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# Use of remote sensing and GIS techniques for land use and land cover mapping in a part of Sone basin, Bihar, India

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■ **ABSTRACT :** The main purpose of the study was to make a maximum use of remote sensing data and GIS techniques to assess land use and soil classification in a part of Sone basin, Bihar. Land use and land cover change has become a central component in current strategies from managing natural resources to monitoring environment change. The advancement in the concept of vegetation mapping has greatly increased research on land use and land cover change thus providing an accurate evaluation of the spread and health of the world's forest, grassland and agricultural resources has become an important priority. Satellite images from Resourcesat-1: LISS-III sensor, on a scale of 1:50,000 (geo-coded, with UTM projection, spheroid and datum WGS 84, Zone 44 North) have been used supervised classification for delineation of thematic layers such as land-use and soil types. Digital Elevation Models (DEMs) are used in extracting the topographic features, watershed delineation and identification of suitable sites for water harvesting structures. The land use is Agricultural land 1312.17 $km^2$ (50%), Settlement 117.17 $km^2$ (5 %), Forest cover 452.38 $km^2$ (17%), Wasteland 88.57 $km^2$ (3%) Waterlogged 56.76 $km^2$ (2%) and Water bodies 567.05 $km^2$ (23%). In this study area, the soil is classified into different categories on the basis of NBSSLUP, all of those soils are fine textured (clay to silt clay) and their soil fertility is generally poor, being susceptible to soil erosion. Fine-loamy, coarse-loamy is higher than other. The study may help in identifying land use and land cover classes, and the data can be used for future environmental monitoring studies.

■ **KEY WORDS :** Remote sensing, GIS, Land use, Land cover, Linear image self-scanning (LISS) III

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In the present day, land use and land cover mapping is of great significance in scientific, research, planning and management. Regional land use pattern reflects the character of interaction between man and environment and influence to the mankind's basic economic activities. Due to advancement in satellite sensors, their analysis techniques are making remote sensing systems fruitful, realistic and attractive for use in research and management of natural resources. Land use map is a valuable tool for agricultural and natural resources studies, updation of these maps are essential due to strength of natural resources, remotely sensed satellite images provides a synoptic overview of the terrain or earth in a very short time span (Lillisand and Kiefer, 2000).

This leads to quick and truthful representation of the real world in the best possible way. Remote sensing provides land resource data in the digital form and

different bands of the electromagnetic spectrum. Availability of such type data in different bands makes it very useful and easy way for delineation of land use / land cover classes. Land cover mapping both by visual interpretation and digital analysis is possible by satellite remote sensing techniques (Singh and Singh, 2011). The classification system facilitates the planners and researchers to study the spatial difference and distinction between various lands are types, from multi temporal satellite data.

Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use / land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare (Rai and Rai, 2009). Remote sensing (RS) and geographic information system (GIS) are now providing new tools for advanced ecosystem management. GIS involves mapping data and interpreting the relationships among that data and making inferences. The collection of remotely sensed data facilitates the synoptic analyses of earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996). Remote sensing techniques have been used to monitor land use changes; this has an important role in urban development and the determination of water quality parameters. It is also very useful for the production of land use and land cover statistics which can be useful to determine the distribution of land uses in the basin. Using remote sensing technique to develop land use classification, and mapping *i.e.* a useful and detailed way to improve the selection of areas designed to agricultural, urban and / or industrial areas of a region (Selcuk *et al.*, 2003). The evolution in technology of remote sensing has caused it to become one of the most commonly used techniques in the world.

