Land use/land cover change assessment of Kosasthalaiyar sub basin using remote sensing and GIS

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Abstract. Understanding Land use land cover (LULC) changes in the Kosasthalaiyar sub basin is vital for the sustainability of the watershed. Hence mapping of these changes can help visualize the spatio-temporal dynamics in the area. Remote sensing and GIS provides valuable tools to map these changes. In this present study, Remote sensing and GIS techniques has been used to prepare LULC maps for the years 1988, 1998, 2008, and 2018. The changes that has happened from 1988 to 1998, 1998 to 2008, and 2008 to 2018 has been assessed. Images from Landsat-5 and Landsat-8 Thematic Mapper (TM) have been used. Maximum Likelihood Classifier was adopted to produce the LULC maps of the watershed. Ground truth points using GPS was used to check the accuracy of the work. Five major land use classes viz; Built up land, agriculture, forest, waste land and water bodies were identified in the watershed for the study. During the 30-year period from 1988 to 2018, major changes can be observed in a number of LULC classes. About 66.05 Km² of crop land got converted to barren land. Out of 588.86 Km² of crop land only 176.99 Km² remained unchanged. About 119.94 Km² has been converted to settlements. Settlements increased from 59.89 Km² to 341.86 Km². Barren land increased from 168.73Km² to 228.59 Km². The analysis and the results obtained can help policy makers make appropriate policies for the sustainability of the Kosasthalaiyar sub basin.

Keywords: Remote sensing and GIS, Land use land cover, Change detection, Kosasthalaiyar sub basin.

1. Introduction

With the availability of satellite based data, Land use land cover (LULC) mapping and Land use land cover change (LULCC) detection is being widely used in natural resources management [1], [2], [3], [4], [5]. These techniques are found to be very useful especially in watershed management [6], [7]. Rapid changes in LULC has been observed in several parts of the world [8], [9]. The LULC mapping has become the baseline for planning and management of natural resources. Many researchers have shown that the LULCC can affect not only the socio-economic conditions of the society but also have drastic impact on environment [10]. In the present study Multi-temporal satellite images of...
Landsat-5 and Landsat-8 Thematic Mapper (TM) have been used. With increasing anthropogenic activity Kosasthalaiyar sub basin has undergone lot of changes over the past 30 years. In the present study LULCC from the year 1988 to 2018 has been studied. Major land classes have been identified and its spatial and temporal changes have been mapped. The usefulness of remote sensing and GIS in mapping the spatial and temporal changes and applicability in understanding the Land Use Land cover change dynamics have been demonstrated.

2. Materials and Methods

2.1 Study area

The Chennai basin consists of eight sub basins namely 1) The Gummidipoondi sub basin, 2) Araniyar sub basin, 3) Nagariyar sub basin, 4) Nandhiyar sub basin, 5) Kosasthalaiyar sub basin, 6) Cooum sub basin, 7) Adayar sub basin, 8) Kovalam sub basin. Kosasthalaiyar sub basin is biggest amongst the eight. It is located between the latitudes and longitudes of 12° 53’30” to 13° 21’ 23” N and 79° 17’09” to 80° 20’12” E. The total area of the sub basin is 1949.32 Km². The location map of the study area is shown in figure 1. The main river that flows through the basin is the Kosasthalaiyar river which is 136-kilometre long and originates near Pallipattu in Thiruvallur district and drains into the Bay of Bengal. The Poondi reservoir is one of the major reservoirs in this basin and it one of the major source of water supply to Chennai city. This region has a sub-tropical climate. The minimum and maximum temperatures are 20.4°C and 38.7°C. The average annual rainfall in the region is around 1100 mm.

![Figure 1. Study Area Map](image-url)
2.2. Data used and Methodology adopted

Two types of data were used in this research. One satellite data and ancillary data. The satellite data used is shown in Table 1. Ground truth data collected for various LULC classes from topographic maps and GPS survey formed the ancillary data. Landsat satellite images collected from USGS was used. Data was pre-processed in ERDAS imagine software to establish direct relation between acquired data and the biophysical phenomena [11]. Supervised classification of the images were carried out using maximum likelihood algorithm. It is important that the spectral signature involves minimal confusion [12]. Accuracy assessment was done using 100 ground truth data and visual interpretation. Kappa test was performed to measure classification accuracy [13]. Post-classification change detection was done in ArcGIS. The various classes delineated after supervised classification is given in Table 2.

