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EVALUATION OF PARAMBIKULAM ALIYAR BASIN IN TWO DECADES USING GIS AND REMOTE SENSING

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ABSTRACT

Evaluation of any irrigation project involves the assessment of area, improved by the project. In this paper an attempt has been made to find out the change in the land use and land cover of the Parambikulam Aliyar basin in India where Parambikulam Aliyar Project, an interstate project interlinking of 8 reservoirs in 3 sub basins was implemented. In this paper change detection is identified by analyzing the satellite imageries between two decades i.e., 1990 and 2011. Remote sensing, Geographical Information System (GIS) and Global Positioning System (GPS) were used to assess the changes in the land-use pattern and the changes in the agriculture command area due to the implementation of the Parambikulam Aliyar Project. Digital image processing of the Landsat Thematic Mapper image (24th January 1990) and IRS-1C LISS-III image (6th February 2011) and survey of India Toposheets (1972) were used to derive the land-use pattern and classified images were analysed using GIS for detection of changes. The results indicated that agriculture area was increased (8.29%) from 65000ha to 85018ha and forest plantations were increased (2.68%) from 26253ha to 32737ha during 1990-2011. The area under current fallow category reduced (8.62%) from 80778ha to 59960ha in the same period. The area under current fallow is high i.e., 59961ha because the image was taken during non cropping period of Aliyar sub basin of PAP. The reserve forest area was reduced up to 2.76% i.e., from 62868ha to 55194ha. The result shows the improvement in the agriculture area of this basin.

Keywords: satellite imageries, Parambikulam Aliyar basin, change detection, GIS, PAP.

1. INTRODUCTION

Many Indian irrigation systems perform at very low level and number of efforts has been initiated to improve the performance of existing irrigation schemes. The future availability of water for human use depends on how water resources are managed. Especially in water shortage regions, pressures on management of water resources will become more important (Kiyoo Kamiyama et *al*., 1995). In many countries and particularly India, accurate evaluation of irrigation performance and sustainability is hampered by lack of adequate, reliable and timely irrigation statistics (Sakthivadivel *et al.*, 1999). There is a serious lack of reliable and adequate information on the system performance and one of the ordinary characteristics of irrigation projects is that large number of Projects generated revenues in for excess of the largest business Corporate. Improved irrigation management and information decision making, call for adoption of new tools such as satellite remote sensing and Geographic Information System to provide necessary spatial and temporal information on different sub system and different user groups (Thiruvengadacheri, 1996).

Satellite data based monitoring and evaluation of irrigation command areas was initiated by NRSC in 1991-92. Initially baseline inventory of irrigated crop areas and their extent was carried out at distributory group in Bhadra project command area in Karnataka State Bastiaanssen (1998) has listed the performance indicators derived from RS algorithms supplemented by ground data. Raj *et al.* (2002) used Remote sensing data has to compute three indices namely, adequacy (A), equity (EI) and water use efficiency (WUE) for the evaluation of performance of distributaries in the system. Panigrahy *et al.*, (2005) attempted to derive crop indices like Multiple Cropping Index (MCI), Area diversity Index (ADI) and Cultivated Land Utilization Index (CLUI) using satellite derived parameter such as Cropping pattern, Crop rotation and Crop calendar, Crop type, acreage, rotation, Crop distribution. Nikhil raj (2011) carried out Performance evaluation of an Irrigation Project with reference to its irrigation objective using Cost benefit analysis.

Satellite Remote sensing base established itself as an effective and accurate tool for providing essential elements for characterizing the irrigation performance. This method is useful to create time series data as much as 15-20 years for monitoring the changes in time of irrigation systems, benchmarking, identifying low performing pockets, effectiveness and sustainability of cost improvement schemes. System performance monitoring, evaluation and diagnostic analysis are keys to appreciate the improvement or inefficiency in an irrigation project. Irrigated lands baseline inventory in spatial and time domains using spatial information technologies (Satellite Remote Sensing, Digital Image Processing, GIS and GPS) provides an array of performance evaluation matrices to address this issue.

