# SPATIO TEMPORAL DYNAMICS OF URBAN GROWTH ON THE CAUVERY RIVER LAND USE LAND COVER USING GEOSPATIAL TECHNIQUES.

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## Abstract

Rivers in India play an important role in India's economy as India is an agriculture dominated country and nearly 70% population of India depends directly or indirectly on river for their livelihood. Agriculture is a dominant sector in Tamil Nadu Cauvery basin. The study reveals that currently, Cauvery river is facing serious anthropogenic pressures from agricultural expansion, expansion of village settlements, sand mining, tourism, etc. This study attempts to assess the Spatio Temporal Dynamics of Urban Growth on the Cauvery River, Tamilnadu Using Geospatial Techniques. Methods/Analysis: Urban growth has brought serious losses of agricultural land and water bodies. Based on the observations documented during the GIS analysis and also interpretation of the secondary data, the following management plan has been drawn for the conservation both the side of Cauvery River. The spectral radiance was estimated using OLI bands 10. Through the results of NDBI and NDWI we can conclude that temperature was higher in settlement area. Emissivity was derived with the help of NDVI threshold technique for which OLI bands 4 and 5 were used. LULC change information was grouped into the time periods (2009–2019). Land use/cover changes was accomplished by using two satellite images, and classifying them via supervised classification algorithm and finally applying post-classification change detection technique in GIS. Applications/Improvements: This study, therefore, will contribute to the current understanding of urban growth development in Cauvery River from a temporal and spatial point of view. Findings will be able to assist planners, stakeholders, and policy makers in appreciating the dynamism of urban growth and therefore will facilitate better planning for the future to minimize environmental impacts

**Index Terms**: Cauvery River Basin, GIS, Urban Growth, LULC.

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## INTRODUCTION

Today the cities of developed and developing countries are experiencing a rapid change. They are growing in area , population and at the same time they are acquiring a new character as their people perform new tasks in the physical environment , that increas- ingly reflect the use of new technology (Allefsen 1962). In India, currently 27.78% of the population (Census of India, 2001) lives in urban centers, while in the next 15 years it is projected to be around 33%. This indicates the alarming rate of urbanization and the extent of urban growth that could take place. One of the important features of urbanization in India is dualism—urban growth at macro level is decelerating but in class I cities it is growing. An analysis of the distribution of urban population across size categories reveals that the process of urbanization in India has been large city oriented (Kundu 2006). There is massive increase in the percentage share of urban population in Class I cities (i. e., cities with a population of 1, 00, 000 or more) from 26.0 in 1901 to 68.7 in 2001. As a result of this million plus cities of India are expanding at a very rapid rate. The historic city limits thus get expanded to engulf adjoining areas. The direction and rate of growth of such sprawl depends.

Upon factors such as, the quality of land, accessibility, industrial development, and so on (Pathan et al. 1993). The extent of urbanization or its growth is one such phenomenon that drives the changes in land use pattern. These changes in the city margins or urban sprawl are characterized by haphazard patchwork of development, which leads to a disorganized develop- ment in any city. At the same time these mega cities are subject to extreme filthy slum and denying shelter, drinking water, electricity, sanitation to the poor and rural migrants (Kundu et al. 1999).

So for a proper development of city, it is necessary to monitor and plan the growth of a city. Geographers, planners and people from other disci- pline also took a keen interest in the study of this type of phenomena. The conventional surveying and mapping techniques are expensive, and time con- suming for the estimation of urban growth. Statisti- cal techniques along with remote sensing and GIS have been used in many urban growth studies (Sudhira et al. 2004 and Jat et al. 2008).

In recent years it has been found that remote sensing is a cost effective, technologically sound and an increasingly used technique for the analysis of urban growth (Yeh and Li 2001). As a result, increased research interest is being directed to the mapping and monitoring of urban growth using remote sensing and GIS techniques (Epstein et al. 2002). By using the satellite data it is easy to identify the temporal and spatial changes which have occurred over the city landscape. There are several change detection methods using overhead imagery. Some of them are frequently used by scholars such as Change Vector analysis, Decision trees, IHS transform, Image differencing, Image ratioing, Image regres- sion, Kauth-Thomas image differencing, learning vector Quantization, Post classification comparison, Spectral-temporal classification (Hardin et al. 2007). Some of the popular one's are, Image overlay—a simple method to visually identify the location and extent of change, spectral temporal classification— uses a composite image created by adding or stacking the bands from multiple dates of imagery together to form a single image composite and Post-classification comparison is currently the most popular method of urban change detection (Li and Yeh 1998; Sunar 1998; Madhavan et al. 2001; Chen and Chen et al. 2003; Mundia and Aniya 2005; Yu and Ng 2006). In post-classification comparison, each date of rectified imagery is independently classified to fit a common land type schema. Following classification, the resulting land cover maps are overlaid and compared on a pixel-by-pixel basis. Even most of the scholars from India in their studies have used classification & post classification comparison to study the land use land cover changes and to monitor the urban sprawl.

