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LAND USE AND LAND COVER ANALYSIS USING REMOTE SENSING AND GIS TECHNIQUES – A CASE STUDY OF KUMBAKONAM TALUK IN 1970 AND 2009, TAMIL NADU, INDIA

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ABSTRACT

Changes in Land use and Land cover is a dynamic process taking place on the surface and it become a central component in current strategies in managing natural resources and monitoring environmental changes. The objective of this paper is to analyse the land use and land cover changes in Kumbakonam taluk of Thanjavur District. Using SOI Toposheet (1970) and Satellite image of Land sat (2009) data land use and land cover changes has been performed. Result shows the change that has been occurred during 39 years of period.

INTRODUCTION

Land and water are the two most important resources available through which the basic requirements of food, fuel, fodder and shelter are realized. Today, to meet the growing demands of increasing population these resources are being restored to intensive utilization resulting in decrease in vegetative cover, loss of forest wealth, transformation of productive agricultural lands into degraded lands, dwindling of water resources, environmental pollution due to urbanization and industrialization, diminishing per capita availability of land, migration of labour famine and drought etc. To overcome some of these problems there is an urgent need for sustained efforts to reverse the situation too normally through optimal land use planning and scientific management of all the natural resource endowment.

Study Area: Kumbakonam is an important taluk in Thanjavur District. It is generally called as temple town. Kumbakonam Taluk is located at $10^0$58'N to 10.97^{0}N Latitude and 79^{0}25'E to 79^{0}42'E Longitude. Physiographically Kumbakonam is a deltaic region. It lies in the region called the "Old Delta" comprises of the North Western taluk of Thanjavur District that have been naturally irrigated by the waters of the Cauvery and its tributaries for centuries in contrast to the "New Delta" comprising the Southern Taluk that were brought under irrigation by the construction of the Grand Anaicut Canal and the Vadavar Canal in 1934. It has an average elevation of 26 meters. The climate throughout the year is moderate. Kumbakonam is cooler than Chennai. The maximum temperature is summer is about 40^{0}C and the minimum temperature is about 20^{0}C. Occasional rainfall and water stagnation in the wet filed due to irrigation channel of Cauvery give much relief from sweating heat. The town gets its rain mostly during the North East Monsoon. The average annual rainfall for the taluk is 1260mm. The maximum rainfall is during the period from October to December. Kumbakonam receives an annual rainfall of 114.78 cm in every year. There will be summer rain also during March to May which brings down the temperature during summer. This taluk is mainly bounded by two rivers namely Cauvery and Arasalaru. Cauvery runs from west to east direction in the Northern side of Kumbakonam Taluk.

Scope

Outcome of the study will be helpful for the town and regional planning. It will help to understand the extent of land use/land cover and changes during the years.

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Aims and Objectives

The present study includes preparation of LULCC during the last few decades, understanding the influences of human interventions in the basin and formulating comprehensive and effective mitigation strategies for land conservation in the study area using Remote Sensing and GIS.

The objectives are

1. To prepare land use and land cover map preparation in the year of 1970 SOI Toposheet and 2009 data using satellite image.
2. To identify the nature and extent of Land Use and Land Cover changes for the past 39 years.
3. To identify the Change Detection of Land Use and Land Cover in 1970 and 2009.

Selection of the Study Area

To fulfill the above mentioned aim the Kumbakonam Taluk is chosen as the study area. The selection is based on following facts. Kumbakonam Taluk is the most fertile and thickly populated areas in Tamil Nadu as well as in India.

Selection of Data

The study has been used to various primary and secondary data. These data's are included that Toposheet, satellite imagery, and statistics data. A base map was prepared using survey of India Toposheet having the index of numbers, 58 N/ 5 and M/8 on a scale of 1:50,000 as an understanding of this study. Totally 2 Toposheet have covered the study area. The primary data were collected from the Land sat (2009) data on 1:250,000 scale. The supplementary data were generated from the Survey of India (SOI) topographical maps on 1:50,000. This ensured the accuracy of results with possibilities of interpretation by overlooking important and prominent features. The SOI Topographical map is identified from the SOI index map. The coordinates of the study area like latitude and longitude were known from the SOI map (1970).

Techniques Used

In the present study both simple statistical and GIS techniques were used to analyze the secondary data. GIS maps have been drawn to explain the land use and land cover and change detection in Kumbakonam Taluk.