| Study year | Acquisition date | Sensor | Path/Row | Resolution (m) |
|------------|------------------|--------|----------|---------------|
| 1988       | 05.JAN.88        | LANDSAT 5 TM | 142/51   | 30            |
|            | 16.DEC.89        | LANDSAT 5 TM | 143/51   |               |
| 1998       | 17.FEB.98        | LANDSAT 5 TM | 142/51   | 30            |
|            | 01.SEP.97        | LANDSAT 5 TM | 143/51   |               |
| 2008       | 29.FEB.08        | LANDSAT 5 TM | 142/51   | 30            |
|            | 20.FEB.08        | LANDSAT 5 TM | 143/51   |               |
| 2018       | 19.JAN.18        | LANDSAT 8 TM | 142/51   | 30            |
|            | 07.FEB.18        | LANDSAT 8 TM | 143/51   |               |

| Class Name | Description |
|------------|-------------|
| Settlement | Areas designated as residential, commercial, industry, transportation, roads. |
| Crop land  | Cropped area followed by harvest and a bare soil period (e.g. single and multiple cropping systems). Those having a source of irrigation. |
| Dry crop   | Crops irrigated under natural rainfall. |
| Harvested land | Land taken up for cultivation. |
| Fallow land | Land taken up for cultivation temporarily allowed to remain uncultivated for one or more seasons. |
| Plantation | Commercial horticulture plantations, orchards and tree cash crops. |
| Scrub land | Area of land which is covered with low trees and bushes. |
| Shrub land | Land with woody vegetation less than 2 m in height and with greater than 10% shrub canopy cover. The shrub foliage can be either evergreen or deciduous. |
| Barren land | Exposed soil, sand, rocks, or snow and never have more than 10% vegetated cover during any time of the year. |
| River      | Areas with surface water, flowing as streams, rivers, etc. |
| Tank       | Areas with surface water, either impounded in the form of ponds, lakes, reservoirs etc. Can be either fresh or salt-water bodies. |
| Alkalinity | Areas where soil has turned alkaline |
| Hill       | Land forms that is at a greater elevation than the surrounding terrain |
| Reserved forest | Areas with dense coverage of trees |
| Salt pan   | Areas were large water bodies are dried up making ground with salt deposits |
3. Results and Discussion

3.1 LULC scenario in 1988

The land use land cover for the year 1988 is shown in figure 2. During the year 1988, the river basin is predominantly covered with agricultural land. About 57.12% of the land is under agriculture. Water bodies contribute to 12.27%. About 23.13% of land come under wasteland category. Built up land is around 3.07% and 4.41% is the forest cover. The area under each class is shown in Table 3.

![Figure 2. LULC for the year 1988](image_url)

| S. No | Land use/Land cover Category | 1988 (Area in Km²) | % Area |
|-------|-----------------------------|-------------------|--------|
|       | Built up land               |                   |        |
| 1     | Settlement                  | 59.89             | 3.07   |
|       | Agricultural land           |                   |        |
| 1     | Crop land                   | 588.86            | 30.21  |
| 2     | Dry crop land               | 122.04            | 6.26   |
| 3     | Harvested land              | 258.28            | 13.25  |
| 4     | Fallow land                 | 129.16            | 6.63   |
| 5     | Plantation                  | 15.01             | 0.77   |
|       | Forest land                 |                   |        |
| 1     | Reserved forest             | 72.78             | 3.73   |
| 2     | Hill/Out crop               | 13.20             | 0.68   |
|       | Waste land                  |                   |        |
| 1     | Scrub land                  | 177.39            | 9.10   |
| 2     | Shrub land                  | 93.42             | 4.79   |
| 3     | Barren land                 | 168.73            | 8.66   |
| 4     | Alkalinity/Salinity         | 0.67              | 0.03   |
| 5     | Salt pan                    | 10.63             | 0.55   |
|       | Water body                  |                   |        |
| 1     | River                       | 44.63             | 2.29   |
| 2     | Tank                        | 194.63            | 9.98   |
|       | Total                       | 1949.32           | 100.00 |

Table 3. LULC for the year 1988
3.2 LULC scenario in 1998

The land use land cover for the year 1998 is shown in figure 3. In the year 1998, 56.62% of land comes under the category of agricultural land. About 12.11% of the land is water body and 18.85% falls under the category of waste land. Built up land is around 8.03% which is around 4.96% more when compared to year 1988. The area under forest is around 4.39%. The area under each class is shown in Table 4.

