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Spatio-Temporal Changes on Land Use/Land Cover in Vaippar Basin, Tamil Nadu Using Geoinformatics Approach

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Abstract: ***The present study was conducted to find out the land use/land cover changes in Vaippar River basin situated in Madurai, Virudhunagar, Thoothukudi, and Tirunelveli Districts of Tamil Nadu State. The total extent of the study area is 3,532 sq.km. for the spatio-temporal study, Bhuvan Image layer 2005-06 and the satellite image of IRS LISS III 2011-12 were used to demarcate the land use/land cover categories. Geoinformatics technology has used to classify the land use/land cover categories and to detect the changes occurred during the above mentioned periods. Overlay technique is applied to find out the difference in land utilization pattern in the years 2005-2006 and 2011-12. The analysis conclude that the agriculture croplands 11% and built-up land by 0.21% categories have increased in the year 2011-12 when compared to the year 2005-06. It is clearly understood that urbanization is gradually grabbing all natural land uses which results in depletion of various other categories. Urban expansion has brought serious losses of agriculture land and vegetation.***

Keywords: Land use/Land cover, Change detection, Remote Sensing, GIS.

1. Introduction

The land use/land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. 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. Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for monitoring fast land use changes (Sharma, et al. 2013).

Land use includes agricultural crop land, agricultural fallow land, agriculture plantation, built up mining/ industrial area, built up rural, built up urban, forest deciduous, forest evergreen/ semi evergreen, forest plantation, forest scrub, lakes/ponds, reservoirs/tanks, river/ stream, wasteland, wetlands coastal etc. Moreover this type of analysis provides a valuable tool to increase the efficiency of land use/land cover, and to diminish the negative environmental and societal impacts related to LULC.

As far as a river basin is concerned, the spatio-temporal changes of land use in the basin have a direct influence on its hydrological realm. The recent advancement in digital image processing techniques have brought about a profound acceptance of the application of satellite remote sensing data in land use/land cover inventory, mapping and change detection (Kachhwaha 1985; Coppin and Bauer 1996; Star et al. 1997; Xiaomei and Ronqing 1999; Chilar 2000; Elmore et al. 2000; Mukul 2010; Manonmani and Suganya 2010; Abbas and Arigbede 2011; Singh and Khanduri 2011; Tripathi and Kumar 2012). Remote Sensing and GIS have been widely applied to understand the land use/land cover changes and are considered to be a powerful tool to identify the spatio-temporal changes of an area

2. Study Area

The Vaippar Basin (8° 58' to 9° 45' N and 77° 10' to 78° 15' E) with an area of 3532 km^2 covers the parts of Madurai, Virudhunagar, Thoothukudi, and Tirunelveli Districts in Tamil Nadu. On the basis of Physiography, the basin can be divided into two broad sections, namely, the hilly tracts with altitude above 100 metres and the vast stretch of black-cotton soil plains. The basin is located on the leeward side of the Western Ghats. Though the basin extends up to the Bay of Bengal, the direction of monsoon winds restricts the rainfall considerably.

3. Materials

3.1 Ancillary Data

In the land use/land cover map the ancillary data in the form of topographic maps, and other published relevant materials were used as reference data's for preparation. Survey of India (SOI) topographic maps with scale of 1: 50,000 were used for identification of base features and for planning ground based data collection. IRS LISS-III (2012) also used for preparation of Land use mapping. Further Bhuvan, LULC data, and wastelands data of year (2005-06 & 2011-12) were taken from NRSC, Hyderabad.