Data Preprocessing

Pre processing has involved scanning and digitization of Survey of India Toposheet at 1:50000 scale to serve as the base map. Scanned maps don't usually contain information as to where the area represented on the map fits on the surface of the earth, for these images have to register coordinates. To establish the relationship between an image (row, column) coordinate system and a map (x, y) coordinate system we need to align or georeference the raster data (image). Processing has involved application of various GIS function and advanced digital image processing technique including contrast manipulation, edge enhancement, and image registered .The images were geometrically rectified and registered to the same projection namely, Transverse Mercator WGS 1984 to lay them over each other.

Image Classification

The initial Land sat (2009) image is subjected to a classification zones. Change Detection can be performed manually by means of interpretation of the imagery. Satellite imagery in a digital format has become available, and digital change detection techniques have been developed. Visual image interpretation was utilized to classify the images to different land use categories in Table 1. In order to classify the rectified images, eight classes were delineated in the images namely, agriculture, built up land, fallow land, mixed plantation, river, river sand scrub land and water body has shown in Table 1 and 2. The overall testing accuracy for the classification of SOI Toposheet (1970) was 82.14%, while it was 86.46% for satellite image (2009). The land use map prepared for the year 1970 and 2009 are shown in figure 1 and 2 respectively.

Table 1. Land Use 1970

Sl. No.	Land Use	Area in sq. km
1	Agriculture land	149465540.40
2	Built up land	40185587.90
3	Fallow land	19105080.10
4	Mixed Plantation	38350208.70
5	River	15140270.33
6	River Sand	1064288.47
7	Scrub land	19413525.30
8	Water body	7538211.65
	Total area	**290262712.86**

Table 2. Land Use 2009

Sl. No.	Land Use	Area in sq. km
1	Agriculture land	107057697.99
2	Built up land	96724176.06
3	Fallow land	21017490.82
4	Mixed Plantation	30267733.28
5	River	14933775.10
6	River sand	2220993.53
7	Scrub land	10502634.43
8	Water body	7538211.65
	Total area	**290262712.86**

Agricultural Land for 1970 and 2009

Agricultural lands of the Kumbakonam taluk are classified into level III, such as agricultural land (Level I), crop land, fallow land and plantation (Level II) and single crop, (Kharif only and rabi only), and double crop (kharif + rabi) (Level III).

The agricultural lands of the taluk are primarily used for farming activities (domestication of crops and animals). It includes food crops, horticultural crops and commercial crops of different kinds under irrigated and rain fed conditions, which are however grown under different seasons, different farming activities and land use tenure systems. Agricultural activities in the study area are mainly dependent on the southwest monsoons and northeast monsoons. They are affected, mostly by the natural hazards such as the drought due to uncertainty of monsoon rains, floods, soils and topography. The taluk has an area of 149465540.40 sq.km, under agricultural use. It accounts for 51.49 per cent of the total area under regular cultivation in the year of 1970. Based on satellite imageries of 2009, the agricultural area is 107057697.99 sq.km it occupies and account about 36.88 per cent. When compared to 1970 SOI Toposheet and satellite image 2009 the agricultural land has decreased for -14.61%.

