Development of Soil and Water resources through suggested actions using Remote Sensing and GIS-A case study of Muzaffarnagar District

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Abstract

The Socio-economic condition and development of any village/area is based on the potential of land and water resources. Now-a-days these resources are overstretched often leading to depletion due to increase in population and other factors. Therefore it is needed to prudently manage those delicate resources. Action plan preparation is emerging as a potential approach for the further development of soil and water resources of a village/area to usher in democratic decentralization, need based planning and empowerment of the rural region. It covers diverse activities of soil and water conservation, rainfed agriculture, afforestation, wasteland management, rural employment and possibly all other biotic and abiotic activities.

Keeping this in mind, a study was carried out for preparation of parcel level Action Plan for the development of soil and water resources available in Muzaffarnagar district, using CARTOSAT-I and LISS IV merged satellite data. The basic objectives of the task were identification of suitable parameters for the development of soil and water resources and preparation of action plan at parcel level.

To fulfill the above task, four Lohia villages (i.e. Garhi Nawabad, Jaitpur, Kurwa and Mohammadpur Rai Singh) cadastral maps were studied and other thematic maps were prepared to pace the scope of work. There after these maps were integrated to prepare the action plan map at parcel level for soil and water resources. After getting the outputs from the integration of thematic layers, different suitable actions viz. Desiltation, Agroforestry, Agro-horticulture, Check-Road-Bund (CRB), contour bund etc. were proposed. Results show CRB is a prominent action is required to be taken in all selected villages.

Keywords: Depletion, Desiltation, Check road bund Contour Bund, Agro-horticulture.

INTRODUCTION

Land and water resource, the sacred endowment is the vital resources of earth. It is the basis for the existence of mankind and in most countries it is the life support system. Rapidly growing population puts heavy demand on natural resources and the production system. Thus, increasing emphasis is being laid on scientific management, conservation of these resources to ensure their optimal utilization.Action plan development is emerging as a potential approach in India for sustainable development of agriculture. It covers diverse activities of soil and water conservation, rain-fed agriculture, afforestation, wasteland development, rural employment generation and possibly all other biotic and abiotic activities in the area. Action plan programme for these resources includes various aspects viz. control damaging runoff, increase in groundwater recharge, manage and utilize runoff for useful purposes, control erosion and effect reduction in the sediment production, control water and land pollution, save the downstream areas from floods and droughts, use the water and land resources efficiently, take care of forests, wastelands and wetlands,sustainable development of water resources.This research aimed to generate local specific action plans at parcel level by integrating natural resources information generated from satellite data in conjunction with socio-economic data to meet the needs of the local people for sustainable development of the region (Dhinwa et.al, 1995). Remote sensing and GIS are playing a vital role in planning and development of land and water resources. GIS is a tool for the management, query, visualization and analysis of spatially referenced information. GIS technology provides suitable alternatives for efficient management of large and complex databases. These systems are exclusively designed to store information about the location and attributes of spatially referenced objects such as rivers, wells, wetlands and wastelands, land features, subsurface features etc. The main advantage of GIS over conventional information systems is that GIS is capable of handling spatial and non spatial data. In recent times, GIS plays a vital role in water resources planning and management (Mark R. Leipnik et al 2001). The combined GIS and remote sensing technology is an excellent tool for monitoring, land degradation, land use changes as well as soil and water resource changes over space and time. When these two tools are integrated in the research programme, an efficient solution is arrived at to solve any complex problem (Burrough 1996). An attempt has been made to demonstrate the potentiality of LISS IV and CARTOSAT I(PAN) merged data for generating action plans at parcel level with a specific case study comprises of four revenue villages (i.e. Garhi Nawabad, Jaitpur, Kurwa, and Mohammadpur Rai Singh) of Muzaffarnagar district (Table-1). GIS environment is used to create the spatial data base by using ARC/INFO software. Also integration and union of various themes were made to generate action plans for development of land and water resources and for arresting soil erosion and thus conserving productivity.

STUDY AREA

The study area is within the DOAB of the Ganges and the Jamuna between the districts of Meerut on the south and Saharanpur on the North. The surrounding area is having predominant sugarcane crop and the area is popularly known as 'The Sugar Bowl of India'. The economy of the villages is mainly based on agriculture and sugarcane, paper and steel industries. The study area includes following four Revenue villages (Fig.1), falls on Burhana tehsil of Muzaffarnagar district and lies between $29^0$22'39.787"N, $77^0$25'5.26"E to $29^0$22'40.13"N, $77^0$28'57.571"E and $29^0$19'47.781"N, $77^0$25'4.917 "E to $29^0$19'47.781"N, $77^0$28'56.201"E.

Village name	Area (Ha)
Garhi Nawabad	256.64 Ha
Jaitpur	164.09 Ha
Kurwa	406.8 Ha
Mohammadpur Rai Singh	466.86 Ha

Table.1- Area of revenue villages

All the revenue villages are adjacent and lies within the range of 7 to 30 km from district headquarter. Agriculture is the main profession in that area still the area is waiting for Industrial development.