The use of advanced technology tools such as satellite remote sensing, geographic information system (GIS) technique and hydrologic modeling can greatly help to improve irrigation management (Thiruvengadacheri and Sakthivadivel, 1997).

2. STUDY AREA

This study focuses on the Parambikulam Aliyar Project (PAP) is an interstate Water Resources Development Project carried out jointly by Tamilnadu and Kerala in India to harness the water of the Bhrathapuzha, Chalakudi and Periyar basins for irrigation and power production in both states. This Parambikulam Aliyar basin is located in south western part of the Peninsular India and covers area in Kerala and Tamilnadu States. Bharathapuzha is the second largest west flowing river and its drainage is spread over the above two states. The Parambikulam Aliyar river basin has an undulating topography with maximum contour elevation in the plain is 300m. One third of the basin area (822.73sq.km) is covered with hills and dense forest. The total area of PAP basin is 2388.72 sq.km.

This basin is bounded in north and east by Cauvery basin, south and west by Kerala State. This basin area lies (except the ayacut area) within the coordinates of North latitude between 10° 10' 00" to 10°57'20" and East longitudes 76°43'00" to 77° 12' 30" (Figure-1). This PAP sub basin comprises of following four sub basins namely Sholayar (403 sq.km), Palar (534 sq km), Aliyar (575 sq km) and Valayar (877 sq.km). This project is planned originally to irrigate 1, 00, 230ha during one season (135 days) each year, the service area was increased by nearly 71% to 1, 71, 050ha without increasing available water resources PAP includes eight reservoirs (Upper Nirar weir, Lower Nirar dam, Sholayardam, Parambikulam dam, Thunakadavu dam, Peruvaripallam dam, Aliyar dam and Thirumurthy dam). Among this first 6 dams are located in the higher altitudes of the Anamalai hill ranges, and the last 2 dams are located in the plains. The irrigation canals take off and utilize the storages behind these dams to serve the command area.

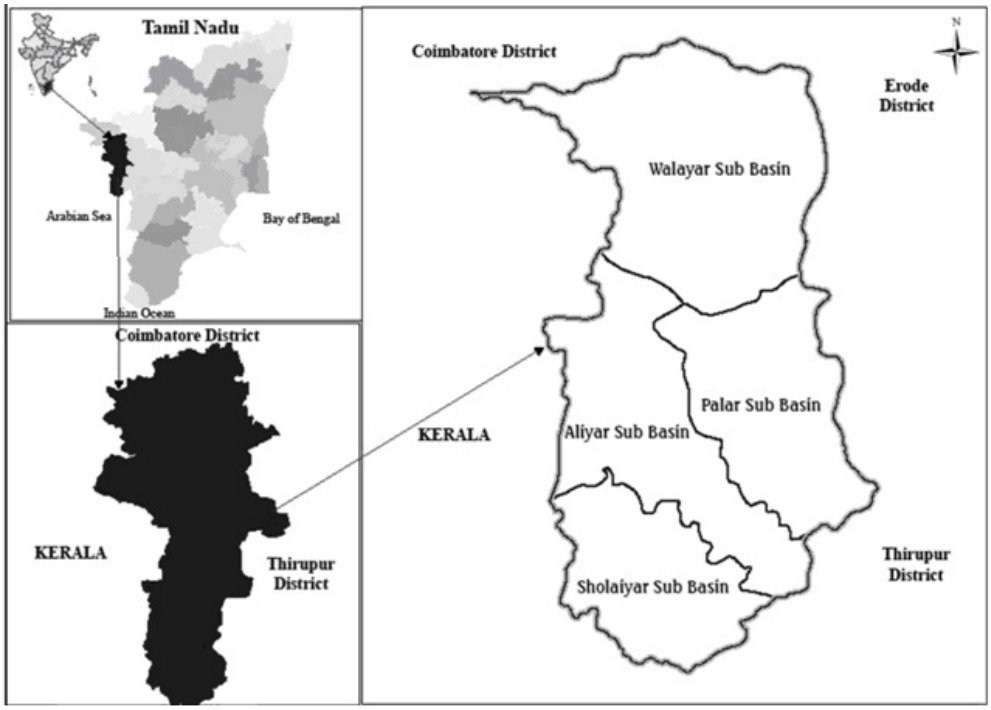

Figure-1. Location map of study area.