This is the manner in which human beings employ land and its resources. Land use includes agricultural land, built–up land, recreational area, wildlife management area etc. Land use is defined as the arrangement activities and inputs people undertake in a certain type to produce, change or maintain it. This definition of land use establishes a direct link between Land cover and the action of people in their environment (Di Gregorio and Jansen, 2005). Land use includes agricultural land, urban development, grazing, mining, recreation area, wildlife management and area which include land for economic activities. Land cover refers to the physical characteristics of earth's surface in the distribution of vegetation, water, soils, and other physical features of the land including those created solely by human activities, e.g., settlement. Land cover plays a pivotal role in impacting many parts of the human and physical environment (Foody Giles, 2002). Human intervention and natural phenomena cause change in land cover day by day. Land cover change give important information about a number of applications like agriculture, hydrology, forestry and ecology, grass land, bare soils etc. For example, in a forestation programme, we need to know the areas where forests are degrading or areas with less forest, etc. Land cover implies the physical or natural state of the earth's surface. It can be covered by the various physical features like vegetation, wetland roads, grassland, water body and hill etc. RS has an important role in the analysis of land use and land cover of area. In order to use land optimally it is necessary to have information of existing land cover/ land use and the capability to monitor the dynamics of land use resulting out of newer demands of increasing population and changed life styles (Singh *et al.*, 2010),

In this study supervised classification method were used, for land use / land cover map and soil map. The aim of this study is to produce a land use/ land cover map of a part of Sone basin in Bihar., for regional planning, management and understanding the earth as system. By using remote sensing techniques to identify the land use of Sone basin in Bihar.

– To create a DEM (Digital Eleviation Map), land use / land cover map, Soil map.

– To determine the trend, nature, rate, location and magnitude of land use / land cover change

– Make comparison between the distribution of land use areas to identify which is the most predominant in the basin (agriculture, settlement / urban area, forest, etc.)

**Study area :**

The Sone river is an important right bank tributary of the Ganga river. The river originates at an elevation of 600 m at Sonbhadra in the Maikala range of hills in

Madhya Pradesh. The total catchment area of the basin is 71,259 sq. km. The important tributaries of the Sone river are Rihand, Kanhar, Ghaghar, and Koel. The Rihand dam has been constructed on the Rihand River. The total length of the river is 784 km, out of which about 500 km lies in Madhya Pradesh, 82 km in Uttar Pradesh and the remaining 202 km in Bihar. The river meets the Ganga river about 16 km upstream of Dinapur in the Patna district of Bihar. But my study area, located in the part of Bihar, comprises with the North - Eastern To South - Eastern portion of the study area and lies between 24° 25' 30'' N to 25° 45' 30'' N of latitudes and 83° 30' 00''E to 82°50' 00'' E of longitude with total area coverage of 2624.11 sq. km. Study area is bounded by Karmnasa basin in the West, which makes the western boundary of the area and Punpun basin is situated in the east which makes eastern boundary of the study area (Fig. A1)