![Figure 3. LULC for the year 1998](image)

Table 4. LULC for the year 1998

| S. No | Land use/Land cover Category | 1998 (Area in Km²) | % Area |
|-------|-----------------------------|-------------------|--------|
|       | Built up land               |                   |        |
| 1     | Settlement                  | 156.55            | 8.03   |
|       | Agricultural land           |                   |        |
| 1     | Crop land                   | 501.29            | 25.72  |
| 2     | Dry crop land               | 153.74            | 7.89   |
| 3     | Harvested land              | 315.90            | 16.21  |
| 4     | Fallow land                 | 121.38            | 6.23   |
| 5     | Plantation                  | 11.19             | 0.57   |
|       | Forest land                 |                   |        |
| 1     | Reserved forest             | 72.45             | 3.72   |
| 2     | Hill/Out crop               | 13.01             | 0.67   |
|       | Waste land                  |                   |        |
| 1     | Scrub land                  | 80.59             | 4.13   |
| 2     | Shrub land                  | 79.49             | 4.08   |
| 3     | Barren land                 | 195.74            | 10.04  |
| 4     | Alkalinity/Salinity         | 9.64              | 0.49   |
| 5     | Salt pan                    | 2.17              | 0.11   |
|       | Water body                  |                   |        |
| 1     | River                       | 42.57             | 2.18   |
| 2     | Tank                        | 193.61            | 9.93   |
|       | Total                       | 1949.32           | 100.00 |


3.3 LULC scenario in 2008
The land use land cover for the year 2008 is shown in figure 4. In the year 2008 we see an increase in area under settlements. Built up land cover 13.85% of the total area. The area under agriculture is around 45.27%. Water bodies contribute 11.79%. About 23.82% fall under the category of waste land and 5.26% under forest land. The area under each class is shown in Table 5.

![Figure 4. LULC for the year 2008](image)

**Table 5. LULC for the year 2008**

| S. No | Land use/Land cover Category | 2008 (Area in Km²) | % Area |
|-------|------------------------------|--------------------|--------|
|       | **Built up land**            |                    |        |
| 1     | Settlement                   | 270.06             | 13.85  |
|       | **Agricultural land**        |                    |        |
| 1     | Crop land                    | 490.49             | 25.16  |
| 2     | Dry crop land                | 144.09             | 7.39   |
| 3     | Harvested land               | 146.77             | 7.53   |
| 4     | Fallow land                  | 83.20              | 4.27   |
| 5     | Plantation                   | 17.98              | 0.92   |
|       | **Forest land**              |                    |        |
| 1     | Reserved forest              | 84.76              | 4.35   |
| 2     | Hill/Out crop                | 17.66              | 0.91   |
|       | **Waste land**               |                    |        |
| 1     | Scrub land                   | 115.83             | 5.94   |
| 2     | Shrub land                   | 112.54             | 5.77   |
| 3     | Barren land                  | 205.05             | 10.52  |
| 4     | Alkalinity/Salinity          | 7.64               | 0.39   |
| 5     | Salt pan                     | 23.39              | 1.20   |
|       | **Water body**               |                    |        |
| 1     | River                        | 44.20              | 2.27   |
| 2     | Tank                         | 185.66             | 9.52   |
|       | **Total**                    | 1949.32            | 100.00 |
3.4 LULC scenario in 2018
The land use land cover for the year 2018 is shown in figure 5. Built up land covers 17.54% of the area and 37.75% of land is under agriculture. About 28.08% falls under the waste land category. The area under water bodies stand at 11.21%. Forest cover is around 5.43%. The area under each class is shown in Table 6.

![Figure 5. LULC for the year 2018](image)

| S. No | Land use/Land cover Category | 2018 (Area in Km²) | % Area |
|-------|------------------------------|--------------------|--------|
| **Built up land** | | | |
| 1 | Settlement | 341.86 | 17.54 |
| **Agricultural land** | | | |
| 1 | Crop land | 440.41 | 22.59 |
| 2 | Dry crop land | 130.35 | 6.69 |
| 3 | Harvested land | 58.25 | 2.99 |
| 4 | Fallow land | 89.11 | 4.57 |
| 5 | Plantation | 17.70 | 0.91 |
| **Forest land** | | | |
| 1 | Reserved forest | 91.52 | 4.69 |
| 2 | Hill/Ot crop | 14.39 | 0.74 |
| **Waste land** | | | |
| 1 | Scrub land | 125.44 | 6.44 |
| 2 | Shrub land | 158.72 | 8.14 |
| 3 | Barren land | 228.59 | 11.73 |
| 4 | Alkalinity/Salinity | 7.18 | 0.37 |
| 5 | Salt pan | 27.32 | 1.40 |
| **Water body** | | | |
| 1 | River | 38.84 | 1.99 |
| 2 | Tank | 179.64 | 9.22 |
| **Total** | | **1949.32** | **100.00** |
3.5 LULC Change over the period of 1988 to 1998
For the period 1988 to 1998 major changes were observed from crop land to barren land and settlements. About 54.3 Km\(^2\) crop land got converted to barren land. About 56.24 Km\(^2\) of crop land got converted to settlements, 27.98 Km\(^2\) into scrub land and 24.07 Km\(^2\) into shrub land. Only 195.64 Km\(^2\) of crop land out of 588.86 Km\(^2\) remained unchanged. The overall loss in crop land was 87.57 Km\(^2\). Alkalinity increased from 0.67 Km\(^2\) to 2.17 Km\(^2\). Settlements increased from 59.81 Km\(^2\) to 156.55 Km\(^2\). The major contribution to change is from the conversion of cropland indicating impact of urbanization on agriculture. Barren land increased from 168.73 Km\(^2\) to 194.74 Km\(^2\). About 10.13 Km\(^2\) of barren land was converted to settlements. LULC change matrix is shown in Table 7.