3. METHODOLOGY

Survey of India topo sheet for the year 1972 (58 A11 and12, A15 and 16, 58B9 to 15 and 58 E3 and 4, E7 and 8 and 58F1 to 4) in 1:50, 000 scale was used as base maps and multi spectral remote-sensing data Landsat Thematic Mapper (TM) for the year 1990 (24th January) with 30m resolution and Indian Remote Sensing (Figure-2) methodology flow chart (IRS), satellite Linear Imaging Self Scanning Sensor (LISS) III data with 23.5 m resolution for the year 2011 (6th February) were used for the assessment of land use pattern of the study are during the last forty years, The methodology used for the study is presented in the Figure-3. Overall Methodology is based on the combination of various image processing techniques and GIS analysis. Raster analysis was done using Erdas imagine 10 and Vector analysis were done using Arc GIS 10.

3.1. Image processing and classification

Survey of India toposheets were rectified using the latitude and longitudinal values of the four corners. According to the study area boundary it was subsetted and mosaiced further for single study area image. Preprocessing is important step to improve the quality of the data with appropriate enhancements filter techniques. Raw digital images are a representation of the irregular

surface of the earth and contain geometric distortions are so significant that they cannot used as maps. (Lillesand and Kiefer, 1999). Satellite images (FCC) for the year 1990 and 2011 were geometrically corrected using the rectified toposheets by assigning ground control points (GCP's). Geographic WGS 84 and datum WGS84 projection system was used. After the geometric correction the FCC was subjected to several image enhancement techniques for the better interpretation of the data.

For the identification of the land use pattern of the study visual interpretation techniques were followed for the image classification based on the interpretation keys. Base maps, land use maps for the year 1990 and 2011 were prepared. For the area calculation it was further projected as UTM projection. For the Impact assessment of changes in land use pattern overlay analysis method was followed.

3.2. Ground truth collection using GPS

Ground truth verification was carried out using handheld Global Positing System (GPS) after the preparation of landuse map for the year 2011 for the doubtful areas. The GPS readings were directly imported to Arc Pad software and updated in the land use map of 2011.