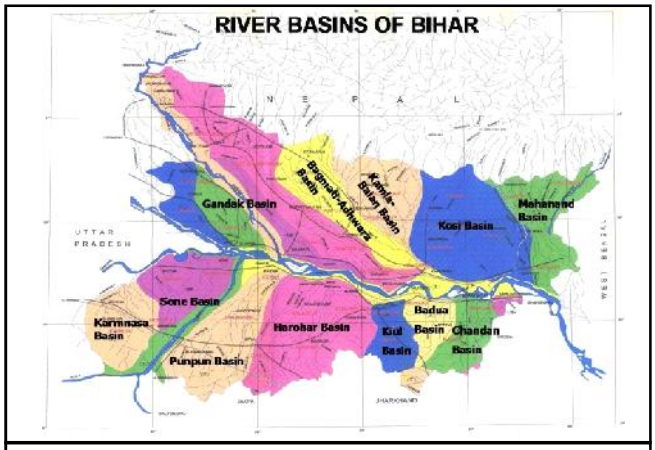


**Fig. A 1: River basin of Bihar (Source: http://fmis.bih.nic.in/riverbasin.html)**

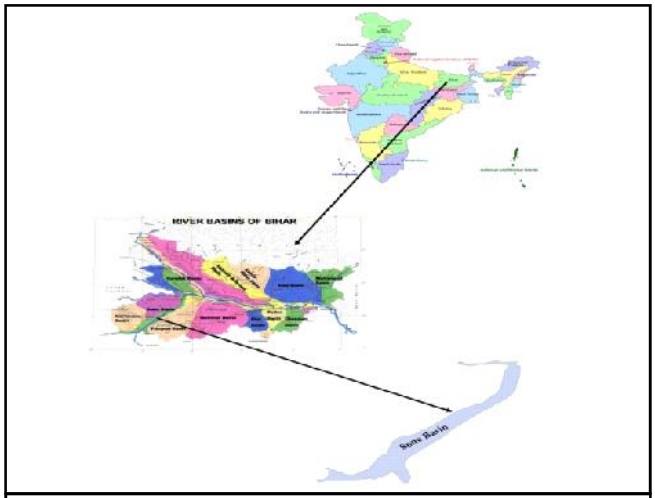


**Fig. A 2 : Location of the study srea**


**Fig. A 3 : Study area on google earth**

## ■ METHODOLOGY

**Data used :**

Geocoded False Colour Composite scene of IRS LISS III(Tiles- NG44X15, NG44S03, NG44X11, NG44X10, NG45M04, NG44X13, NG44X07, NG44X14, NG45S01, NG44X06, NG45M08, NG45S05, NG45S02, NG45M15, NG45M06, NG45M14, NG45M10, NG45M12)data on 1:50,000 scale (year, 2011), (Fig. B) under Bhuvan Thematic Services of National Remote

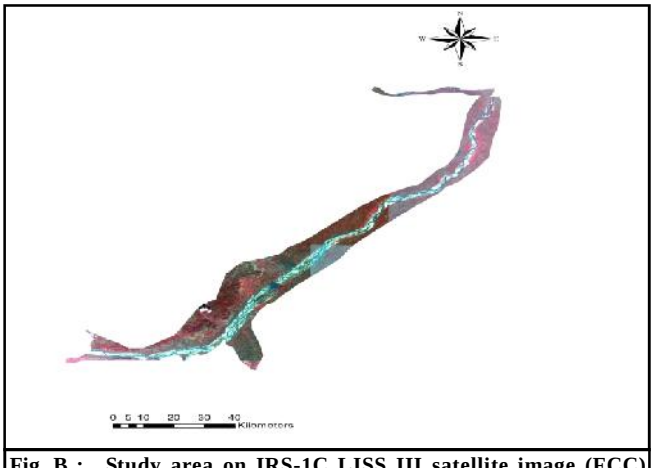


**Fig. B : Study area on IRS-1C LISS III satellite image (FCC) Source: (http//www.nrsc.gov.in)**

Sensing Center (NRSC), ISRO used in the present study

The work is done by visual image interpretation approach. The following steps are involved in the classification procedure.

– Data acquisition, loading, merging and georeferencing.

– Ground data collection.

– Identified by Google earth.

– Identified features with the help of tone, texture, pattern and association.

– Recode to all features and classify the image in different classes.

– Generation of statistics from the classified outputs.

**Digital elevation model (DEM) :**

The Digital Elevation Model (DEM) of the river basin is the first input information of elevationl. In this study, the DEM data with 30-m resolution was ASTER GDEM-version 2 (ASTGTM2_N24E084, ASTGTM2_N24E083, ASTGTM2_N25E084) which can be downloaded from NASA. It is geo-referenced in GIS as shown in Fig. C.