3.6 LULC Change over the period of 1998 to 2008
The period from 1998 to 2008 also saw major changes from crop land to barren land and settlements. Alkalinity also increased drastically. Settlement show rapid increase during this period. About 60.22 Km\(^2\) of crop land got converted to settlements and 40.99 Km\(^2\) of crop land got converted to barren land. Alkalinity increased from 2.17 Km\(^2\) to 23.39 Km\(^2\) which is the highest increase during the 30-year period of study. About 25.46 Km\(^2\) of harvested land got converted to settlements. Overall the settlements increased from 156.54 Km\(^2\) to 270.06 Km\(^2\). Scrub land increased from 80.59 Km\(^2\) to 115.83 Km\(^2\), the major contribution was from crop land about 19.06 Km\(^2\) and tank around 10.29 Km\(^2\). Similarly, shrub land increased from 79.49 Km\(^2\) to 112.54 Km\(^2\). About 27.67 Km\(^2\) of crop land got converted to shrub land. The LULC change matrix is shown in Table 8.

3.7 LULC Change over the period of 2008 to 2018
During the period from 2008 to 2018, 36.49 Km\(^2\) of crop land has converted to barren land. About 47.80 Km\(^2\) of crop land has been converted to settlements. Shrub land increased from 112.54 Km\(^2\) to 158.73 Km\(^2\). Scrub land increased from 115.83 Km\(^2\) to 125.44 Km\(^2\). Harvested land decreased from 146.77 Km\(^2\) to 58.25 Km\(^2\). About 27.78 Km\(^2\) of harvested land became barren land and 17.32 Km\(^2\) of it became settlements. Alkalinity increased from 23.39 Km\(^2\) to 27.32 Km\(^2\). About 31.93 Km\(^2\) of barren land got converted to settlements. Substantial portion of barren land about got converted to shrub land and scrub land. About 20.05 Km\(^2\) of barren land got converted to shrub land and 24.97 Km\(^2\) of barren land got converted to scrub land. The LULC change matrix is shown in Table 9.

3.8 Overall LULC Change over the period of 1988 to 2018
During the 30-year period from 1988 to 2018, major changes can be observed in a number of LULC classes. Alkalinity saw a steep rise from 0.67 Km\(^2\) to 27.32 Km\(^2\). About 2.98 Km\(^2\) of crop land has become Alkaline. Barren land increased from 168.73Km\(^2\) to 228.59 Km\(^2\). About 66.05 Km\(^2\) of crop land got converted to barren land. Other major contributors to barren land were scrub land, harvested land and fallow land. About 38.22 Km\(^2\) of scrub land got converted to barren land, 25.92 Km\(^2\) of harvested land and 24.71 Km\(^2\) of fallow land also got converted to barren land. Out of 588.86 Km\(^2\) of crop land only 176.99 Km\(^2\) remained unchanged. About 119.94 Km\(^2\) has been converted to settlements. Settlements increased from 59.89 Km\(^2\) to 341.86 Km\(^2\). Shrub land increased from 93.42 Km\(^2\) to 158.72 Km\(^2\). Harvested land decreased from 258.28 Km\(^2\) to 58.25 Km\(^2\). About 37.38 Km\(^2\) of harvested land is converted to settlements. There is also conversion of harvested land to barren land. About 25.92 Km\(^2\) of harvested land got converted to barren land. The area under tank reduced from 194.63 Km\(^2\) to 179.64 Km\(^2\). The LULC change matrix is shown in Table 10. The overall change progression is shown in figure 6.
| LULC Class                    | 1988 (Area in Km²) | 1998 (Area in Km²) |
|------------------------------|--------------------|--------------------|
|                             | Alkalinity         | Barren             |
|                             |                    | Crop land          |
|                             |                    | Dry crop           |
|                             |                    | Fallow land        |
|                             |                    | Harvested land     |
|                             |                    | Hill               |
|                             |                    | Plantation         |
|                             |                    | Reserved Forest    |
|                             |                    | Salt Pan           |
|                             |                    | Scrub land         |
|                             |                    | Settlement         |
|                             |                    | Total              |
| Alkalinity                  | 0.23               | 31.85              |
| Barren land                 | 0.00               | 27.40              |
| Crop land                   | 0.00               | 24.14              |
| Dry crop                    | 0.00               | 14.14              |
| Fallow land                 | 0.00               | 1.01               |
| Harvested land              | 0.00               | 0.01               |
| Hill                         | 0.00               | 0.00               |
| Plantation                   | 0.00               | 0.00               |
| Reserved Forest             | 0.00               | 0.00               |
| Salt Pan                    | 0.00               | 0.00               |
| Scrub land                   | 0.00               | 0.00               |
| Settlement                  | 0.00               | 0.00               |
| Total                        | 2.17               | 194.63             |