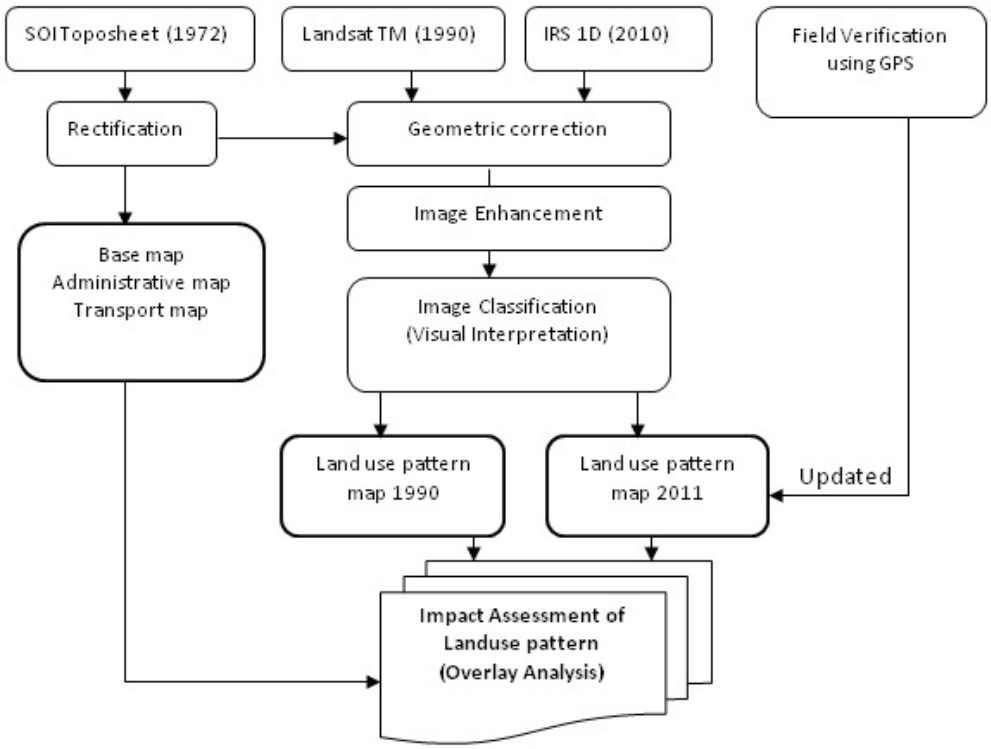

Figure-2. Methodology flow chart.

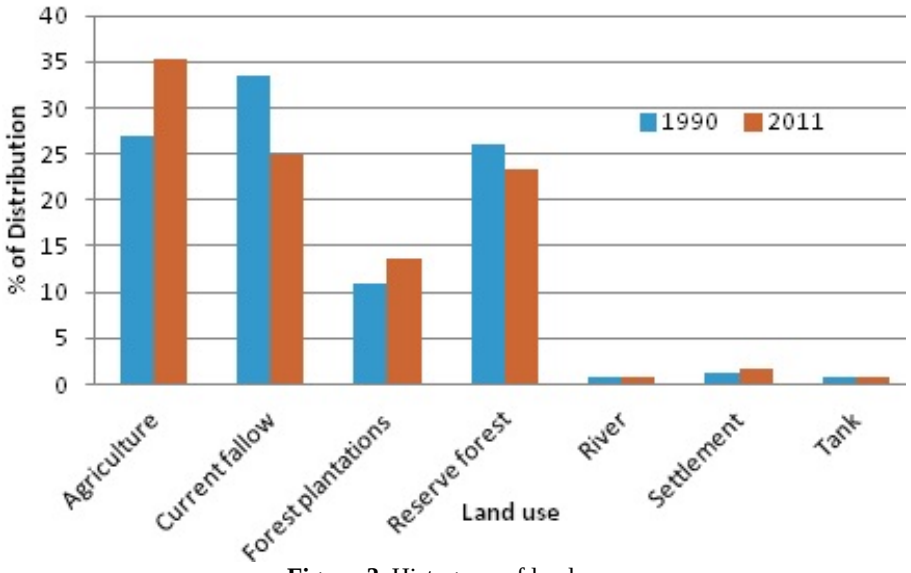

Figure-3. Histogram of land use.

4. RESULTS

The spatial distribution of land use was assessed geographically and their areal extents of land use changes in the study area during 1990-2010 are shown in Table-1. The agriculture area and forest plantations of Parambikulam Aliyar Basin were increased by 8.29% (20018 ha) and 2.68% (6484ha) during the period of 1990-2011 respectively. Current fallow and Reserve Forest area were decreased by 8.62% (20817ha) and 2.76% (6674ha) in the same period. The river area and tank area were remain mostly unchanged whereas the settlement was increased to 0.42% (1007ha) during this period. Histogram showing the pattern of Land use is given in Figure-3. Matrix of change detection analysis is given in Table-2.

Parambikulam Aliyar basin agriculture area has been increased (8.29%) in 2011 (Figure-5) from 64999.84ha to 85018.12ha due to conversion of current fallow land of (Figure-6) (41265ha) to agriculture and conversion of Tank area of 15.47ha into agriculture. In the Reserve Forest area (Figure-5) 7359.93ha, was converted into Forest plantation. This shows the increase in the settlement in that area. This was conformed because the settlement area of 2786.22ha in 1990 (Figure-4) was increased to 3793.37ha in 2011 (Figure-5) due to change of agriculture land of 250.23ha, Current fallow of 565.57ha, and Forest plantation of 190.91ha to settlement. Tank area was slightly reduced in the period 1990-2010. This may due to siltation and encroachment in the tank area. From the results it is clear that current fallow was reduced from 80778.45ha to 59961ha in this period.