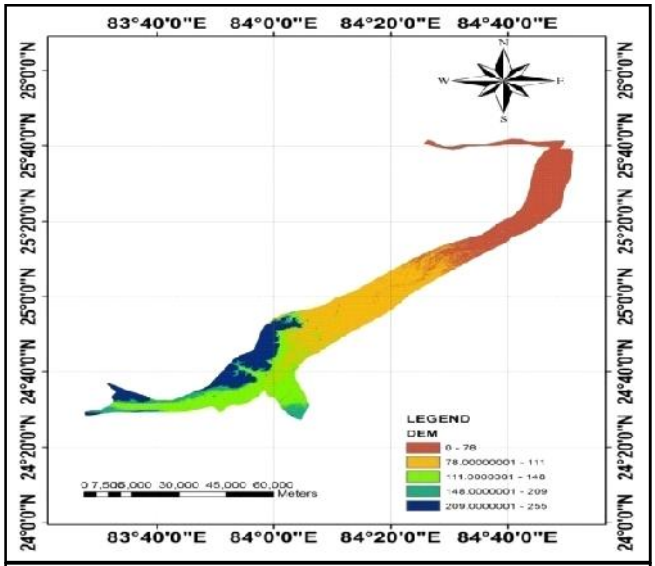


**Fig. C : Digital elevation model (DEM) of the study area**

**Landuse/Land cover :**

Satellite images from Resourcesat LlSS-III sensor, on a scale of 1:50,000 (geo-coded, with UTM projection, spheroid and datum WGS 84, Zone 44 North) have been used supervised classification for delineation of thematic layers such as land-use and soil types. These thematic layers were converted into a raster format (30 m resolution) before they were brought into GIS environment. A classification scheme was developed in which separate codes are given for the classes.

**Soil map :**

The soil map of the study area has been obtained from the National Bureau of Soil Survey and Land Use Planning (LBSS&LUP).

## ■ RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

**Digital elevation model (DEM) :**

Digital elevation model (DEM) based on the principle of a steep slope and the concept of the smallest threshold of a catchment area. A DEM is a raster representation of a continuous surface, usually referencing the surface of the earth. The accuracy of this data is determined primarily by the resolution (the distance between sample points). Other factors affecting accuracy are data type (integer or floating point) and the actual sampling of the surface when creating the original DEM. In this map, elevation is decreases south to north and mostly plane area. Some area of southern west part is hilly that area is Kaimur range. The elevation of study area is 0 to 255 metre. In this area, Sone river flows.

**Land use / Land cover map :**

The term land use relates to the manner in which human beings employ the land and its resources or to the human activity or economic function associated with specific piece of land and land cover is a term that relates to the type of features present on the surface of earth or implies the physical or natural state of the earth surface. Land use and land cover information are important for several planning and management activities concerned with the surface of the earth (Lillesand and Keifer, 1994 and Smits *et al.*, 1999).

There are a number of different units that contain several features/ inclusions. These inclusions couldn't be separated because of their small extents. So approximations of inclusions are based on the colour tone

reflected on the scene and proportion of their extent (Boakye *et al.*, 2008). The land use/land cover types are classified as follows and details of land use/land cover statistics of study area is given in the Table 1 and overall units are shown in the Fig. 1 and the percentage distributions of all classes shows by Fig. 2.

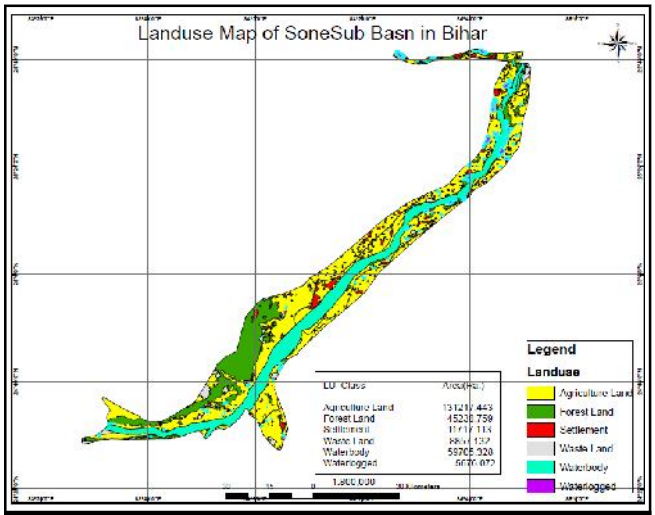


**Fig. 1 : Land use / land cover map of the study area**

**Table 1 : Land use/Land cover statistics of study area**

| Sr. No. | Land use/land cover classes | Approx. area in hectare | Percentage |
|---|---|---|---|
| 1. | Agriculture land | 131217.443 | 50 |
| 2. | Forest land | 45238.759 | 17 |
| 3. | Settlement | 11717.113 | 5 |
| 4. | Waste land | 8857.132 | 3 |
| 5. | Water body | 59705.328 | 23 |
| 6. | Waterlogged | 5676.072 | 2 |
| Total area (Hectare)- | | 262411.847 | |