**Role of Geoinformatics**

Geoinformatics is the spatial hub of the IT industry. Town and regional planning and environmental and biodiversity management are increasingly becoming reliant on Spatial Information Systems together with the use of air- and space-borne observation platforms. Huge amounts of data are being collected which needs to be analysed. The derived results from such analyses need to be disseminated in user friendly formats that are regularly updated. The Internet has become the de facto instrument for disseminating information to broader audiences. With technological advances comes the need for training in the use and development of such systems. It is this milieu that the intended MSc and PhD programme in Geo-Informatics wishes to address.

**Need for Information on Land Use**

Land use has been a central consideration of the town and country planning system in the UK for over 50 years. Official policy statements and guidance and best practice documents provide a framework for local planning authorities in determining issues of balance and priority on land use matters under Town and Country Planning legislation. However, despite the importance of and long-established nature of the land use planning process, it is widely acknowledged that the available information on land use is incomplete and does not add up to the national information base that is required.

The United Kingdom is a highly urbanized and densely populated country in which pressures on land are extreme. Reliable and up-to-date geo-referenced information on land use is required to provide a basis for the sustainable development of land resources in both urban and rural contexts and to inform the development of policies across all areas of human activity at national, regional and local levels, including planning and regeneration, housing, employment, transport, agriculture, environment and recreation. Within government the need for information on land use is evident through published policy documents and through the large number of surveys sponsored by government and other bodies to collect such information since the mid 1970s.

The Land Use Change Statistics (LUCS) classification was developed by DOE in the early 1980s (Selwood, 1987) and although influenced by the NLUC it is a significantly modified and simplified classification by comparison. The classification was designed for recording land use change by Ordnance Survey (OS) field surveyors during the course of map revision. It is a hybrid classification that uses both land use and land cover categories. Since 1985 the LUCS classification has provided the basis for recording land use and land cover change derived from OS mapping and is used in the preparation of annual statistics by ODPM (ODPM, 2004).

**Development of a Standard Land Use Classification**

Within government use of different land use classifications results in an uncoordinated approach and the collection of incompatible data. A standard and consistent approach to land use classification at the national level will improve the quality of data collected and promote a framework for a harmonised approach leading to the development of a nationally complete and consistent land use.

**Objectives:**

The report has been prepared after studying, comparing thematic data sets in a geographic information system (GIS) environment; assessment and quantification of landscape change; and identification of critical areas for conservation and developing suitable action plan for such areas in the Cauvery river basin. Specific livelihood in concerns of the local people and their dependence on the river has been documented in developing suitable action plans with participatory approach in the area of study. Overall objective of this study was to improve the understanding of ecological relationships between potential threats, habitat vulnerability, and water quality of the study area and also developing the strategies for conservation and sustainable management of the Cauvery river and its buffer zone. The Key objectives of the study are:

1. Assessment of the current status of the Cauvery River (including 30 km buffer on both side of river basin) in Karnataka in terms of current land-use and land-cover practices, water quality, current management and vulnerability. The ecology and biodiversity of Cauvery River and 30 km buffer zone and the encroachment on Cauvery river bed assessed based on the secondary authenticated data from the consent Authorities.

2. Identification of areas with unique ecological features those are suitable for biodiversity conservation, wetlands development and important eco-sensitive zones.

3. Recommend action plan for preservation and conservation of Cauvery river basin (30 Km buffer on both sides of the river) arising out of the objectives 1 and 2

**Aim and Objectives**

• To study the main aim of the project in Cauvery River 30 km Buffer zone of land use and land cover classification of Cauvery River. The specific objectives are:

• To establish for naming and defining groups of land use and land cover features and

• To provide basis for identifying, recording and reporting land use and land cover.

**Literature Review**

Rivers are the most important freshwater resource for man. Over the years, the River Cauvery has been subjected to human interference regularly and water quality is getting deteriorated profoundly. Major anthropogenic activities practiced in and around the stretch: agriculture, abstraction of water for irrigation and drinking, washing cloths and utensils, discharging of sewage waste, sand dredging, boating, fishing, open defecation and religious ritual activities, along the stretch are generating serious threat to the biota of the river by altering the physicochemical and biological concentration of the river system.