Table-1. Areal extent of different classes in Parambikulam Aliyar project.

Land classification	**Extend of land use in ha**		**% of Land use**		**Change** (%)
	1990	**2011**	**1990**	**2011**	
Agriculture	65000	85018	26.91	35.2	8.29
Current fallow	80778	59961	33.45	24.83	-8.62
Forest plantations	26253	32737	10.87	13.56	2.68
Reserve forest	62867	56194	26.03	23.27	-2.76
River	1685	1685	0.7	0.7	0
Settlement	2786	3793	1.15	1.57	0.42
Tank	2132	2114	0.88	0.88	-0.01
Total	241501	241501	100	100	0

Table-2. Land use change detection matrix -1990-2010.

	Area in January 1990	Area in February 2011						
		Agriculture	Current fallow	Forest plantations	Reserve forest	River	Settlement	Tank
Agriculture	65000	43737.65	21011.96	0	0	0	250.23	0
Current fallow	80778	41265	38947.22	0.65	0	0	565.57	0
Forest plantations	26253	0	0	25375.67	686.18	0	190.91	0
Reserve forest	62867	0	0	7359.96	55507.54	0	0	0
River	1685	0	0	0	0	1684.6	0	0
Settlement	2786	0	0	0	0	0	2786.27	0
Tank	2132	15.47	1.39	0.72	0	0	0.39	2114
	241501	85018	59961	32737	56194	1685	3793	2114