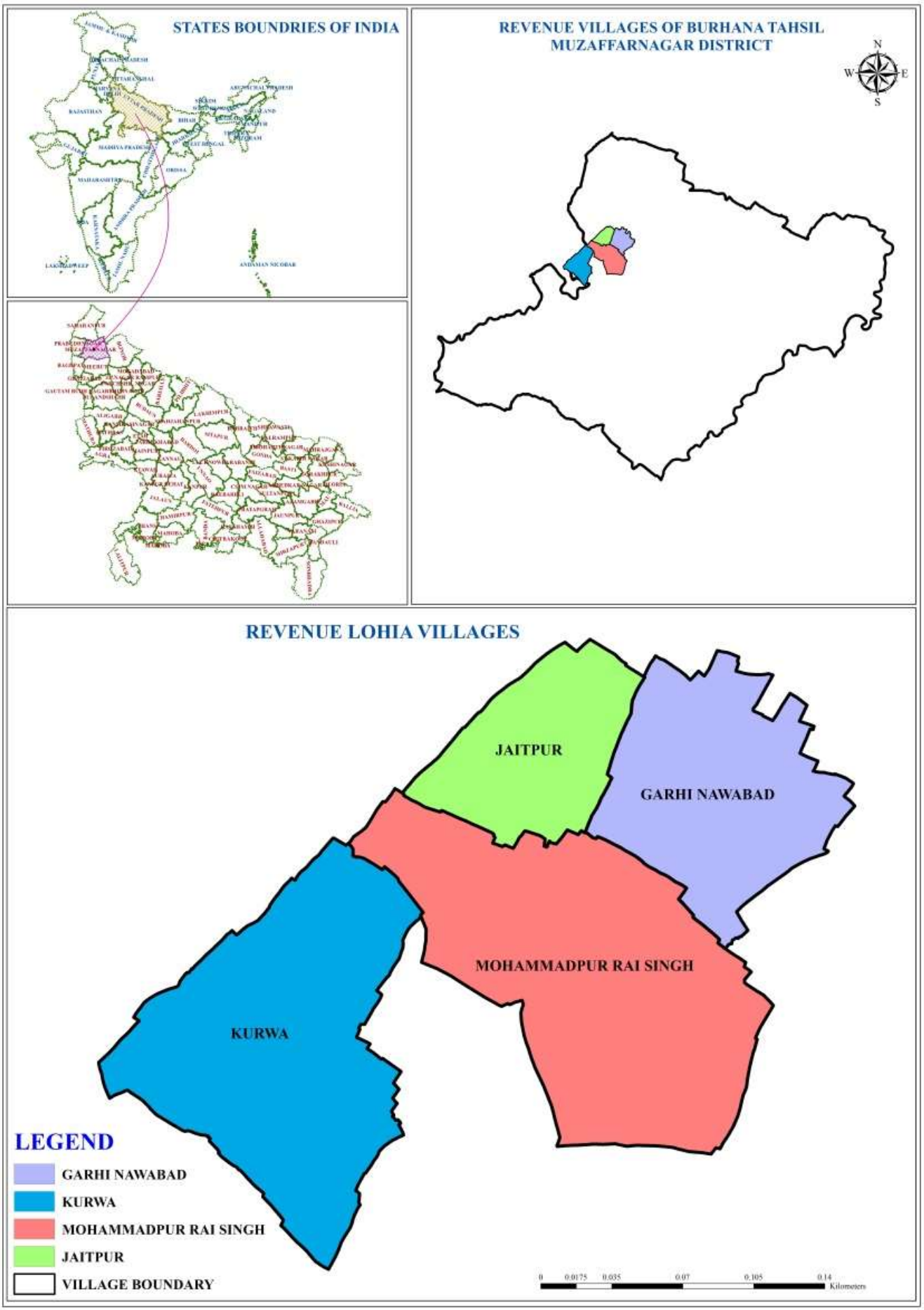

Fig.1- Study area

DATA USED

A reliable and authentic data is the basic need for the execution of any project work. The different types of data which were used for the study, as follows:-

a) Satellite Date

In this work, the Indian Remote Sensing Satellite image Cartosat-1 (PAN) with spatial resolution of 2.5 m and IRS-1D LISS-IV multispectral (3 band) image with spatial resolution of 5.8 m merged data were used. The data is acquired in three spectral bands namely visible and near infrared (B2, B3 and B4). The satellite images have a spatial resolution of 2.5 meter and cover a swath of 30 km. The cameras maneuver across the direction of the satellite's movement to facilitate the imaging of an area more frequently. The images taken by CARTOSAT-1 cameras are compressed, encrypted, formatted and transmitted to the ground stations.

b) Cadastral Data

Cadastral maps are the important documents for the revenue department and to complete the project for selected four nos. of Dr. Ram Manohar Lohia villages, the cadastral map sheets of the revenue villages were collected from Abhilekhagaar, Muzaffarnagar district.

c) Collateral Data

Apart from the resource information derived from satellite data, collateral information is collected from various sources. The data included Survey of India topographical maps (1:50,000 scale), information on slope, soil resource etc.
Cadastral maps and certain maps are prepared on 1:4,000 scale and rest of the maps are prepared on1:25,000 scale.

METHODOLOGY

The methodology comprises the establishment of a spatial resource database and its analysis to arrive at land and water resources development plan. The cadastral maps for all the four revenue villages were collected and made digitally. Thereafter those maps were georeferenced using high resolution satellite data (i.e. CARTOSAT-I and LISS-IV merged data).The work was done on micro level and the information was transferred at parcel level. As per need of the study the cadastral maps were updated to know the current status of the present land holdings.

Various other thematic maps i.e. Infrastructure, drainage/water body, groundwater prospect, land use / land cover, soil maps etc. were prepared on 1:4,000 scale using CARTOSAT- I (PAN) and LISS-IV merged data. Slope and contour maps were prepared using SRTM DEM (30m resolution). Spatial database for all the above maps were prepared and created with the help of ARC/INFO software. Later on, those layers were integrated for the preparation of specific action plan for soil and water resources at parcel level (Fig-2).Decision rules were taken into consideration for suggesting the various actions for soil and water resources on the study area. Suitable measures were suggested for optimal use of agricultural land, best possible use of waste land and fallow land, arresting of soil erosion, conserving water resources and thus conserving natural resources in a meaningful manner. The appropriate actions such as agro-forestry, agro-horticulture and check road bunds (CRB) were proposed for land resource development. Similarly contour bunds and desiltation were suggested for water resource development.
The procedure taken into the consideration for the execution of the project is as follows:

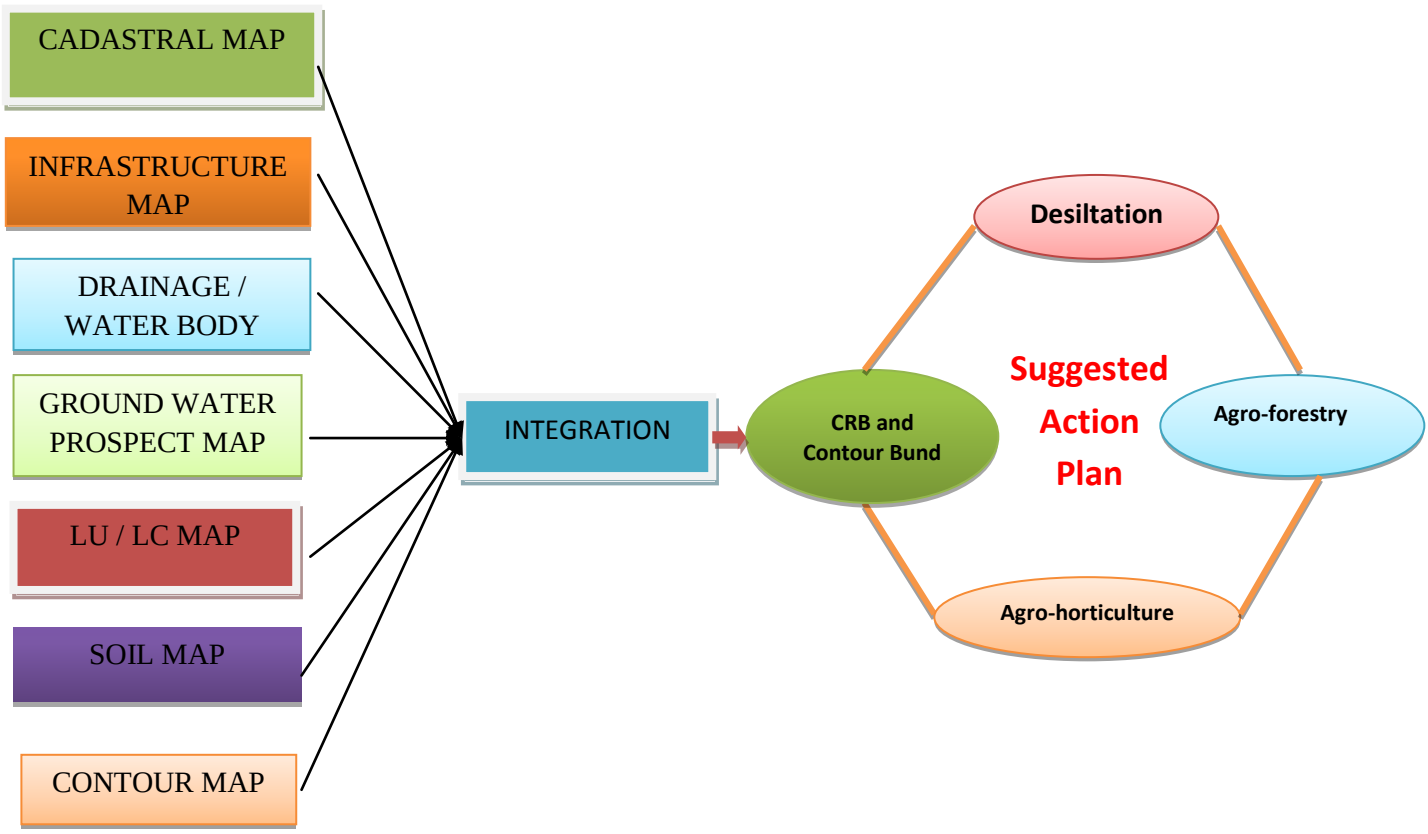

Fig.2 Flow chart

Different thematic maps are prepared with the use of above high resolution satellite data are as follows:

Cadastral Map:

Updated Cadastral Map provides the information regarding the change in size of land holdings over a period of times. Parcels are splitted due to certain socio-economic factors, generation factors, liability etc. Hence it is required to get the updated cadastral map those could be prepared with the use of recent high resolution satellite data. In view of that updated cadastral maps of all the revenue villages were prepared with the use of CARTOSAT-I and LISS-IV merged data (Fig- 3 to 6).

Infrastructure Map:

Infrastructure Maps provides spatial data base by mapping existing facility like rail, road, canal, plantation, water bodies and there connectivity to the user. The Infrastructure Map of the study area shows that proper road network further should be developed (Fig- 3 to 6).

Ground Water Prospect Map:

The groundwater prospect map is prepared under Rajiv Gandhi national Drinking Water Mission Project (Ph IV) using IRS - LISS III satellite data (Fig.7). The various thematic layers were integrated for the preparation of groundwater prospect map viz. geomorphology, lithology, hydrology, structure, drainage and water body etc. The study area mainly includes the category of alluvial plains older canal command with a very good ground water prospect. This area is having characteristics of high fertile soil range.

Land use/Land cover:

Land use is a description of function, the purpose of which the land is used. By land cover is meant the physical chemical or biological categorization of the terrestrial surface, whereas land use refers to the purpose that are associated with that cover. The LULC map of the study area shows that apart from settlement, most of the area is covered with Kharif crop (Fig.9 to 12). It has a lot of water bodies. Though, there is some fallow land which needs proper management.

Soil Map:

Generally soil maps are used to identify soil and their properties but sometimes are required for more specific purpose, such as determining the suitability of a soil for particular crops on the land drainage capability of the area. The soil type of the region is fine loamy to coarse loamy. About 90% of the area is covered with fine loamy to loam soil type excepting around 10% area of Mohammadpur Rai Singh village covering coarse loamy soil (Fig.8).