**Geographical Information System (GIS):**

Civilization started along the course of the rivers, since the resources along the river was abundant for the survival of human beings. Now a situation is come were these natural abundant resources are getting depleted due to over exploitation. The influence of human intervention along the river banks over the years has to be monitored and studied in order to know the change in the river dynamics and the associated parameters like the land use pattern. Recent approach towards the use of satellite imageries and GIS techniques has advantage over the conventional methods for the change study of land use land cover. The following literature study is to know the decadal changes in land use and land cover pattern along the river course using satellite imagery and GIS techniques.

Rubina Parveen et al. (2017) had demonstrated the capabilities of the Remote Sensing and powerful tool ArcGIS in mapping and monitoring the land use changes. The author has discussed the challenges of interpreting qualitative satellite imagery. In this study IRS 1C LISS III data has been used to classify the land cover. The spectral response of the satellite sensor was the main element of this study. The key elements for visual interpretation of the satellite image have been discussed. Based on this the characteristics of each land use has been tabulated. The author has concluded the study, that the spectral responses can be identified based on the interpretations of the satellite imagery and has also claimed that IRS 1C LISS III is best suited for Land Use / Land Cover classification. The key element extracted from this study is the basics of remote sensing, the characteristics of each land use class and also the change detection.

Vani Timmapuram et al. (2016) had demonstrated in their study that Landuse categories can be mapped by visual interpretation techniques on ArcGIS platform. The distribution of the landuse classes in percentage areas for multiple dates has been showcased in this study. The statistics of the percentage change in the landuse areas has been tabulated.

The author has made an attempt to show the influence of LULC change on environmental changes. The author has concluded their study by stating that GIS and Remote sensing technologies can be used for management of natural resources and scientific planning. The statistical percentage change in the areas for different years is the key point derived from this paper for our study.

Kefyalew Sahle Kibret et al. (2015) had demonstrated the change in land use and land cover pattern for South Central Ethiopia region for four decadal changes. The author has used satellite temporal data for the satellite image classification and later study the dynamics of land use changes using GIS overlay techniques and comparison of post classified data. The challenges faced during the analysis was that seasonal data was analyzed and in which there was misclassification of the classes, for example most of the agricultural land was misclassified as grass or trees outside forest, since the image was taken during the vegetation period and when compared to the later seasons the scenario of classification was again different. Hence in such cases visual interpretation overrides the other classification types. The study was concluded that the use of multi-temporal satellite images combined with integrated visual interpretation and image classification led to improved overall accuracy compared to the conventional single imagery approach. Ancillary data has been used in this study to serve the same. The keys points drawn from this paper for our study change detection in land use pattern using high resolution data, field observations and Google Earth images can be in a way used to derive detailed land use information.

Rawat and Manish Kumar (2014) had demonstrated the use of multi temporal satellite imagery for change detection. In this study they have used Landsat TM images. Supervised classification was the method adopted for land use classification. The author has discussed the importance of the change detection of land dynamics over the years. In this paper the importance of Remote Sensing and GIS technologies over the conventional methods for change detection study has been highlighted. The key element drawn from this paper for our study is the change detection methodology for different land use classes.

Muhammad Farooq Iqbal and Iftikhar Ahmad Khan (2014) had demonstrated the Landuse Land cover change analysis and erosion risk mapping for Jammu and Kashmir region. Here supervised classification of the satellite imagery was carried out for LULC classification. Post classification, overlay analysis technique was adopted for the years from 1998-2009. The change detection for the mentioned years were done by overlaying the classified images and find out the percentage change in each land use category. The author has discussed the impact of population increase on the land use changes. The key point derived from this paper is the overlay analysis technique for change detection analysis for the temporal spatial data.

Gerhard Kemper et al. (2004) had demonstrated the different Remote Sensing and GIS techniques for land use change detection. In this study, the reference satellite imagery for the years 1945, 1969, 1988 and 2000 were considered. The satellite imagery was digitized and interpreted manually on screen for the classification of different land use classes. Likewise for all reference decadal satellite imagery the digitization was carried out. Change detection is carried out by down dating the land use classes of the different date imageries. The change in the area is detected by overlaying the different .shp layers of different years. Along with these data the author has referred to ancillary data like topo sheets, DTM, administrative borders, geological maps and so on, to achieve accuracy for the classified data. The key element taken from this paper is the use of ancillary data for the change detection of the land use land cover for temporal data.methodology is more feasible to estimate NDVI and surface emissivity [7].

