keolari block.

VII. RECOMMENDATIONS

Present study is concentrated on the land resource management to increase the crop productivity by using the land for the suitable farming practices. For the further study, new tools, techniques and technology should be use for proper management and conservation practices for land resources. To obtain more effective result we can further use high spatial resolution satellite data at micro-level study. In this way the result will be more proficient to use.

VIII. ACKNOWLEDGEMENT

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