Contour map:

A topographic map on which the shape of the land is shown by contour lines, the relative spacing of the lines indicating the slope of the land. SRTM DEM data is downloaded to prepare the contour map for four revenue villages. Contours are drawn at the interval of 0.5 m (Fig- 13 to 16) to facilitate the action plan by using the concept of slope over the area.

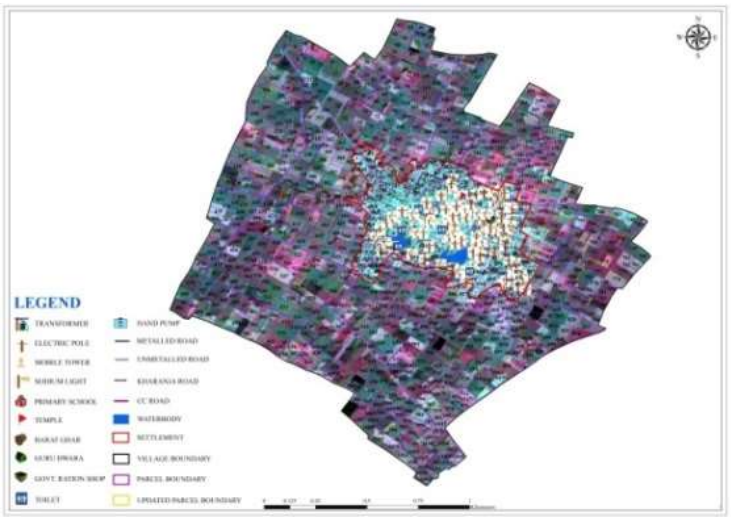

Fig.3 Infrastructure map of Garhi nawabad

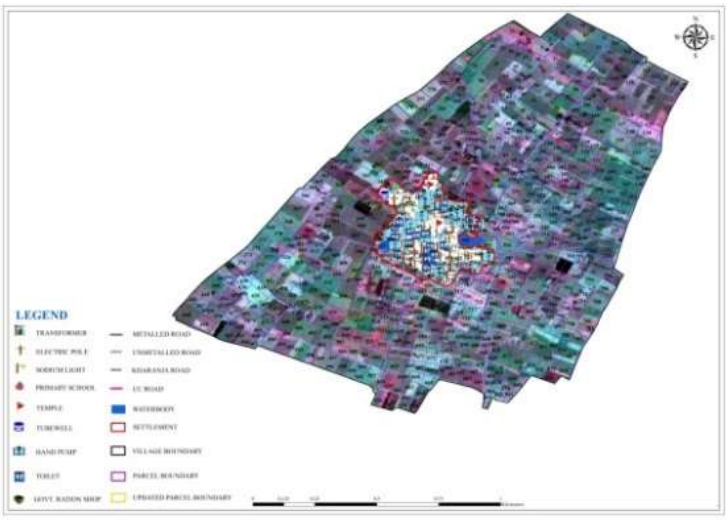

Fig.4 Infrastructure map of Jaitpur

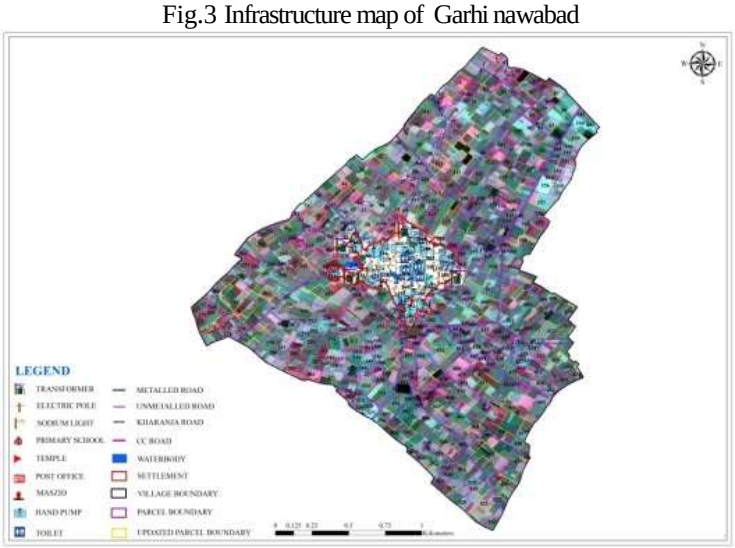

Fig.5 Infrastructure map of Kurwa

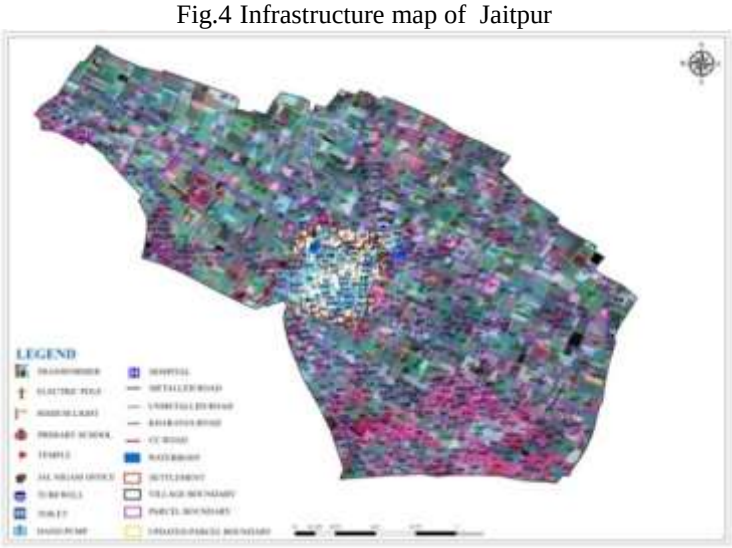

Fig.6 Infrastructure map of Mohammadpur Rai Singh

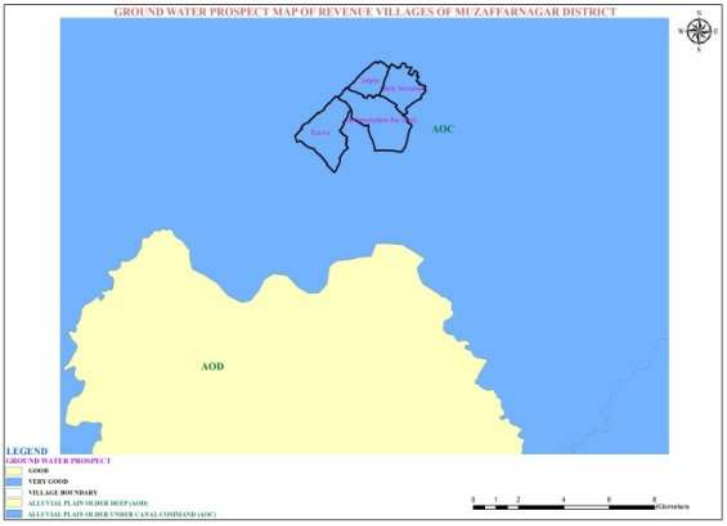

Fig.7 Ground water prospect map

Fig.8 Soil map

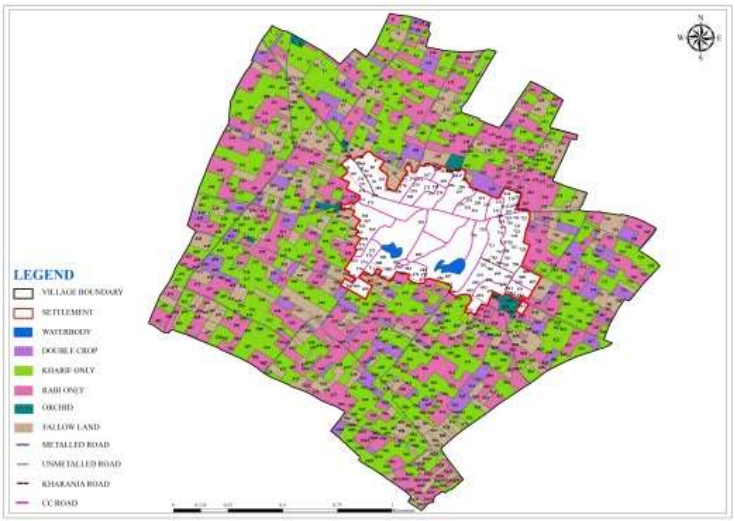

Fig.9 LU/LC map of Garhi nawabad

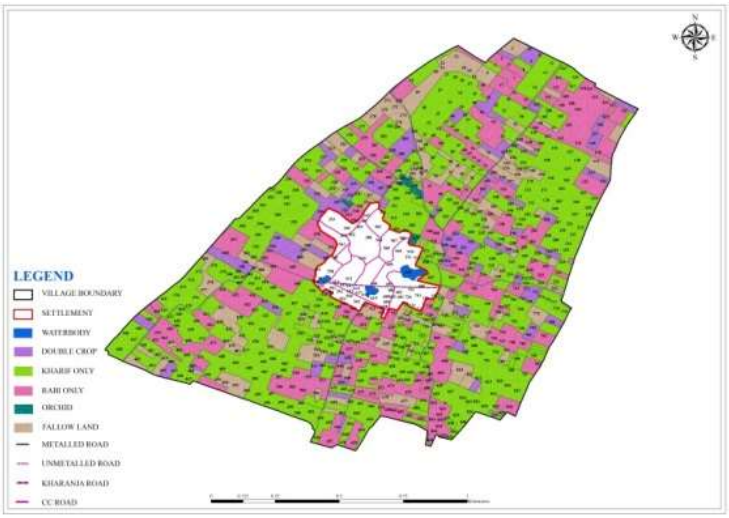

Fig.10 LU/LC map of Jaitpur

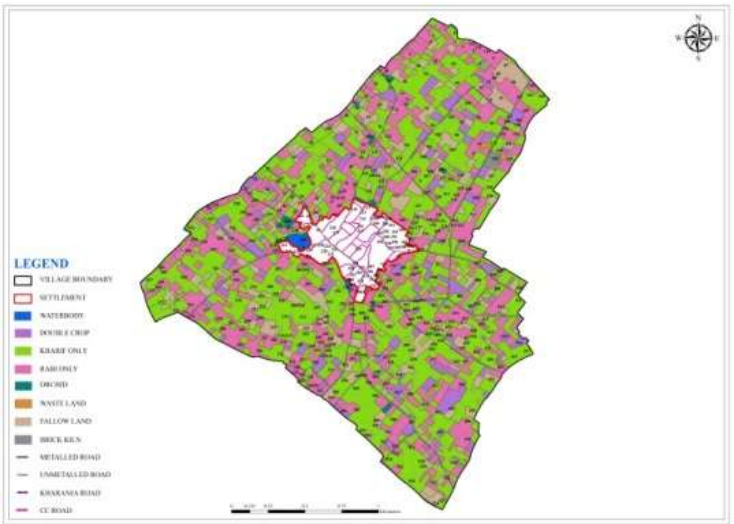

Fig.11 LU/LC map of Kurwa