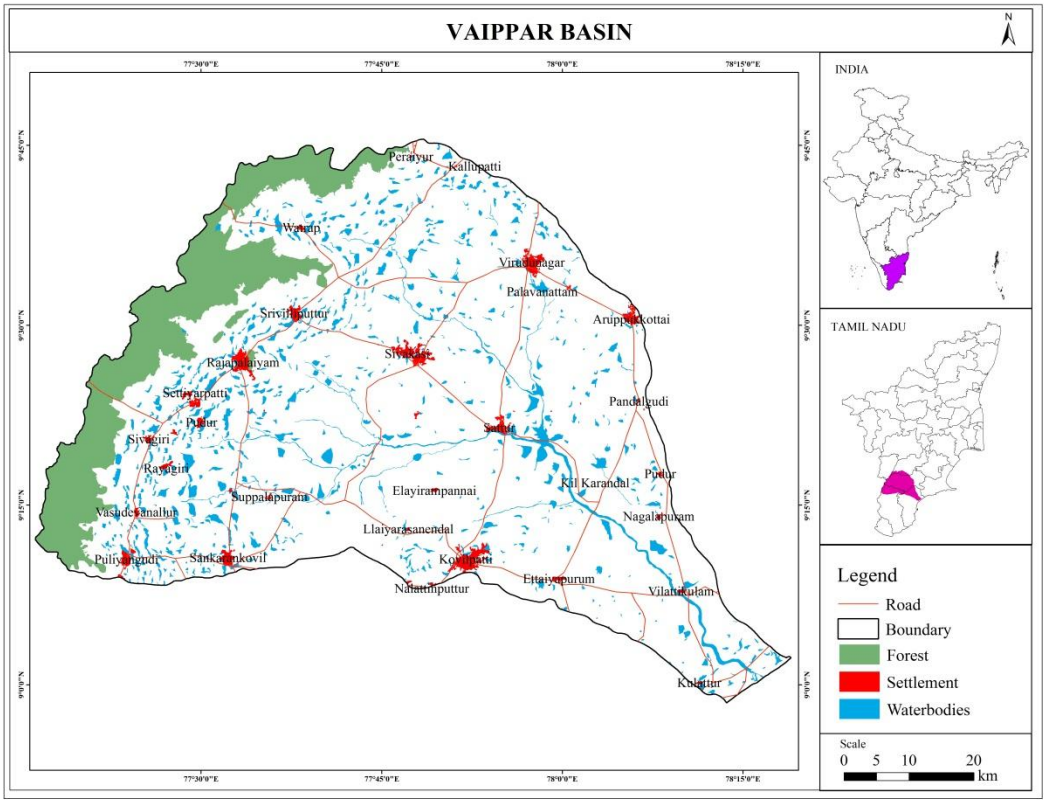

Figure 1: Study Area Map

3.2 Software Used

- ERDAS IMAGINE v9.2: In this study ERDAS was applied in importing, image rectification, and Geo-referencing.
- ArcGIS v10: for digitization, preparation of land use/land covers layer and for composition and generation of maps
- Microsoft Office: for database preparation.

4. Methodology

The methodology followed was on-screen visual interpretation using interpretation keys like tone, shape, texture, size, pattern, and association etc. Change detection is the process of categorizing differences in the state of an object or phenomenon by observing it at different times. Remote sensing methods of mapping LULC change include multi-date composites, change vector, image algebra (image differencing, image ratio), on-screen digitization, GIS overlay and post-classification comparison (Zubair, 2006; Coppin et al., 2004; Lu et al., 2004, Lunetta and Elvidge, 1999 and Campbell, 2000). Flow chart provided in chart 1 indicates different steps followed in the updation of land use/land cover map of 2005-06 using Bhuvan data, to prepare Land use/Land Cover (LU/LC) map of 2011-12 using IRS LISS III image and provide the Land use/Land cover change Detection Map.

5. Analysis

Land use/Land cover change analysis was done by computing different land use categories from the year 2005-06 to 2011-12.

Relative Deviation (RD %) was computed as under :

$$\%\,RD = \frac{A\,(2011\text{-}12) - B\,(2005\text{-}06)}{B\,(2005\text{-}06)} \times 100$$

Where: A is the area under a specified land use class for the year 2011-12. B is the area under the same land use class for the year 2005-06.