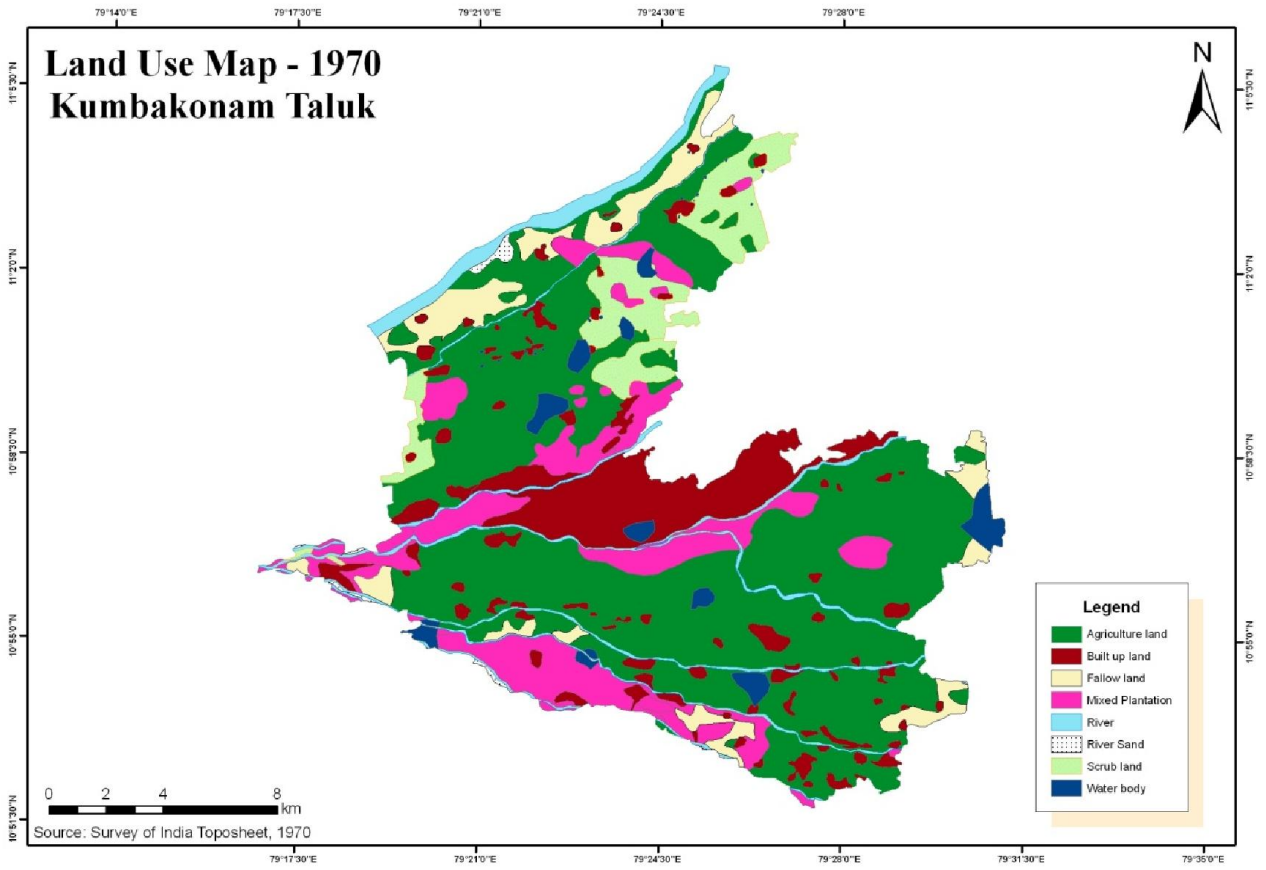