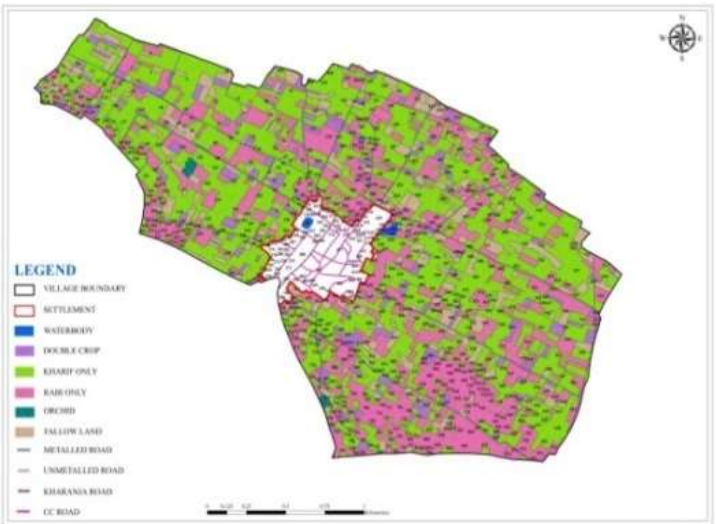

Fig.12 LU/LC map of Mohammadpur Rai singh

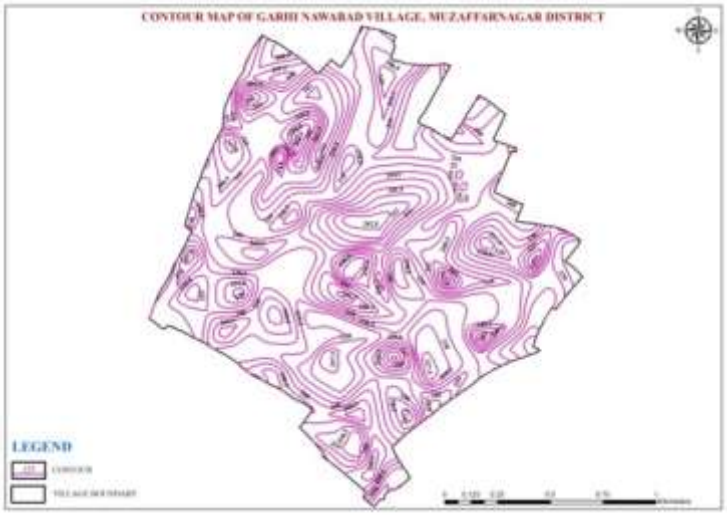

Fig.13 Contour map of Garhi nawabad

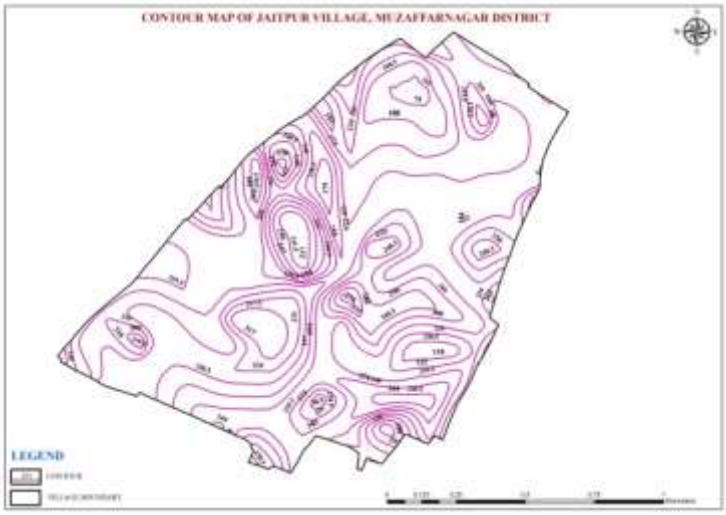

Fig.14 Contour map of Jaitpur

Fig.15 Contour map of Kurwa

Fig.16 Contour map of Mohammadpur Rai singh

ACTION PLAN MAP:

The action plan for soil and water resources is an innovative plan for the development of an area/village to usher in democratic decentralization, need based planning and empowerment of the rural region. This will help in achieving the vision of the state government in making a poverty free state. The village development action plan process will also help to evolve a need based planning mechanism for the area. It will prioritize certain growth due to its focus on the development of the poorest of the poor.

Action plan for improving water use efficiency and sustainable participatory groundwater management is highly useful. Ground water recharge in villages is also the need of hour to raise the ground water level. Challenges in the water sector are raising demand on growing human population, economy strains, demand supply balance, limited water resource with spatial and temporal variation, falling ground water tables, ground water contamination, surface water pollution and climatic change on hydrological cycle. The specific measures are to be identified on the deprived area on the basis of present need. In lieu of above, the action plan maps for soil and water resources were prepared (Fig- 17 to 20) at parcel level by the integration of all the above mentioned thematic layers and perceptions were also used judiciously. It was found suitable structures like Agro-horticulture, Agro-forestry, Check road bund (CRB) were appropriate for soil resources structure. Similarly, Desiltation and contour bund structures are appropriate for water resources structures. Also a statistics related to above on plot level for each village is prepared for the suggested structures (Table-2)