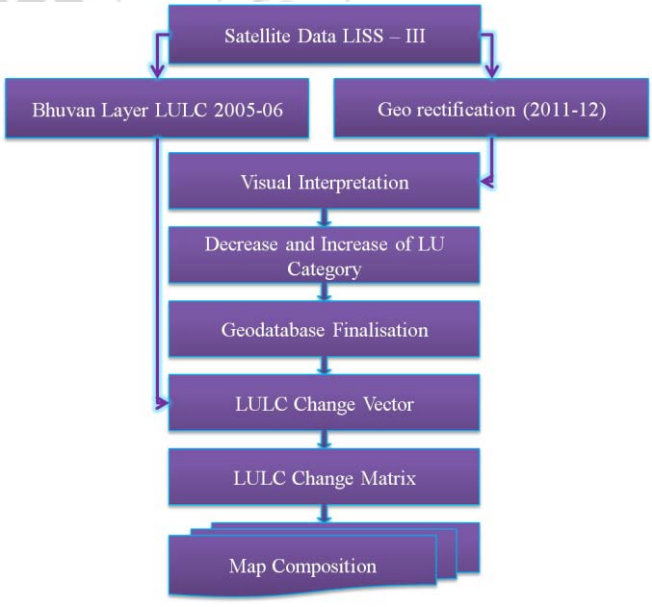

Chart 1: Work flow

5.1 Agricultural Cropland

The crop land is the part of agriculture land. The agriculture lands are identified by their characteristic like red tone, square or rectangular shape of the agricultural fields, association with the water bodies, and topography. The

distribution of crop is spread throughout the study area with the exemption of cropland in the western most regions covering forest area. The Kharif crops (paddy, groundnut and cotton) are cultivated in the months of June, July and August. The Rabi crops mostly paddy, maize and millets are cultivated in the months of October, November and December. In Vaippar Basin, the agricultural cropland was 2078.0 sq. km. (38.97%) in year 2005-06 and increased to 2692.4 sq.km. (50.52%) in year 2011-12. It has been increased (11.32%) mainly due to excess of agricultural practices leading to decrease (-11.5%) in agricultural fallow land.

5.2 Agricultural Fallow Land

The fallow land is the cultivated land left uncultivated temporarily for more than one season, but not less than one year. It was identified by their dark greenish tone, smaller sized rectangular parcels and medium texture. In Vaippar Basin, the agricultural fallow Land area was 1902.65 sq. km. (35.68%) in year 2005-06 and decreased to 1289.65 sq. km. (24.2 %) in year 2011-12. It has been reduced mainly due to increase in agricultural practices paddy, sorghum, pulses etc.

5.3 Agricultural Plantation

The plantation crops include coconut, banana trees etc. Such areas were found in dark red colour in the western part of the region. In Vaippar Basin, the agricultural Plantation area was 176.89 sq. km. (3.32%) in year 2005-06 and decreased to 174.66 sq. km. (3.28%) in year 2011-12. It has been reduced mainly due to the increase in agricultural crop land.

5.4 Built up Urban Area

The built-up land has been considerably increasing with physical structures around the urban centres. Comparison of the temporal data shows that built-up area has considerably increased in Vaippar basin showing urban sprawl in and around the urban centres. It was as low as 52.02 sq. km. (0.98 %) in year 2005-06 and it has increased to 63.37 sq. km. (1.19%) in year 2011-12. The built up area was converted (.21%) from agricultural cropland and fallow land areas.

Built up Rural Area

The lesser extent of the population and size of the area based on hamlet and villages are considered as the built up rural area. The size of built up rural area in this study varies from small and big, discontinuous shape, irregular, and in scattered patterns. The built up rural area was 50.03 sq. km. (0.94%) in year 2005-06 to 50.05 sq. km. (0.94%) in year 2011-12. In the period of 2005-06 to 2011- 12 the built up rural area was converted from agricultural cropland and fallow land areas.

5.5 Built up Mining / Industrial Area

Mines are the regions excavated for the mineral purposes. The large scale quarrying and mechanization results in mining and mine dumps. It includes surface rocks, stone quarries, sand gravel pits and brick kilns etc. The industrial area is the human manufacturing regions. Heavy metallurgical industry, thermal, cement, petrochemical, engineering plants etc. They are identified with dark bluish green tone and white patches in between and have coarse texture (NRSC manual 2012). They are identified with greyish colour with a mix of very light blue tone. The Built up mining / industrial area was 12.15 sq. km. (0.23%) in year 2005-06 and 12.15 sq. km. (0.23%) in year 2011-12. Further, there are no changes during the period of 2005-06 to 2011-12 in Built up Mining / Industrial area.

5.6 Forest Deciduous

Deciduous Forest Land includes all forested areas having a predominance of trees that lose their leaves at the end of the frost-free season or at the beginning of a dry season. These lands are identified by their red to dark red tone and varying in size. The Deciduous forest was around 280.72 sq. km. (5.26%) in year 2005-06 and decreased to 262.11 sq. km. (4.92%) in year 2011-12. Added, it has change to Forest Plantation and Scrub Forest in this period of 2005-06 to 2011-12.