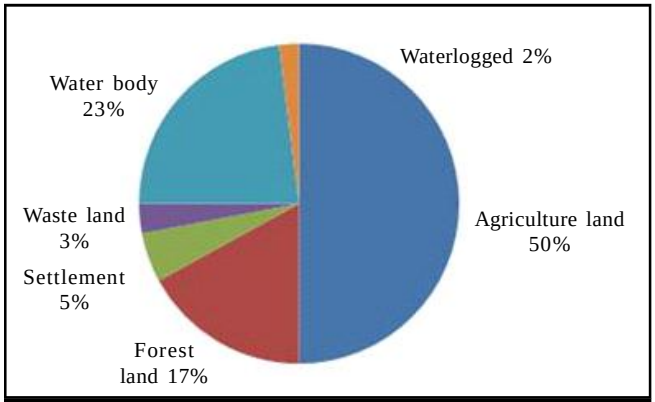


**Fig. 2 : Distribution of land use/Land cover classes**

**Forest area :**

The area of forest cover is usually associated with high relief, especially in Kaimur region, presenting a prominent and distinct texture. They have brighter tone of brown and red colour in Fig. C, but in Fig. 2 mention by green colour. Forest cover is a open mixed jungle type mainly composed of bamboos, It occupies 452.38 sq. km (17%) of total study areas. There are mainly two forest reserve are present in the study Kaimur region *viz.*, Bhabua and Rohtas reserve forest. they are well recognize in the South of the study region. In this region moderately dense forest (MDF) and open forest (OF). Forest land represent areas that have a tree crown or areal density of 10 % or > 10.

**Agricultural area / Cultivated area :**

The agricultural land may be defined broadly as land used primarily for production of food and fibre. The observation with the help of the image interpretation reveals that the area under study is predominantly an agricultural region. Agricultural area is mainly present in north, central and southern east part of the study area. It occupies 1312.17 sq. km (50%) of the total study area

Agricultural land occupies in sizeable area. Sugarcane, vegetables, *Jowar*, jute, urad, wheat and rice are the major crops in this basin. Sugarcane are the main crops under cultivation as of these cash crops are more profitable in terms of monetary benefits. In the per cent basin the vegetation cover has decreased mainly due to human activity such as agricultural, settlements, road transport, is dominant in this area.

**Waste land :**

Waste land is described as degraded land, which can be brought under vegetation cover with reasonable effort. This unit have patches are registered more in white colour and a little of yellow or brown colour on the whole imagery especially in south and middle portion of the imagery in Fig. C. Southern west of the study area comes under plateau region, so maximum portion of the waste land is categorized under barren rocky waste. It occupies 88.57 sq km (3 %) of the total study area.

**Water bodies :**

The streams/rivers, canals, ponds etc. is considered under this category. The prominent streams/river, ponds /lakes/Nala are easily detected on satellite imagery by

their black and dark blue tones in Fig. C. Ponds are mainly found in south and south east portion of the study area. Sone river, along with their tributaries North Koel, Indrapuri Barrage etc. drain the area. Sone river is flowing middle part of the study area south to north direction. Canals are easily recognized in the south - western and eastern part of the imagery. Rivers are the excellent source of fresh water, plays important role in drinking water for living beings. Water is the most important factor of life play vital role in crop irrigation and other daily uses of living beings, this unit explains lake, pond etc. This unit has occupied 597.05 sq km (23%) of total study area.