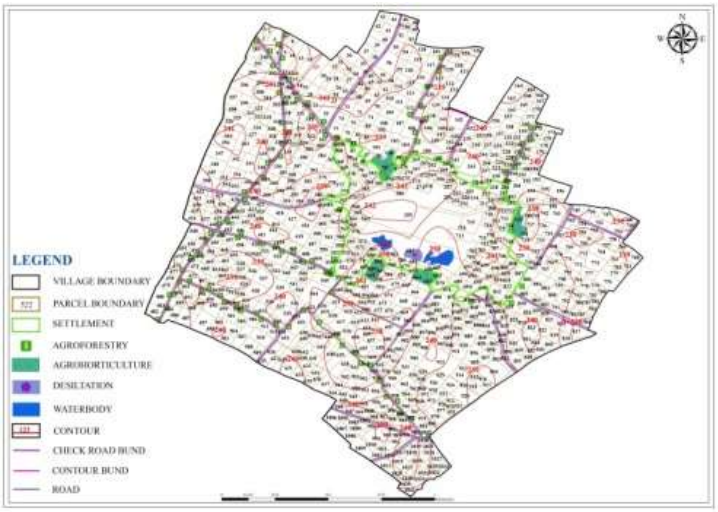

Fig.17 Action plan map of Garhi nawabad

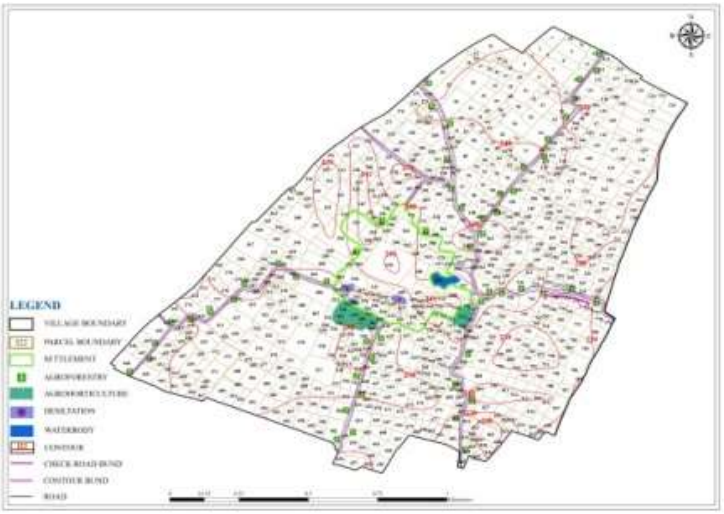

Fig.18 Action plan map of Jaitpur

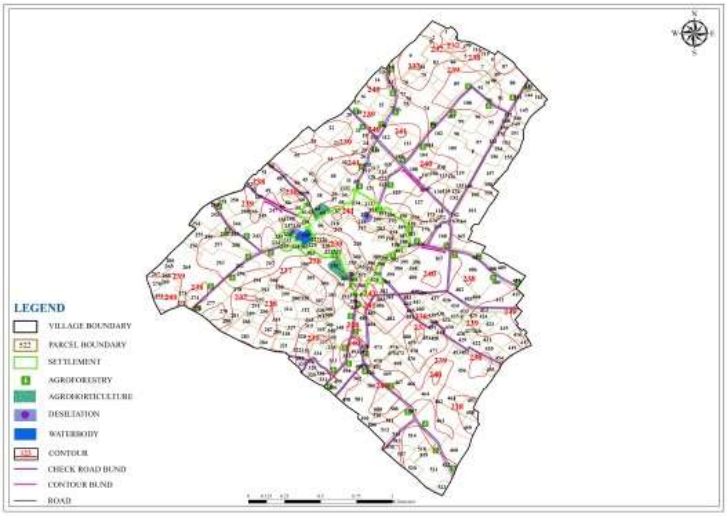

Fig.19 Action plan map of Kurwa

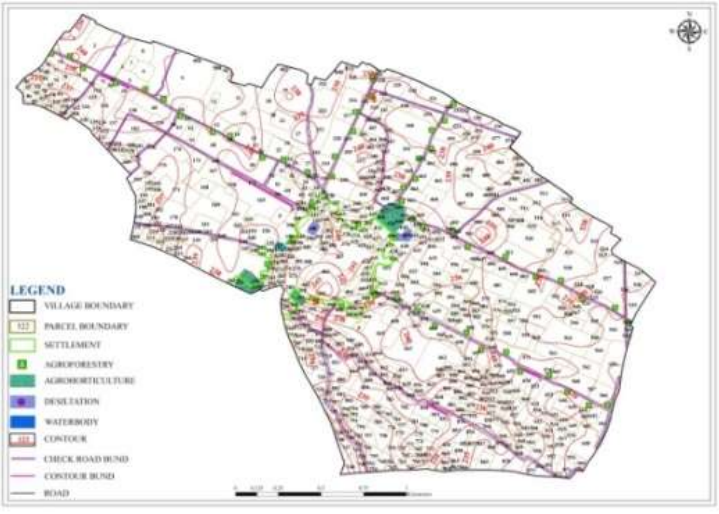

Fig.20 Action plan map of Mohammadpur Rai singh

S.No.	VILLAGE NAME	MAP/FIG. No.	PROPOSED STRUCTURES	PARCEL No.	AREA/LENGTH
1	Garhinawabad	Fig.17	AGROFORESTRY	7, 15, 19, 22, 112, 550, 642,..... ,930 & 1012	0.71, 2.94, 0.63, 0.64, 0.33 Km
			AGROHORTICULTURE	96, 100, 589, 590,… ....,724 & 739	0.78,0.62,0.54,0.51 Ha
			CHECK ROAD BUND	4, 7, 35, 67, 81,....., 151, 205, 789 & 845	0.71, 2.94, 0.63, 0.64, 0.33, 0.39, 0.47, 0.64, 0.72, 0.23 Km
			CONTOUR BUND	15, 142, 817 & 820	0.08, 0.09, 0.10 Km
			DESILTATION	683 & 684	0.29 Ha
2	Jaitpur	Fig.18	AGROFORESTRY	12, 15, 78, 110, ... ,684, 779 & 844	0.533, 0.61, 0.44, 1.01, 0.58 Km
			AGROHORTICULTURE	533, 539, 546, ... ,736 & 738	0.99, 0.38 Ha
			CHECK ROAD BUND	12, 44, 50, 112,.....,.698 & 844	0.533, 0.61, 0.44, 1.01, 0.58, 0.40 Km
			CONTOUR BUND	764, 771, 772, 774 & 776	0.17 Km
			DESILTATION	554, 557 & 609	0.101, 0.05, 0.11 Ha
3	Kurwa	Fig.19	AGROFORESTRY	10, 21, 73, 141,....., 496 & 522	0.71, 1.32, 0.77 ,0.50, 0.94, 1.55 ,0.77, 1.09 Km
			AGROHORTICULTURE	64, 65 ,355 & 356	1.001, 0.61 Ha
			CHECK ROAD BUND	38, 47, 51, 118,.....,229, 410 & 523	0.71, 1.32, 0.77, 0.50, 0.94, 1.55, 0.77, 1.09, 1.45, 0.63, 0.93, 0.79 Km
			CONTOUR BUND	125, 127, 167 & 247	0.18, 0.16, 0.22 Km
			DESILTATION	236, 237 & 238	0.35, 0.33, 0.25 Ha
4	Mohammadpur Rai Singh	Fig.20	AGROFORESTRY	27, 49, 75, 121, 342,....., 566 & 640	1.63, 0.72, 0.69, 1.27, 1.41 Km
			AGROHORTICULTURE	251, 252, 257,..... ,437 & 466	1.82, 0.41, 1.31 Ha
			CHECK ROAD BUND	3, 64, 72, 102,....., 873 & 955	1.63, 0.79, 0.69, 1.27, 1.41, 1.37, 0.70, 1.05, 1.57, 0.60 Km
			CONTOUR BUND	69, 70, 71, 165,..... ,654 & 852	0.18, 0.40, 0.15, 0.14 Km
			DESILTATION	143, 147 & 448	0.47, 0.33 Ha