Table 7: LULC change matrix 1988 to 1998
### Table 8. LULC change matrix 1998 to 2008

| LULC Class       | 1998 (Area in Km²) | 2008 (Area in Km²) | 2008 Area Difference | 1998 Area Difference |
|------------------|--------------------|--------------------|-----------------------|-----------------------|
|                  | Alkalinity         | Barren land        | Crop land             | Dry crop              | Fallow land          | Harvested land       | Hill                 | Plantation           | Reserved Forest     | River                | Salt Pan             | Scrub land           | Settlement            | Shrub land           | Tank                  | Grand Total          |
|                  | 0.77               | 0.87               | 0.16                  | 0.06                  | 0.04                 | 0.00                 | 0.03                 | 0.00                 | 0.00                 | 0.00                 | 0.04                 | 0.04                 | 0.04                 | 0.02                 | 0.14                 | 2.17                 |
| Alkalinity       |                    |                    |                      |                      |                     |                      |                     |                      |                      |                      |                     |                     |                      |                      |                      |                     |                     |
| Barren land      | 6.39               | 39.02              | 33.41                 | 19.70                 | 8.04                 | 10.57                | 0.85                 | 2.39                 | 4.48                 | 2.35                 | 1.48                 | 18.27                | 25.41                | 16.07                | 7.30                 | 195.75               |
| Crop land        | 1.97               | 40.99              | 234.42                | 37.79                 | 16.86                | 40.92                | 0.74                 | 3.40                 | 0.17                 | 2.70                 | 0.07                 | 19.06                | 60.22                | 27.67                | 14.30                | 501.29               |
| Dry crop         | 0.67               | 23.96              | 31.10                 | 29.57                 | 10.39                | 8.83                 | 0.75                 | 0.53                 | 2.47                 | 0.96                 | 0.31                 | 13.24                | 15.39                | 11.31                | 4.26                 | 153.74               |
| Fallow land      | 8.82               | 20.67              | 10.84                 | 6.59                  | 23.10                | 17.12                | 0.91                 | 0.96                 | 0.73                 | 0.17                 | 0.00                 | 9.04                 | 12.66                | 5.01                 | 4.76                 | 121.38               |
| Harvested land   | 0.85               | 23.96              | 128.62                | 24.48                 | 15.33                | 58.46                | 0.17                 | 0.74                 | 1.26                 | 1.40                 | 0.00                 | 13.40                | 25.46                | 13.38                | 8.38                 | 315.90               |
| Hill             | 0.00               | 0.02               | 0.00                  | 0.14                  | 0.00                 | 0.00                 | 12.80                | 0.00                 | 0.00                 | 0.00                 | 0.00                 | 0.01                 | 0.00                 | 0.03                 | 0.01                 | 13.01               |
| Plantation       | 0.10               | 0.63               | 1.13                  | 0.43                  | 0.10                 | 0.12                 | 0.00                 | 2.54                 | 0.04                 | 0.56                 | 0.00                 | 0.79                 | 2.46                 | 1.88                 | 0.39                 | 11.18               |
| Reserved Forest  | 0.03               | 3.29               | 0.01                  | 2.19                  | 0.00                 | 0.02                 | 0.00                 | 0.02                 | 64.09                | 0.00                 | 0.00                 | 2.45                 | 0.13                 | 0.17                 | 0.06                 | 72.45               |
| River            | 0.01               | 2.21               | 2.74                  | 0.33                  | 0.13                 | 0.47                 | 0.00                 | 0.24                 | 0.00                 | 31.82                | 0.22                 | 0.68                 | 1.51                 | 2.07                 | 0.13                 | 42.57               |
| Salt Pan         | 0.00               | 0.73               | 0.00                  | 0.00                  | 0.00                 | 0.00                 | 0.00                 | 0.00                 | 0.00                 | 0.00                 | 4.68                 | 1.76                 | 0.00                 | 1.37                 | 0.03                 | 9.64                |
| Scrub land       | 1.83               | 18.66              | 4.57                  | 6.98                  | 1.24                 | 1.64                 | 0.12                 | 2.60                 | 5.57                 | 0.67                 | 0.65                 | 14.56                | 13.12                | 4.11                 | 4.28                 | 80.59               |
| Settlement       | 0.06               | 10.26              | 21.03                 | 6.07                  | 1.66                 | 2.69                 | 0.54                 | 1.28                 | 0.24                 | 0.65                 | 0.00                 | 5.93                 | 92.99                | 10.42                | 2.73                 | 156.54              |
| Shrub land       | 0.72               | 11.48              | 8.21                  | 6.74                  | 1.24                 | 1.54                 | 0.70                 | 2.68                 | 5.69                 | 1.43                 | 0.22                 | 6.30                 | 15.28                | 11.35                | 5.91                 | 79.49               |
| Tank             | 1.17               | 8.30               | 14.23                 | 3.01                  | 5.07                 | 4.39                 | 0.05                 | 0.42                 | 0.05                 | 0.59                 | 0.00                 | 10.29                | 5.40                 | 7.68                 | 132.96               | 193.62              |
| Grand Total      | 23.39              | 205.05             | 490.49                | 144.08                | 83.20                | 146.77               | 17.66                | 17.98                | 84.79                | 44.20                | 7.64                 | 115.83               | 270.06               | 112.54               | 185.66               | 1949.32              |
## Table 9. LULC change matrix 2008 to 2018