Single –Window algorithm for estimating LST was adjusted for

Landsat 8 data for better accuracy. The basic inputs for SW algorithm were brightness temperature and Land Surface Emissivity (LSE). The study was conducted in the northern Negev Desert, Israel [8]. Sobrino and Mao methods were used individually for retrieving LST with MODIS data in Hebei and Shanxi, North China Plain. The maximum, minimum and mean of Sobrino and Mao LST methods were cross checked with the standard LST values and found that Sobrino output range greater while Mao method had less value than standard LST. Hence, a combined method of Sobrino and Mao was evolved as Sobmao method. It is as accurate as Sobrino and simple to use [9]. Along-Track Scanning Radiometer-2 (ATSR-2) data was processed in MODTRAN 3.5 simulations. Split-Window, dual-angle and mixed structures algorithms were used to generate LST and Sea Surface Temperature (SST) in a part of New South Wales.

Thus many researchers had estimated LST using satellite image. A number of algorithms were developed and adopted by them to estimate LST. Some of the frequently used algorithms are Split-Window (SW), Sobrino, Mao, Dual-Angle, and Sobmao. Most of the studies were done for urban areas and arid and semi-arid regions and in many of the studies, single thermal band was used. In the present study LST was estimated for the entire district using two TIR bands and four OLI bands.

The major objectives of the study are to find the brightness temperature using band 10 and band 11 of TIR, calculate the LSE using NDVI threshold technique and estimate the LST of Dindigul district using Split-Window (SW) algorithm.

## Study Area

In Tamil Nadu, the Cauvery continues to flow eastwards and forms a boundary between Erode and Salem districts. The river takes a southernly course at Hogennekkal falls and enters the Mettur Reservoir which was constructed in the 1934. On the right bank, about 45 km below the Mettur reservoir, the river Bhavani joins the Cauvery and from here it takes an easternly course to enter the plains of Tamil Nadu, where it is joined on the right bank by two more tributaries, the Noyil and the Amaravathi and thereafter enters Tiruchirapalli district. Immediately after crossing the Tiruchirapalli district, the river splits into two branches, the Northern branch is being called as 'The Coleron' and Southern branch remains as Cauvery, form here the Cauvery delta begins. These two rivers rejoins again at 16 Km below near Srirangam and thus form 'Srirangam Island''. On the Cauvery branch a Grand Anicut has been constructed and it is said that the Anicut has been constructed by a Chola King in 1st Century A.D. Below the Grand Anicut, the Cauvery branch splits into two, the Cauvery and the Vennar. These branches in-turn divide and subdivide into innumerable smaller branches and spread across the Delta region by forming a network before it outfalls to Bay of Bengal.

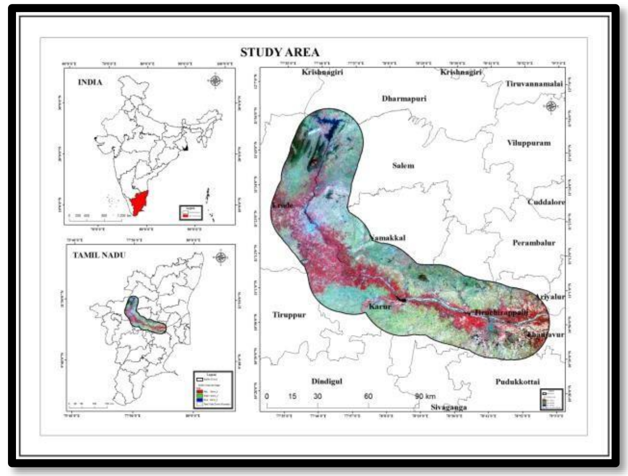



**Fig.1 Location map of the study area**

The major part of the basin is covered with agricultural land accounting for 66.21% of the total area; while waterbodies cover 4.09% of the basin area and 20.50 % of the basin is covered by forest area. There are 132 watersheds, the Cauvery upper sub-basin comprises of 18 watersheds, Middle sub-basin comprises of 86 watersheds and Lower sub-basin comprises of 28 watersheds and the maximum number of watershed are falling in the Cauvery middle-basin.

The average annual surface water potential of the basin has been estimated to be 21.4 km3 and presently 18.0 km3 surface water is being used in the basin. The states of Tamil Nadu and Karnataka depend upon Cauvery for irrigation, drinking and industrial needs. There are about 29 major and medium irrigation projects in Karnataka and 25 major and medium irrigation projects in Tamil Nadu.