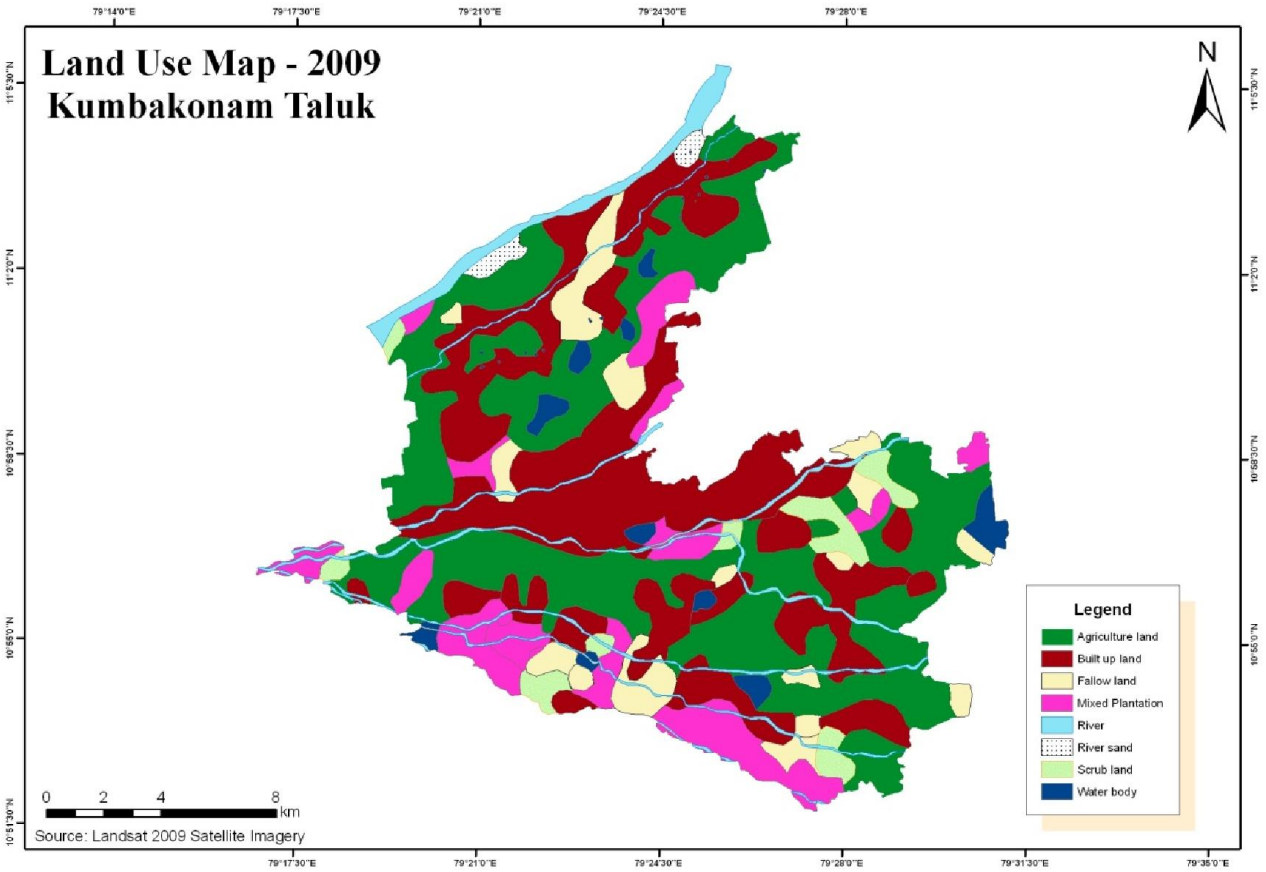