5.7 Forest Evergreen / Semi Evergreen

Evergreen Forest Land includes all forested areas in which the trees are predominantly those which remain green throughout the year. Both coniferous and broad-leaved evergreens are included in this category with their irregular in shape with smooth texture. The evergreen / semi evergreen forest was around 166.88 sq. km. (3.13%) in 2005-06 and also in 2011-12. Further, there is no changes in evergreen / semi evergreen forest areas where the western part of the basin covered by forest lands of the Western Ghats.

5.8 Forest Plantation

These are the areas of tree species of forestry importance, raised and managed especially in notified forest areas. The species mainly constitute teak, Sal, eucalyptus, casuarinas, bamboo etc. The forest plantation was around 15.89 sq. km. (0.30%) in year 2005-06 and increased to 21.29 sq. km. (0.40%) in year 2011-12. Moreover, it has been increased mainly due to decreasing deciduous forest areas.

5.9 Forest Scrub

These are the forest areas where the crown density is less than 10% of the canopy cover and settlements where there is biotic and abiotic interference. The scrub forest was around 80.86 sq. km. (1.52%) in year 2005-06 and increased to 95.68 sq. km. (1.79%) in year 2011-12. Moreover, it has been increased (.27%) due to decreasing deciduous forest areas.

5.10 Water Bodies

The water bodies include both natural and man-made water features namely rivers, streams, lakes, tanks and reservoirs. The water features appear black in tone in the satellite image. The shallow water and deep water features appear in light blue to dark blue in colour. In the study area a number

of tanks with plantation and without plantation are well distributed. Tanks with plantation are identified by the square/rectangle shape and red colour tone. Tanks without plantation are recognized by the shape and light blue to dark blue tone. It covers an area of 336.63 sq. km. (6.31%) in year 2005-06 and decreased to 333.40 sq. km. (6.25%) in year 2011-12. Present study, built-up areas is occupied near to the river course, and few patches of water bodies are converted into the grazing land and other purposes.

5.11 Wastelands

Land, which does not support any kind of vegetations are known as waste lands. Barren rocky, salt affected land, land with and without scrub, sandy area, sheet rocks and stony regions include in this category. Such lands are formed due to the chemical and physical properties of soil, temperature, rainfall and local environmental conditions. In the study area wastelands was 174.40 sq. km. (3.27%) in year,