The dependable yield for the basin is utilized under number of major, medium and minor irrigation projects of the basin and irrigation is being carried out in the area under these projects viz., dams,barrages,diversion structures and other lift irrigation systems. In addition to providing many ancient and modern canals with water from the River for irrigation purposes, the river Cauvery also serves as the main drinking water source for many towns and villages and the cities.

Some of the main industries in the basin are Paper mills, Sugar mills, Chemical industries, and Cotton mills. Mining activities in the basin includes building stone mining for construction and road works.

The basin is distinguished with unique forests and with some of distinct fauna and flora and home to many sanctuaries and National Parks and also, the river system is very rich in fish biodiversity.

The rocks predominantly found throughout the basin are metamorphic and igneous. Southern part of the basin is characterized by laterised and ferruginous sandstone. Certain coastal areas also have conglomeratic sandstone, coralline limestone and shale. Around 38,000 sq.km of the area in the basin is covered by hard rock and around 11,000 sq.km by sedimentaries comprising mainly the delta portion.

In the Cauvery basin, four distinct seasons occurs i.e. Winter, Summer, South-West monsoon, and North-East monsoon. The basin is mainly influenced by South-West monsoon in

Karnataka and Kerala, and North-East monsoon in Tamil Nadu. In the Cauvery basin the average rainfall in Karnataka is between 600 mm to 800 mm resulting in semi-arid condition; in Tamil Nadu the average rainfall is low ranging from 500 mm to 1000 mm and is semi-arid and normal annual rainfall in Kerala region is about 2400 mm. Rainfall in the delta area is of the order of 1000 mm annually.

Soil types vary across the basin. The principal soil types found in the basin are black soil, red soil, laterites, alluvial soil, forest soil, and mixed soil. Red soil predominantly occupies large areas followed by black soil in the basin. Alluvial soil is found in the delta areas and is the most fertile region in the basin. The cultivable area of the basin is about 58, 000 Km2 which is about 3% of the cultivable area of the country. The land under cultivation is 48% out of which 24% of cultivable area is under irrigation. There are mainly three crop seasons in the basin viz. kharif, rabi and summer. The kharif crops are paddy, bajra, jowar, maize, ragi, cotton, millets, etc. Paddy is the most important crop in this basin, whereas Ragi, Jawar and other millets constitute the important crops under rainfed conditions. Coconut, betel leaves, pepper, oranges and lemon are grown as horticulture crops throughout the year. The main forest products are sandalwood, bamboo, teak, eucalyptus, blue gum, wattle etc. The Cauvery delta region is known as the ‘Rice Bowl of South India’ or the ‘Food basket of Tamil Nadu’ providing 40% of agricultural production of Tamil Nadu.

The river flows about 800 km before out falling into the Bay of Bengal of which 320 km is in Karnataka, 416 km in Tamil Nadu and 64 km in the common boundaries between Karnataka and Tamil Nadu. The Cauvery river system consists of 21 principal tributaries out of these 9 are located in Karnataka and 12 in Tamil Nadu.

The important tributaries joining the River Cauvery from the left bank are the Harangi, the Hemavathi, the Shimsha and the Arkavathi; whereas the Lakshmanthirta, the Kabini, the Suvarnavathi join from right bank in Karnataka. Further, down the river enters Tamil Nadu a tributary Bhavani joins Cauvery on the right bank about 45 kms below Mettur Reservoir. Thereafter it takes Easternly course to enter the plains of Tamil Nadu and further two more tributaries Noyil and the Amaravathi joins Cauvery from the right bank and here the river widens with sandy bed and flows as ‘’Akhanda Cauvery”.

Immediately after crossing Tiruchirapalli district, the river divides into two parts, the northern branch being called ‘’The Coleron” and Southern branch remains as Cauvery Delta begins. After flowing for about 16 kms, the two branches join again to form ‘’Srirangam Island’’. On the Cauvery branch lies the ‘’Grand Anicut’’ below the Grand Anicut the Cauvery branch splits into two, Cauvery and Vennar. These branches divide and subdivide into small branches and form a network all over the delta.

Research Rationale and Need:

A preliminary review of the available literature on Cauvery basin indicates certain areas of concern such as change in land use and land cover adversely affecting the ecology of the riverine system, presence of pollutants, deforestation etc. One of the major basin-specific features that may be adversely affecting Cauvery basin ecology is the expansion of coffee, tea and, to a limited extent, cardamom plantations. The high elevation in the upstream parts of Cauvery creates ideal conditions for these cultures. These developments, due to the removal of riparian forests, have lead to denudation. In addition, the associated population growth has resulted in abstraction of water from first and second order streams for domestic use, while the increased waste loads might be damaging the endemic fauna (IWMI, 2007).