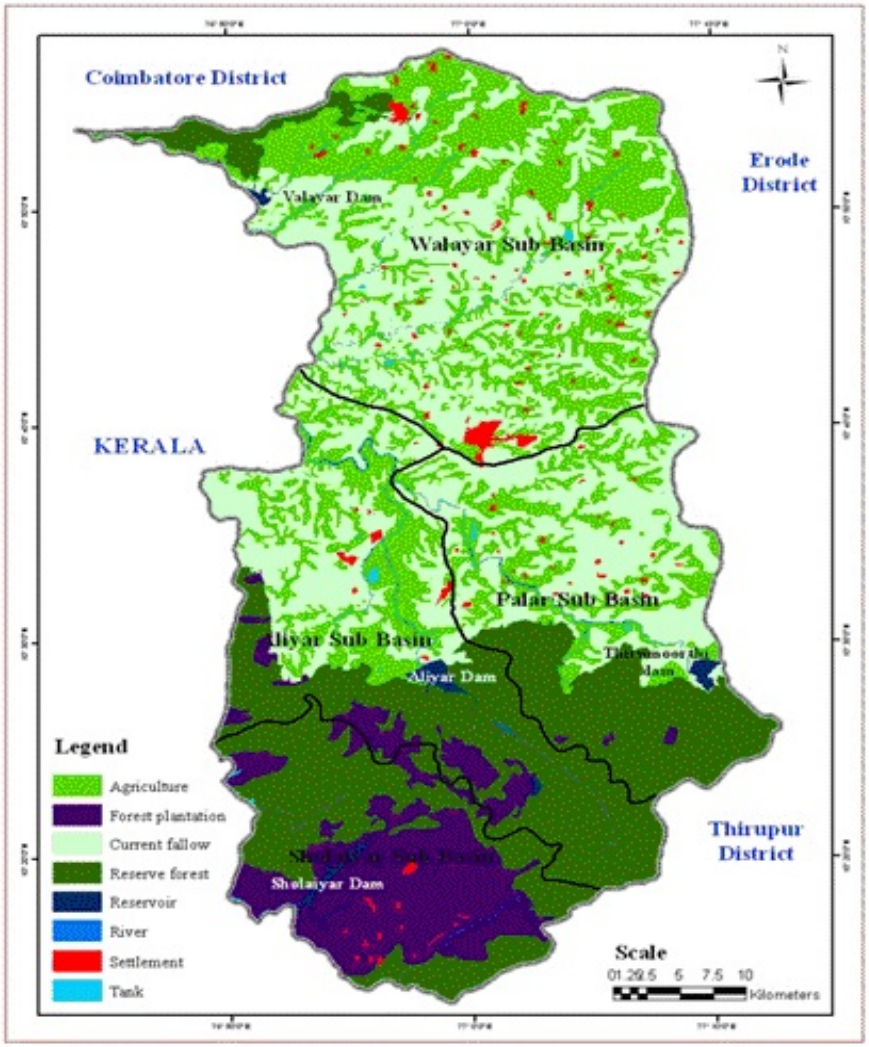

Figure-4. Land use map of Parambikulam Aliyar basin in 1990.

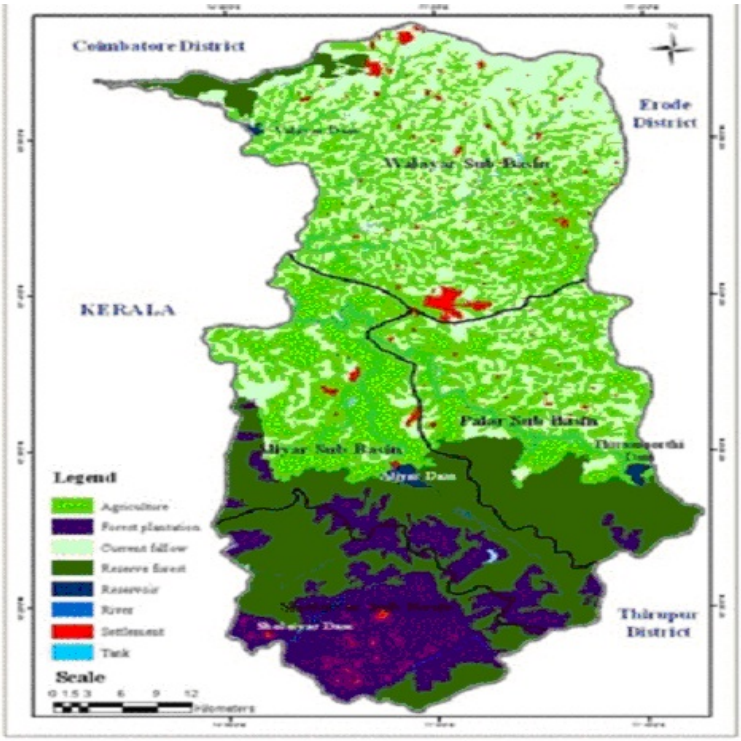

Figure-5. Land use map of Parambikulam Aliyar basin in February 2011.