**Settlement :**

They are mainly located in northern, middle, south-eastern, north western part of the study area. In study area most suitable area for human occupancy are form the flat river valleys and basins of the Sone. The identification of settlement in satellite imagery was based on tone and colour. They have tone of grayish and light bluish colour. It occupies 117.17 sq km (5%) of the total study area. The large settlement of study area like Daudnagar, Shahpur, Bhaunathpur, Jagdishpur, Rohtas, Shivpur, Khudra, Aurangabad, Dehri on sone, Makhdumpur, Indrapuri, Koilwar etc. have been marked on the land use/land cover map with the help of imagery. This unit includes roads and other infrastructure related to human beings.

**Waterlogged :**

Water logging is considered as physical deterioration of land. It is affected by excessive ponding / logging of water for quite some period and affects the productivity of land or reduces the choice of taking crops. These areas are surface pounded areas due to flooding by river water or submergence by rain water or human intervention in natural drainage systems where the water stagnates for quite a long time. Waterlogged areas induced by rise in groundwater level were also assessed spatially under GIS environment. Results show that the total surface waterlogged area in study area is 56.76 Sq. km. which is 2% of study area.

**Soil :**

The soil map of the study area has been obtained from the National Bureau of Soil Science and Land Use

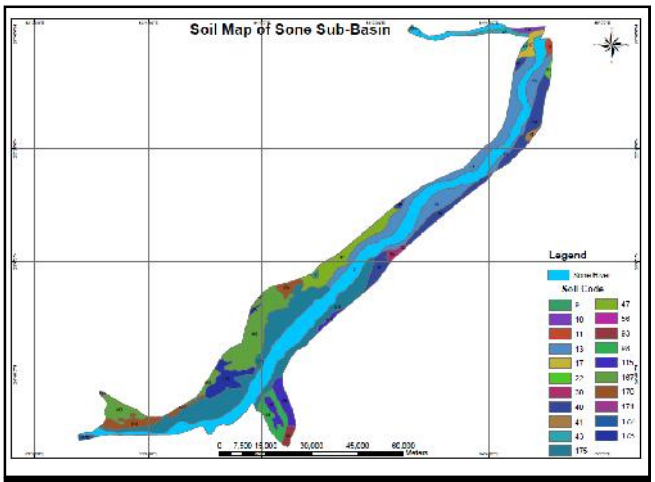


**Fig. 3 : Soil map of study area**

Planning (NBSS&LUP). The soil is classified into different categories on the basis of USDA taxonomy *viz.*, Typic Paleustalfs, Aeric Ochraqualfs, Vertic Ustochrepts, Typic Haplustalfs, Typic Haplaquepts, Typic Ustochrepts, Typic Ustifluvents, Typic Ochraqualfs, Aquic Ustipsamments, Lithic Ustorthents, Aeric Haplaquepts, Vertic Ochraqualfs, Typic Haplaquents and Fluventic Ustochrepts.

**Conclusion :**

The present study was focused on demarcating boundaries of different land use/land cover units from an analysis of different types of land use/land cover units from satellite imagery. Today, land use and land cover mapping has a great significance in scientific research, in planning and in management. Regional land use pattern represent the character of interaction between man and environment and influence the resources based on mankind's basic economic activities (IGCMC,2005). Remotely sensed satellite images provide synoptic coverage and overview of the whole region. It provides coordinate relationship among transportation, residential, industrial and recreational land uses, besides providing broad-scale inventories of natural resources and monitoring environmental issues, including land reclamation, and restoration, disaster management, water quality and planning, economic development. Land use land cover maps helps in planning in effective and best possible way, and in utilization of its resources besides providing a comprehensive view of the total area land use/land cover has been mapped through satellite imagery