| LULC Class | 2008 (Area in Km²) | 2018 (Area in Km²) |
|------------|--------------------|--------------------|
|            | Alkalinity         | Barren land        | Crop land | Dry crop | Fallow land | Harvested land | Hill | Plantation | Reserved Forest | River | Salt Pan | Scrub land | Settlement | Shrub land | Tank | Grand Total |
| Alkalinity | 20.43 1.98 0.03 | 0.01 0.01 0.45     | 0.00 0.00 0.01 | 0.00 0.00 |            |                |      |            |                |       | 0.00     | 0.00      | 0.21      | 0.01      | 0.23 | 23.39     |
| Barren land| 2.77 51.36 21.69 | 17.12 11.69 4.51  | 0.57 3.55 5.03 | 2.47 0.53 | 24.97 31.93| 20.05 6.79   | 205.05 |            |                |       | 0.00     | 0.00      | 0.56      | 0.02      | 0.01 | 112.23    |
| Crop land  | 0.77 36.49 237.00 | 36.74 27.26 28.25 | 0.05 2.98 0.08 | 3.95 0.00 | 11.63 47.80| 41.25 16.24 | 490.49 |            |                |       | 0.00     | 0.00      | 0.56      | 0.03      | 0.01 | 117.98    |
| Dry crop   | 0.73 16.41 35.62 | 34.98 3.73 3.91  | 0.44 0.89 1.98 | 0.14 0.00 | 13.44 14.68| 13.39 3.74   | 144.09 |            |                |       | 0.00     | 0.00      | 0.11      | 0.07      | 0.02 | 17.66     |
| Fallow land| 0.00 21.96 16.15 | 4.28 8.90 3.61    | 0.02 0.61 0.00 | 0.51 0.00 | 11.23 7.07 | 4.77 4.08   | 83.20  |            |                |       | 0.00     | 0.00      | 0.56      | 0.07      | 0.02 | 17.66     |
| Harvested land | 0.00 27.78 54.49 | 7.14 10.86 6.21   | 0.00 0.77 0.06 | 1.46 0.00 | 3.64 17.32 | 11.79 5.23  | 146.77  |            |                |       | 0.00     | 0.00      | 0.11      | 0.07      | 0.02 | 17.66     |
| Hill       | 0.00 3.63 0.01  | 0.63 0.00 0.00    | 0.00 13.18 37.00| 0.00 0.00 | 0.00 11.23 | 7.07 4.77   | 83.20  |            |                |       | 0.00     | 0.00      | 0.56      | 0.07      | 0.02 | 17.66     |
| Plantation | 0.00 0.71 0.98  | 0.49 0.38 0.00    | 0.00 0.58 0.02 | 0.21 0.03 | 2.44 10.32 | 1.55 0.27   | 17.98  |            |                |       | 0.00     | 0.00      | 0.56      | 0.07      | 0.02 | 17.66     |
| Reserved Forest | 0.46 2.15 0.06  | 0.64 0.04 0.05    | 0.00 79.86 0.00 | 0.00 0.37 | 0.30 0.84 | 0.02 84.79  |        |            |                |       | 0.00     | 0.00      | 0.11      | 0.07      | 0.02 | 17.66     |
| River      | 0.05 4.14 3.65  | 1.05 0.62 0.52    | 0.00 0.51 0.02 | 24.61 0.50 | 1.29 5.47 | 1.33 0.44   | 44.20  |            |                |       | 0.00     | 0.00      | 0.56      | 0.07      | 0.02 | 17.66     |
| Salt Pan   | 0.00 0.00 0.00  | 0.00 0.00 0.00    | 0.00 5.40 0.49 | 1.29 0.40 | 0.03 7.64  |        |        |                |       | 0.00     | 0.00      | 0.56      | 0.07      | 0.02 | 17.66     |
| Scrub land | 0.04 17.77 11.64 | 7.30 6.10 2.24    | 0.06 1.70 2.87 | 0.63 0.59 | 18.31 17.09| 20.32 9.17  | 115.83 |            |                |       | 0.00     | 0.00      | 0.56      | 0.07      | 0.02 | 17.66     |
| Settlement | 0.71 20.35 31.74 | 9.53 13.06 6.42   | 0.00 2.15 0.84 | 2.30 0.00 | 7.45 158.44| 12.04 5.03  | 270.06 |            |                |       | 0.00     | 0.00      | 0.56      | 0.07      | 0.02 | 17.66     |
| Shrub land | 0.38 11.34 17.75 | 6.77 4.49 1.01   | 0.02 2.88 0.69 | 2.17 0.03 | 13.43 19.82| 22.04 9.70  | 112.54 |            |                |       | 0.00     | 0.00      | 0.56      | 0.07      | 0.02 | 17.66     |
| Tank       | 0.98 12.51 9.61  | 3.66 1.94 1.06    | 0.05 1.08 0.04 | 0.34 0.09 | 16.62 10.11| 8.86 118.67| 185.62 |            |                |       | 0.00     | 0.00      | 0.56      | 0.07      | 0.02 | 17.66     |
| Grand Total| 27.32 228.59 440.41| 130.35 89.11 58.25| 14.40 17.70 91.52| 38.84 7.18 | 125.44 341.86| 158.73 179.64| 1949.32 |            |                |       | 0.00     | 0.00      | 0.56      | 0.07      | 0.02 | 17.66     |
### Table 10. LULC change matrix 1988 to 2018