The chemical content, particularly in the downstream, reveals substantial presence of pollutants due to movement of fertilizers, agricultural ashes, industrial effluents and other anthropogenic wastes. A number of recent studies have reported habitat fragmentation due to various anthropogenic activities viz, construction of dams for hydropower, extension of agricultural fields into forest areas, and urbanization (Vasudevan et al., 2001; Gururaja et al., 2003; Aggarwal, 2004). Anthropological pressures leading to decimation of habitat, blocking of corridors have created isolated populations among elephants in southern India including Cauvery belt. These isolated or meta-populations have restricted interaction with other population thereby, reducing the gene pool- which becomes a serious draw back for the sustenance of the species.

Tributaries and landscapes within the watersheds of Cauvery river, the 30 km buffer zone on both the sides have undergone tremendous alteration in the past, which has resulted in the loss of natural wetland vegetation and hydrologic characteristics of the landscape that are unique to wetlands. In this context, a need was felt to understand the current status of the Cauvery river on the either side of the Cauvery river in Salem mettur dam to kallanai (30 km buffer) for the sustainable management of Cauvery water in the catchment area, its biodiversity (including terrestrial and aquatic flora and fauna) and conservation of wetlands. This could improve the decision-making processes for future land use planning in the Cauvery River and surrounding 30 km buffer zone and also strengthen the carrying capacity of the area by adding more protection and by reducing the negative impacts of manmade interventions (industrial, agricultural, unplanned development, etc.).

**Geomorphology**

The geomorphologic features identified from the study area are plateau region, shield of ridges, relict hills, low lying flats /plains, structural plains, plantation surfaces etc.,

Most part of the study area is covered by the plateau region which has been formed at the end of cretaceous period in between 67 to 65 million years ago. Northern part of the study area is mainly occupied by this plateau region and it is formed due to the volcanic activity that lasted many thousands of years.

There is a shield of ridges/ hills which covers the north, north eastern and southern boundary of the study area. These shields of ridges are of several types and it forms as a continuous chain of elevated crest from some distances.

Relict structures or minerals were formed due to parent rock that did not undergo metamorphosis when the surrounding rock did, or to rock that survived a destructive geologic process. These distinguished features are found in north eastern part of the study area. Some of the other geomorphic features like slope facets, colluvial foot slopes are sparsely found in the basin.

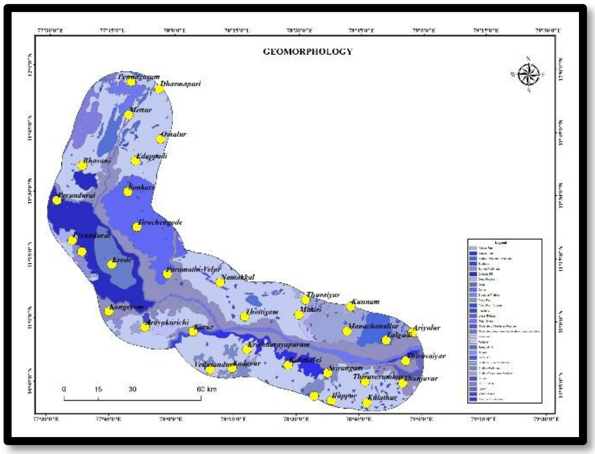



Fig:2 Geomorphology Setting of Study Area

**Geology**

The Khondalite and Charnockite groups of rocks and their reworked equivalents occupy large tracts of the Cauvery basin Most part of the basin is covered by the Charnockite groups of rocks, which belongs to Archaean era, and Anorthosite type of rocks belonging to Charnockite groups are bounded by the eastern and southern part of study area. Northern part of the study area is almost covered by granite which belongs to Late Archaen – Early Proterozoic age.