**Table 2 : Soil description and taxonomy**

| Mapping unit | Description | Soil taxonomy |
|---|---|---|
| 9 | Very deep, well drained caleareous fine loamy soils on very gently sloping plain with loamy surface texture, moderate erosion and moderate flooding | Fine – loamy |
| 10 | Very deep well drained sandy soils on very gently sloping plain with sandy surface texture and slight erosion | Coarse loamy |
| 11 | Very deep, well drained, coarse loamy soils on very gently sloping plain with loamy surface texture | Coarse loamy |
| 13 | Very deep poorly drained, calcareous fine loamy soils on very gently sloping plain with loamy surface texture and slight erosion | Fine – loamy |
| 17 | Very deep, well drained, calcareous coarse loamy soils on very gently sloping plain with loamy surface texture and moderate erosion | Coarse loamy |
| 22 | Very deep, poorly drained fine soils on level to nearly level plain with clayey surface texture and slight erosion | Fine – loamy |
| 30 | Very deep, poorly rained cracking clayey soils on very gently sloping plain with clayey surface texture, very slight erosion and moderate flooding | Fine |
| 40 | Very deep, poorly drained fine soils on level to nearly level plain with loamy surface texture, slight erosion and slight sodicity | Fine |
| 41 | Very deep, moderately well drained coarse loamy soils on level to nearly level plain with loamy surface texture and slight erosion | Coarse loamy |
| 43 | Very deep, poorly drained, very fine cracking soils on level to nearly level plain with clayey surface texture , very slight erosion and severe flooding | Very – fine |
| 47 | Very deep, poorly drained, fine soils on level to nearly level plain with clayey surface texture, very slight erosion and slight salinity sodicity | Fine |
| 56 | Very deep, poorly drained fine soils on very gently sloping plain with clayey surface texture, slight erosion, moderate flooding and slight salinity | Fine |
| 93 | Very deep, imperfectly drained fine, soils on very gently sloping hill slope with loamy surface texture and moderate erosion | Fine – loamy |
| 98 | Deep, well drained gravelly loamy soils on gently sloping undulating plain with loamy surface texture and moderate erosion | Loamy- skeletal |
| 115 | Very deep, poorly drained, fine soils and very gently sloping valley with clayey surface texture and slight erosion | Fine |
| 167 | Deep, well drained, fine loamy soils on gently sloping hill slopes with loamy surface texture and moderate erosion | Fine – loamy |
| 170 | Deep, well drained fine loamy soils on very gently sloping undulating upland with loamy surface texture and moderate erosion | Fine – loamy |
| 171 | Deep, moderately well drained fine soil on very gently sloping undulating plain with loamy surface texture and moderate erosion | Fine |
| 172 | Very deep, moderately well drained calcareous fine – loamy soils on gently sloping undulating plain with loamy surface texture and severe erosion | Fine – loamy |
| 173 | Very shallow, excessively drained gravelly loamy soil on moderate steep sloping undulating plateau with loamy surface texture and several erosion | Loamy- skeletal |
| 175 | Very deep, moderately well drained, fine soils on very gently sloping undulating upland with valley with loamy surface texture and slight erosion | Fine – loamy |

and for uses of land has been shown as forest land, land under cultivation (agriculture land), land not suitable for cultivation (Waste land) and land not available for cultivation (settlement/urban built up etc.). There have been marked changes in the land use/land cover under uncultivated areas and built up areas. New developments have been found due to improvement of saline patches and barren land through new agricultural techniques. Deforestation of the areas and rapid rate of urbanization have resulted marked changes in the settlements, roads etc. Supervised classifications were conducted to define land cover and land use types for the area. The land use and land cover map clearly shows that area of cultivate land is higher than others. The map shows clearly in the near Sone river increase in industries, built-up land, and in other agriculture land, forest area is decreased. Mostly the contributors for the development are identified as waste land. Field observation also proves that polluted in the Sone river zone because of fishing, industrial and waste dumpsite activities. Accurate bank of Sone river regulation should be strictly implemented to protect the construction and other related activities near to the Sone river. The resulting products of the exploratory analyses and classification were used to assess spatial patterns of land cover and land use mapping of the area.

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*http//www.nrsc.gov.in*