Land Use Map - 1970
Kumbakonam Taluk
N
Legend
Agriculture land
Built up land
Fallow land
Mixed Plantation
River
River Sand
Scrub land
Water body
0 2 4 8
km
Source: Survey of India Toposheet, 1970

Fig. 1


Land Use Map - 2009
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Agriculture land
Built up land
Fallow land
Mixed Plantation
River
River sand
Scrub land
Water body
0 2 4 8
km
Source: Landsat 2009 Satellite Imagery

Fig. 2

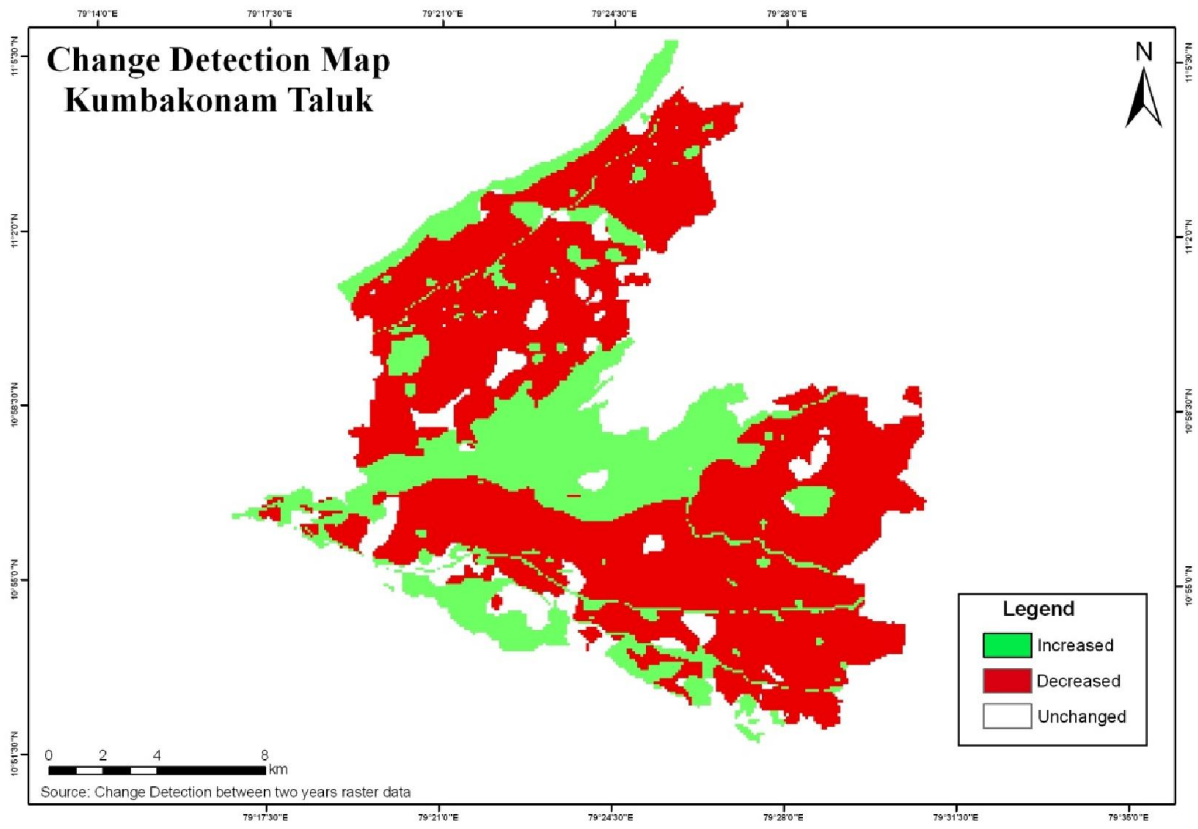

Fig.3

Table 3. Change Detection for Land Use Categories in 1970 and 2009

LAND USE CATEGORY	AREA IN SQ. KM	AREA IN % 1970	AREA IN SQ. KM	AREA IN % 2009	CHANGES
AGRICULTURE LAND	149465540.40	51.49	107057697.99	36.85	14.64
BUILT UP LAND	40185587.90	13.84	96724176.06	33.32	-19.49
FALLOW LAND	19105080.10	6.60	21017490.82	7.26	-0.69
MIXED PLANTATION	38350208.70	13.21	30267733.28	10.42	2.79
RIVER	15140270.33	5.21	14933775.10	5.14	0.07
RIVER SAND	1064288.47	0.38	2220993.53	0.76	-0.6
SCRUB LAND	19413525.30	6.68	10502634.43	3.65	3.07
WATER BODY	7538211.65	2.59	7538211.65	2.59	0
TOTAL	**290262712.86**	**100**	**290262712.86**	**100**	**0**

Built up land for 1970 and 2009

It is described as an area of human habitation developed due to non-agricultural uses and that it has a cover of buildings, transport, communications and utilities in association with water, vegetation and barren lands. This can be confirmed by the convergence of transportation networks such as railway lines and roads. Topography of the area, transportation facilities, economic activities and other important facilities are the factors determining settlement location. Built up areas are classified as level II classes such as those of towns and villages. Kumbakonam taluk has an area of 40185587.90 sq.km in SOI Toposheet 1970. The areal extent of built up land in the study area is 13.84%. In the year of 2009 satellite imageries built up land is 96724176.06 sq.km and observed 33.32 %. When comparison of SOI and satellite imageries 19.48% has increased (Table.3).

Fallow land for 1970 and 2009

It is described as an agricultural land, which is cultivated every year but is temporally allowed to rest uncropped for one or more seasons but not more than whole year. The lands, which lie uncropped during the seasons (kharif and Rabi), are known as the fallow lands. In the year 1970 the fallow lands were 19105080.10 sq.km and accounted for 6.58% per cent to the total area. The fallow lands were 21017490.82 sq.km and accounted for 7.24%. Hence the fallow lands of the taluk are increased 0.66% of total geographical area of the taluk. However, this change is not appreciable. As the study area has one fourth of the area under fallow, which diminish the potential land available for cultivation.

Mixed plantations for 1970 and 2009

These are shown health clear-cut sizes and shapes on the satellite images because these areas are planned and have defined boundaries. It is an area under agricultural tree crops such as cashew, casuarinas, eucalyptus and other mixed plantation, grown as dry crops and coconut under irrigation condition. Agricultural plantation consists of a variety of trees, orchards and groves. In the year of 1970, fallow land covers an area of 38350208.70 sq.km and observed 13.21%. 2009 has covered an area of 30267733.28 sq.km and 10.42%. Mixed plantations are decreased -2.79%.

River in 1970 and 2009

These are impounded water and often with a resultant flow of water. They include both natural and man-made reservoir/lakes/tanks/canals and creeks, rivers and streams and tanks are so identified in the study area. River covered an area of 15140270.33 sq.km and occupies 5.2% in the year of 1970 and in the year of 2009 satellite image, river covers 14933775.10 sq.km. and covers an area of 5.14%. When differentiate between 1970 and 2009 -0.07% has decreased in 2009 image.