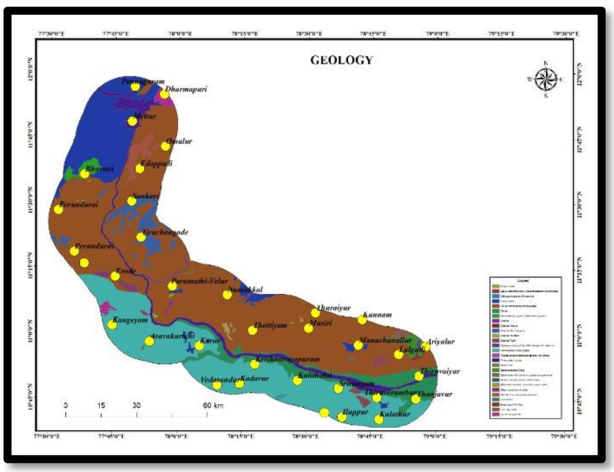



Fig:2 Geological Setting of Study Area

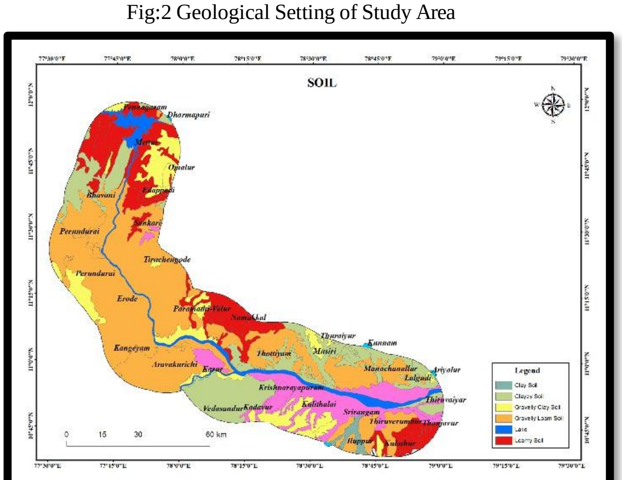



Fig:3 Soil distributions in of Study Area

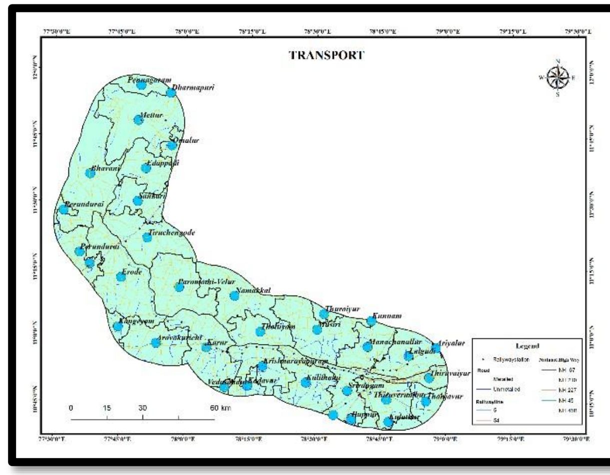



Fig:4 Transport Network

**METHODOLOGY**

Data Collection and Methodology

Cloud Free Landsat satellite data of 2009 & 2019 for the study area has been downloaded from USGS Earth website. All the data are pre-processed and projected to the Universal Transverse Mercator (UTM) Projection system.

Table 1: Detail of data collection.

| **Sensor / Satellite** | **Date of Image** | **Path / Row** |
|---|---|---|
| Landsat TM 5 | April 2009 | 143/52, |
| Landsat 8 OLI | April 2019 | 143 / 52, 144/52 |

Study of the following methodology is adopted which involves satellite data collection. classification of the imagery, preparation of NDVI class, retrieval LULC maps and correlation studies. These are briefly outlined here.

**NDVI**

The Normalized Difference Vegetation Index (NDVI) is a measure of the amount and vigour of vegetation at the surface. The reason NDVI is related to vegetation is that healthy vegetation reflects very well in the near infrared part of the spectrum. The range of the value -1 to + 1.

$$NDVI = (NIR – RED) / (NIR + RED)$$

Table 2: Detail band for NDVI

| **Data** | **Band** | **Band** |
|---|---|---|
| Landsat 5 | Band 4 | Band 3 |
| Landsat 8 | Band 5 | Band 4 |