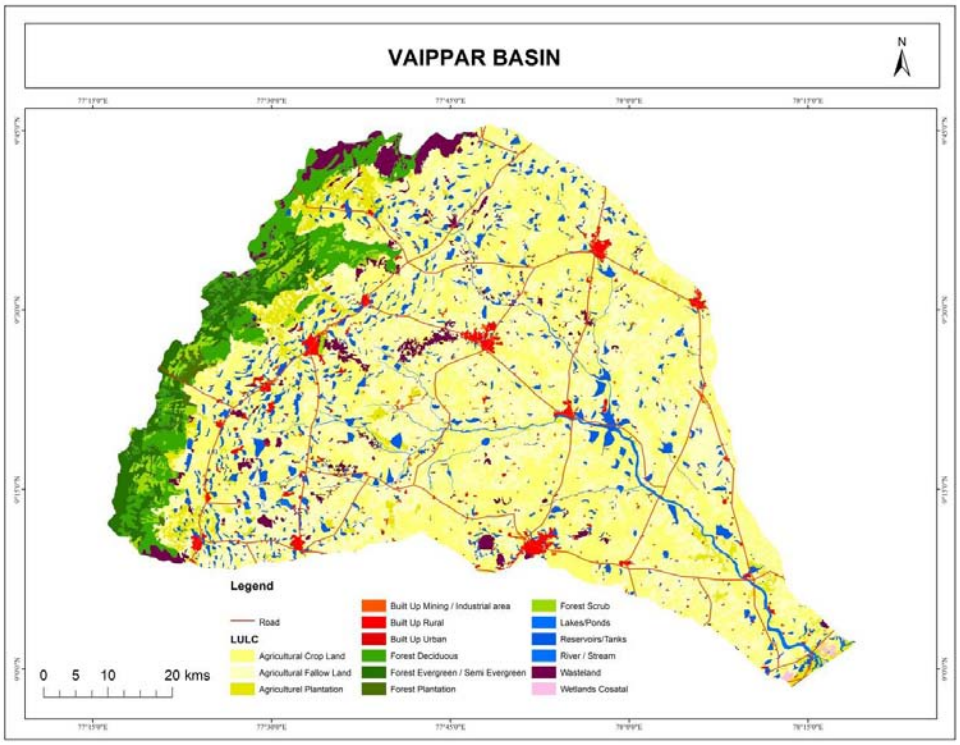

Figure 2: Land use/Land cover 2005 – 06

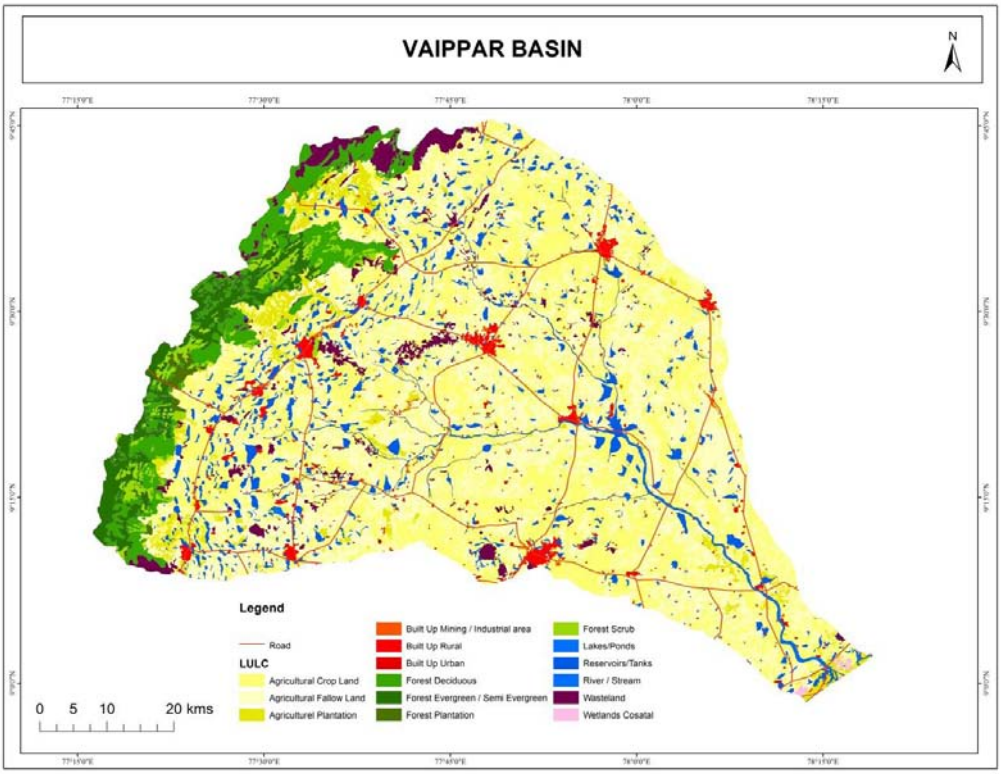

Figure 3: Land use/Land cover 2011 – 12

Table 1: Land use/Land cover 2005- 06 and 2011 – 12

LULC Class	2005-06		2011-12		Differences		Relative Deviation
	(Area in Sq.Km)	(Area in %)	(Area in Sq.Km)	(Area in %)	(Area in Sq.Km)	(Area in %)	% from 2005-06 to 2011-12
Agricultural Crop Land	2078.14	38.97	2682.09	50.29	603.95	11.32	29.06
Agricultural Fallow Land	1902.65	35.68	1289.65	24.18	-613	-11.5	-32.22
Agriculture Plantation	176.89	3.32	174.66	3.28	-2.23	-0.04	-1.26
Built Up Mining / Industrial area	12.15	0.23	12.15	0.23	0	0	0
Built Up Rural	50.03	0.94	50.05	0.94	0.02	0	0.04
Built Up Urban	52.02	0.98	63.37	1.19	11.35	0.21	21.81
Forest Deciduous	280.72	5.26	262.11	4.92	-18.61	-0.34	-6.63
Forest Evergreen / Semi Evergreen	166.88	3.13	166.88	3.13	0	0	0
Forest Plantation	15.89	0.3	21.29	0.4	5.4	0.1	33.98
Forest Scrub	80.86	1.52	95.68	1.79	14.82	0.27	18.33
Lakes/Ponds	1.9	0.04	0.24	0	-1.66	-0.04	-87.37
Reservoirs/Tanks	285.3	5.35	284.52	5.34	-0.78	-0.01	-0.27
River / Stream	49.43	0.93	48.64	0.91	-0.79	-0.02	-1.6
Wasteland	174.4	3.27	176.12	3.3	1.72	0.03	0.99
Wetlands Coastal	5.5	0.1	5.31	0.1	-0.19	0	-3.45
Total	5332.76		5332.76				