| LULC Class | 1988 (Area in Km²) | 2018 (Area in Km²) | Alkalinity | Barren land | Crop land | Dry crop | Fallow land | Harvested land | Hill | Plantation | Reserved Forest | River | Salt Pan | Scrub land | Settlement | Shrub land | Tank | Grand Total |
|------------|---------------------|---------------------|------------|-------------|-----------|----------|-------------|----------------|------|------------|----------------|-------|----------|------------|------------|------------|------|--------------|
| Alkalinity | 0.23                | 0.01                | 0.00       | 0.10        | 0.00      | 0.00     | 0.00        | 0.00           | 0.00| 0.00      | 0.00            | 0.00  | 0.00    | 0.27       | 0.03       | 0.03       | 0.67 |
| Barren land| 5.94                | 26.80               | 34.95      | 15.79       | 5.74      | 6.46     | 0.85        | 1.44           | 2.75| 2.26      | 0.26             | 18.47 | 25.82   | 15.30      | 5.90       | 168.73    |
| Crop land  | 2.98                | 66.05               | 176.99     | 35.05       | 39.09     | 23.51    | 0.11        | 2.11           | 3.54| 2.69      | 0.29             | 36.85 | 119.94  | 57.68      | 17.81      | 588.86    |
| Dry crop   | 1.94                | 15.00               | 24.39      | 27.05       | 1.30      | 1.50     | 0.28        | 0.75           | 6.05| 0.45      | 0.00             | 9.96  | 19.69   | 11.94      | 1.73       | 122.04    |
| Fallow land| 6.69                | 24.71               | 37.03      | 5.05        | 7.40      | 4.49     | 0.00        | 0.80           | 1.12| 1.37      | 1.02             | 9.55  | 17.12   | 9.23       | 3.57       | 129.16    |
| Harvested land | 1.63           | 25.92               | 107.01     | 14.91       | 24.20     | 12.38    | 0.00        | 0.76           | 0.01| 1.20      | 0.00             | 6.65  | 37.38   | 21.39      | 4.85       | 258.28    |
| Hill       | 0.00                | 0.07                | 0.01       | 0.11        | 0.00      | 0.00     | 0.13        | 0.00           | 0.00| 0.00      | 0.00             | 0.00  | 0.00    | 0.00       | 0.00       | 13.20     |
| Plantation | 0.02                | 1.57                | 2.64       | 1.46        | 0.51      | 0.52     | 0.00        | 0.98           | 0.03| 0.52      | 0.00             | 0.21  | 4.66    | 1.63       | 0.32       | 15.01     |
| Reserved Forest | 0.32           | 0.11                | 0.10       | 0.42        | 0.01      | 0.06     | 0.00        | 0.02           | 69.25| 0.00      | 0.00             | 1.64  | 0.13    | 0.69       | 0.03       | 72.78     |
| Forest     | 0.02                | 4.79                | 2.07       | 0.99        | 0.34      | 0.42     | 0.00        | 0.38           | 0.03| 26.58     | 1.07             | 0.50  | 0.10    | 0.43       | 0.00       | 44.63     |
| River      | 0.00                | 0.17                | 0.00       | 0.00        | 0.00      | 0.00     | 0.00        | 0.00           | 0.00| 0.00      | 0.00             | 0.43  | 5.57    | 0.00       | 0.10       | 10.63     |
| Salt pan   | 0.00                | 5.19                | 38.22      | 17.94       | 18.39     | 4.04     | 4.91        | 0.06           | 4.19| 5.60      | 1.09             | 0.46  | 21.67   | 28.10      | 17.44      | 177.39    |
| Scrub land | 0.32                | 1.48                | 5.92       | 1.26        | 1.34      | 0.57     | 0.00        | 0.43           | 0.13| 0.48      | 0.14             | 0.76  | 44.32   | 22.24      | 0.52       | 59.89     |
| Settlement | 0.56                | 10.29               | 14.17      | 4.92        | 1.87      | 1.62     | 0.00        | 0.91           | 2.65| 1.73      | 0.56             | 6.22  | 26.35   | 10.73      | 10.83      | 93.42     |
| Shrub land | 1.48                | 12.39               | 17.19      | 4.96        | 3.17      | 1.81     | 0.10        | 0.75           | 0.36| 0.39      | 0.00             | 12.53 | 8.67    | 7.45       | 123.39     | 194.63    |
| Tank       | 27.32               | 228.59              | 440.41     | 130.35      | 89.11     | 58.25    | 14.40       | 17.70          | 91.52| 38.84     | 7.18             | 125.44| 341.86  | 158.72     | 179.64     | 1949.32   |