Table-2 Statistics of suggested structures

RESULTS AND DISCUSSIONS:-

The study results in an integrated plan for the development of both soil and water resources at parcel level through high resolution satellite data and GIS software with the use of cadastral maps.

Though the villages are located in flat terrain but the variation of contours are from 233-244m. Though Lohia villages are moderately saturated with the different amenities like handpump, awas, toilets, electric poles etc. but the primary health centres are lacking in 3 villages. Similarly the primary school is present in all the four revenue villages. The region is having a very good ground water prospect and this shows that wherever boring will be done for tubewells which will yield very good discharge of water.

As per present condition of the Lohia villages it needs a lot of action for soil and water resources development so that normal condition could be sustained. After the integrated study, the suitable structures for action plan were suggested for both the resources. The action plan for development of soil and water resources are prepared based on the information obtained from remote sensing and other collateral sources on the theme of land use/land cover, contour, drainage network, groundwater prospect, soil etc.

Under the water resources development action plan, the suggestion for the development of water resources of four villages are spatially detected and depicted. Contour bunds and Desiltations were the measures recommended for overall development of water resources which improve the ground water conditions and help to bring additional lands under assured irrigation.

Similarly land resources development action plan consisting of alternate land use practices like agro-forestry, agro-horticulture, check road bund were considered for the current situations. Sufficient care was taken not to disturb the existing land use on a major scale so that the suggested actions on land use is technically feasible, economically viable and socially acceptable for the local farming community. The different practices suggested for the development of resources are:

i. **Agro-forestry:** A length of about 22 km was suggested for this category. This system was suggested along the road sides to protect the roads from the damage caused by water. Agroforestry is a landuse management system in which trees or shrubs are grown around or among crops or pastureland.
Agro-horticulture: In agriculture land which is permanently fallow, agro-horticulture is recommended. The fruit trees like custard apple, tamarind, ber, mango, guava, sapota and teak plantations with pulses like cluster bean, horse gram, etc. are suggested for this system, which accounts for 8.9 ha in all the four revenue villages. Growing of horticultural crops along with agricultural crops increases economic returns.

ii. **Check road bunds:** This category includes a length of about 34 km .Check road bunds are required to prevent the check roads from damage caused due to runoff**.** Appropriate nos. of Check road bunds were proposed on specified parcel no. in all the revenue villages.

iii. **Contour bund:** Contour Bund is a proven sustainable land management practice for marginal, sloping and hilly land where the soil productivity is low. This technology is used to control soil erosion, promote water retention and increase crop production. Runoff water can be slowed down by establishing contour bunds. Contour bunds are permanent ridges of earth that follow positions located at the same altitude. It is also important to have contour bunds to retain the water at its various levels of contours so that ground water may get recharged with water (ground water level) for the using agricultural purposes; therefore it is suggested for contour bunds.

iv. **Desiltation:** An area of about 2.3 ha was suggested for this category. Wherever water body has a significant amount of silt within it, a desilting structure may be necessary for removal of sediment before the water enters the storage pond. After the desilting process, all the dams have reported the increase in their storage capacity within few days. Advantages of silt removal and silt application:

- The water retention capacity of the soil will increase, thereby increasing the number of wettings.
- Desilting will improve groundwater recharging capacity and increase the capacity of the tank thereby increasing the availability of water even during the summer for irrigation and drinking water purposes.
- As per studies conducted, it is observed that due to desilting the fluoride content in the ground water will be reduced considerably.
- Silt can be used as nutrient/fertilizer to the plant which generally reduces the usage of fertilizer.

CONCLUSION:-

The socio economic development of any village is based on land and water resources. Therefore it is necessary to prudently manage those resources and hence the action plan map for soil and water resources are judiciously been prepared to use effectively in village. The study has revealed that high resolution satellite data are very important for preparation of an inventory of natural resources, creation of spatial database and mainly for generation of action plans for land and water resources development at micro level and for arresting soil erosion and thus conserving productive land including the overall development of village. The study has demonstrated that action plans prepared at micro level are more accurate and provides better scientific and technical information content existing at the farm and thus suggested measures are also more accurate and better workable to implement with. The created database would be useful for the department mainly Rural development Department, Irrigation Department, PWD Department, Town and Country Planning etc. The study has presented the usefulness of Cadastral Maps which provides the information regarding the change in size of land holding in preparation of action plan at micro level.

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