River Sand in 1970 and 2009

These lands occurred in small patches in some part of taluk. In the year of 1970 about 1064288.47 sq.km and accounts on 0.36% and 2009 satellite image represents 2220993.53 sq.km and occupy 0.76%. Comparison of 1970 and 2009 river sand has increased 0.4%. Sandy areas of the taluk are essentially tank beds with long deposited down by streams in the catchment. During rainy seasons the gentle sloping areas of sandy clay are subjected to soil erosion. As soon as the raindrops strike the ground the sand particles are separated from clay. Due to slope condition of the topography, the sands are drained into the stream courses and finally deposited in the tank areas. It is common scenario in the sandy clay or alluvial soils. But growing veteveria as their roots spread as mesh can prevent them.

Water Body in 1970 and 2009

In the year of 1970 7538211.65 sq.km and 2.59% and in the year of 2009 the water body covers a same area 7538211.65 sq.km and accounts 2.59%. In 1970 and 2009 water body is same during these 29 years.

Scrub land 1970 and 2009

It is one of the wasteland categories. It is generally associated with foothills, bazadas, relatively high topography like the uplands, the high grounds, and areas covered by a thin veneer of soils, eroded lands, and bad land topography and so on. In general, in the year 1970 19413525.30 sq.km and accounts 6.68% and in satellite image represents 10502634.43 sq.km and accounts 3.61 %. With the comparison of 1970 and 2009 scrub land has decreased -3.07%.

Change Detection

Change detection analysis encompasses a broad range of methods used to identify, describe and quantity difference between SOI Toposheet and Land sat (2009) at different times or under different conditions many of the tools can be used independently or in combination as part of a change detection analysis. Change detection menu after a straight forward approach to measuring changes between a Toposheet and image. When compared to 1970 and 2009 built up land has highly increased in agricultural land, fallow land, mixed plantation and sand land. This is due to over population and migration of people from one place to another place due to occupation. Agricultural land has decreased for the past 39 years. Mostly water body and fallow land is not changed during this 1970 Toposheet and 2009 satellite image. Table.3 and Fig.3 have shown the changes between 1970 and 2009.

Summary and Conclusion

Summary

The major common Land use and Land cover categories such as wasteland, settlement, water bodies (river and tanks), agriculture land are identified and mapped from the SOI topographic sheets of the year 1970, and it was compared with those prepared from the satellite image. The drawn maps for the year 1970 and 2009 have digitized and rasterised, it have been carried out using Arc GIS 9.1 Software to create land use coverage and LULCC are identified. Land use and Land cover map of 1970 was prepared from SOI Toposheet while those of 2009 were prepared from the satellite image based on ground truth observations and verifications. The Visual interpretations techniques adopted and identify its areal extent of total area 290262712.86 sq.km. The most salient changes in land use and land cover have been quick augment in total area as percentage represented by graphically. The Land use and Land cover changes map (1970 – 2009) deduced. Agricultural plantations changes into other category are built-up land.

Conclusion

Agricultural lands have decreased considerably because of human interference. It is necessary, before implementing any sort of land use practices in the study area in future by considering the existing socio-economic scenario. It has expected that the findings of the investigation will undoubtedly be useful to planners and local bodies to implement suitable land use plans in the watershed, thereby achieving eco-preservation and enabling the restoration of degraded land units to the maximum possible extent. Local people should aware of the consequences of conversion of paddy fields. Land and water management activities should conducted only after detailed land use planning, sand mining from rivers should be regulated and further expansion of agricultural plantation at the expense of other crops. Remote sensing was quite useful for land use and land cover mapping. It was found that main impact of random growth of settlement is on the surrounding agriculture land and land with scrub. Under utilization of potential land, increased population, and land conversion are the major driving forces for the change in land use during the 39 years. The overall accuracy of the present land cover study is 85%. Based, on the analysis of changes in land use/land cover some of the remedial measures are suggested, which are essential for optimum and sustainable utilization of land resources and prevention of further undesirable and deteriorated changes in land use. Crop rotation could help to improve the land potential and to avoid poor yield. Based on the soil suitability fruit trees could be planted to improve the economy of the people.

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