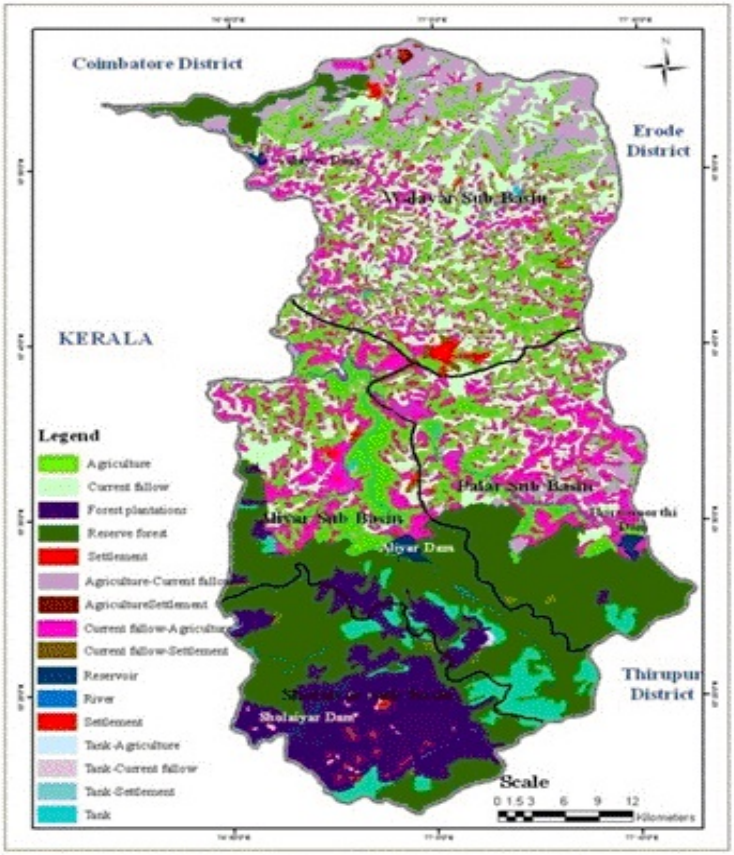

Figure-6. Change detection of Parambikulam Aliyar sub basin in 1999-2011.

5. DISCUSSION AND CONCLUSIONS

The visual interpretation and on screen digitization of land use classes extracted the information from the satellite data and free from classification errors which can occur in supervised classification. The effective implementation of visual interpretation procedure, however, relies heavily on operator's skill in photo interpretation and knowledge of the study area, in conjugation with other ancillary data (Ai Tahir and Saeed, 2003). But the use of Global positioning systems (GPS) have greatly aided the spatial accuracy of ground-truthing and field verification, in most cases removing the need to use surveying techniques completely and can give real time locations accurate to less than a meter and with post processing to within a few millimetres. Overlaying analysis is used to intersect both the maps and find out the extent of conversion. Overlay produces a thematic map comprising thematically comparable homogeneous units and expanded attribute table.

Parambikulam Aliyar Project contemplates diversion of the surface water from Anaimalai hills of the Western ghat to irrigate the dry command areas of Coimbatore and Erode Districts. This Project is successfully accomplished the diversion and integration of eight west flowing rivers for the benefit of drought prone areas in Coimbatore and Erode Districts in Tamilnadu State. Through this project initially the water was supplied to entire command area. After that due to increase in the command area the water for irrigation is restricted to the 50% of the command area under Aliyar dam in one year followed by 50% in the next year whereas in Palar system i.e., from Thirumoorthy dam 25% of the command area is being irrigated in one year. In Aliyar basin most of the area was planted with perennial crops like Coconut, Sugarcane along with Coco, Vanilla etc. In the balance area crops like maize, paddy, groundnut, turmeric were planted. Even though the supply of water is restricted to 50% of the area in Aliyar and 25% of the area in Palar, this study shows that there is an increase in the area of Agriculture during last 20 years. This was confirmed because in the study of Land use and Land Cover for three decades by Renuka Devi and Santhosh Baboo (2012) result shows that the crop land of Coimbatore District was increased by 27.55% during 1990-2010. This shows that the groundwater utilisation is increased in this area. As per the status of ground water development statement in 2003 (Micro level study in PAP Basin) 10 blocks in this sub basin, 6 blocks are in over exploited condition, two blocks are in critical condition and 2 are in semi critical condition. Even though the increase in the agriculture command area is a good sign of improvement, but the exploitation of groundwater for agriculture cannot be accepted. Because improper management of surface water and groundwater for agriculture activities leads the depletion of groundwater level in many parts of the Coimbatore area now facing the critical water scarcity. (Renuka Devi, Santhosh Baboo, 2012). Hence suitable cropping pattern may be evaluated with the consultation of farmers and implemented through Agriculture Department. Artificial recharge structures can be constructed to augment the groundwater position of this basin. The area of current fallow is increased up to 8.62% and this was due to deficit of water. The increase in the area of Forest Plantations shows the destruction of Reserve Forest area. There is a need to protect the Reserve forest. This can be achieved by regular monitoring the area using the modern tools like GIS and remote sensing.

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