1988 (Area in Km²)
4. Conclusion

Assessment of LULC change of the kosastalaiyar sub basin has clearly brought out the dynamics of changes that has happened from the year 1988 to 2018. The basin was predominantly and agricultural zone with crop land covering 30.21% of the total area in 1988. In 1988 the crop land has decreased to 25.72%, in 2008 it has come down to 25.16% and in 2018 it is at 22.59%. The total decrease in crop land is around 7%. Settlements in the area has increased from 3.07% in 1988 to 17.54% in 2018 clearly and indication of increasing population and shift in occupation from agriculture to other means of living. The area under water bodies have not seen much changes from 1988 to 2018. The area covered by river was 2.29% in 1988 and 1.99% in 2018. The Tank area in 1988 was 9.98% and in 2018 it was 9.22%. Hence decrease in cropland is mostly due to lack of adequate income through agriculture and conversion of agricultural land to settlements. However, availability of ground water for irrigation has to be studied in order see if it has an impact on the decrease in crop land. Barren land has increased from 8.66% in 1988 to 11.73% in 2018. Most parts of the barren land eventually get converted to settlements. The utilization of Remote sensing and GIS as a very useful tool in spatio-temporal analysis has been demonstrated in this study. The ability to map large areas with ease and with good level of accuracy has proved its superiority over conventional mapping techniques. The analysis and findings of this study will help policy planners to implement sustainable practices in Kosasthalaiyar sub basin as it plays a very important role in the Chennai basin as a whole.

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