Table 2: Land use/Land cover Change Detection Matrix (2005 – 06 and 2011- 12)

2005/ 2011	AGCL	AGFL	AGPL	BUIM	BURU	BUUR	FD	FE/SE	FPL	FS	L/P	R/T	R/S	WL	WC	Total
AGCL	2056.5	8.4	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2078.1
AGFL	621.2	1281.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1902.7
AGPL	0.0	0.0	174.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	176.8
BUIM	0.5	0.0	0.0	12.15	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2
BURU	0.0	0.0	0.0	0.0	50.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.3
BUUR	0.0	0.0	0.0	0.5	0.0	52.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.0
FD	0.0	0.0	0.0	0.0	0.0	0.0	262.1	0.0	0.0	18.6	0.0	0.0	0.0	0.0	0.0	280.7
FE/SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	166.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	166.9
FPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.9	0.0	0.0	0.0	0.0	0.0	0.0	15.9
FS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.9	0.0	0.0	0.0	0.0	0.0	80.9
L/P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.7	0.0	0.0	0.0	1.9
R/T	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	282.5	0.0	0.0	0.0	285.2
R/S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	48.6	0.0	0.0	49.4
WL	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	173.9	0.0	174.4
WC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	5.3	5.5
Total	2682.4	1289.7	174.6	12.15	50.5	63.3	262.1	166.9	21.2	95.7	0.2	284.5	48.6	176.1	5.3	5332.7

AGCL- Agricultural Crop Land, **AGFL**- Agricultural Fallow Land, **AGPL**- Agriculture Plantation, **BUIM**- Built Up Mining / Industrial area, **BURU**- Built Up Rural, **BUUR** - Built Up Urban, **FD**- Forest Deciduous, **FE/SE** -Forest Evergreen / Semi Evergreen, **FPL** -Forest Plantation, Forest Scrub, **L/P** Lakes/Ponds, **R/T** -Reservoirs/Tanks, **R/S** -River / Stream, **WL** -Wasteland, **WC** -Wetlands Coastal 2005-06 which has increased to 176.12 sq. km. (3.30%) in year 2011-12 and changed into agricultural cropland.

5.12 Wetland

Wetlands are frequently associated with topographic lows, even in mountainous regions. Wetlands are those areas where the water table is at, near, or above the land surface for a significant part of most years. Few regions are established with aquatic or hydrophytes vegetation, although alluvial and salt pan may be non-vegetated.In the study are the wetland area has decreased from 5.50 sq. km. (0.10%) in year 2005-06 to 5.31 sq. km. (0.09%) in the year 2011-12 because of water logging in some of the agricultural crop land.

6. Result and Discussion

Following results have been concluded on the basis of the land use / land cover maps prepared for the two different years using multi-date satellite image i.e. 2005-06 and 2011-12. The distribution of land use/land cover change map of Vaippar basin for 2005-06 and 2011-12 are represented in map. The area available in each class has calculated by using basic statistics tools and GIS software and that has been graphically represented. Tabulations and area calculations provide a comprehensive data set in terms of the overall landscape and the types and amount of changes, which have occurred. The table no.1 shows the estimated land use/land cover transitions based on the comparison of the image interpretation results for the 2005-06 and 2011-12 images.

7. Conclusions

The present study shows that satellite remote sensing based land cover mapping is very useful & effective. The study demonstrated that the application of GIS helps in studying the changes in land use pattern of an area. The land use/land cover has been changes from 2005-06 to 2011-12 in this

agriculture crop land has been increased 11.30 %; and urban area increased to 1 % due to migration of people to cities for employment & education purpose, there is no changes in Evergreen forest in Vaippar basin. Different types of human activities had contributed in vast changes in the land use/land cover of the study area.

8. Acknowledgement

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