**NDWI (NORMALIZED DIFFERENCE WATER INDEX )**

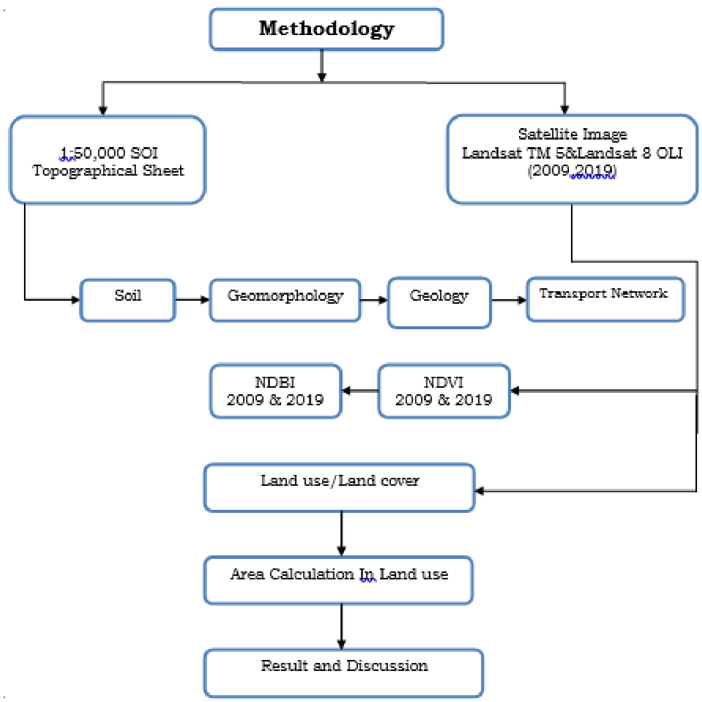
Gao (1996) Proposed the NDWI to delineate open water features. NDWI is expressed as follows:

$$NDWI = ( NIR – SWIR ) / ( NIR + SWIR)$$

**NDBI (NORMALIZED DIFFERENCE BUILT – UP INDEX)**

This method is less effective in TM image. Low –

resolution image frequently have more spectral information rationally. Using of the NDBI based on the rule that the build –up aera has higher reflection rationally in Mid – Infrared is higher band is higher than the Near – infrared band.




## RESULT AND DISCUSSION

The purpose of land use / land cover change detection is to maximize the productivity. Due to climate factors, soil characteristics, slope of the land, and degree of erosion, water supply, and environmental condition, the change of land use / land cover is inevitable.

## BUILT-UP LAND

It is an area of human habitation developed due to non-agricultural use and that has a cover of buildings, transport and communication, utilities in association with water, vegetation and vacant lands. Land use / land cover map consists of 2 classes under built-up viz., urban and rural. In this area built -up land area human interaction highly improved in the Cauver river 30 km Buffer zone.

## URBAN

Urban areas are non-linear built up areas covered by impervious structures adjacent to or connected by streets. This cover is related to centers of population. This class usually occurs in combination with, vegetated areas that are connected to buildings that show a regular pattern, such as vegetated areas, gardens etc. and industrial and other areas. Economic development, demand for housing by households and rapid changes in their structure, and the extension of transport networks. Land use by urban area has the highest impact on the environment due to 'sealing of soil' and the environmental impact from transport, waste dumping and pollution. The urban highly developed area cover in Tiruchirappalli, Srirangam and recently development taluk Manapparai. In this area NH7 and village others roads network, railway network.

## RURAL

These are the lands used for human settlement of size comparatively less than the urban, settlements of which the majority of population is involved in the primary activity of agriculture. These are the built-up areas, smaller in size, mainly associated with agriculture and allied sectors and non-commercial activities. In this rural area viralimalai, velliyanai and some other areas recently expansiondevelopment government of building, roads and railway network and dement of resources Cauver river 30 km Buffer zone.

## AGRICULTURAL LAND

These are the lands primarily used for farming and for production of food, fiber, and other commercial and horticultural crops. It consists of double crop lands any one combination of double crop lands.

## PLANTATIONS

These are the areas under agricultural tree crops planted adopting agricultural management techniques. Depending on the location, they are exhibit a dispersed or contiguous pattern. Use of multi-season data will enable their separation in a better way. It includes agricultural plantation horticultural plantation (like recant, citrus fruits, orchards, fruits, trees, vegetable gardens banana, coconut, mango,guava, other plantations etc). The highly cover plantation area Kulithalai, Krishnarayapuram and Tiruchirappalli river basin area. In this area cultivated of plantation banana, coconut and others plantations.

## CURRENTLY FALLOW LAND

An agricultural system with alternation between a cropping period of several years and a fallow period. In another terms these are the lands, which are taken up for cultivation but are temporarily allowed to rest, un-cropped for one or more seasons. In this area Thiruverumbur, Pothukkodai and Kulathur in correctly follow land, the recently un-irrigated land.

## FOREST

The term forest is used to refer the land with a tree canopy cover of more than 7.35% cover in Cauver river 30 km Buffer zone.

## SEMI-EVERGREEN

This term as such describes the phenology of perennial plants that are never entirely without green foliage. This category comprises of tall trees, which are predominantly remain green throughout the year. Semi- evergreen is a forest type that includes a combination of evergreen and deciduous species with the former dominating the canopy cover. In this area cover in semi-evergreen forest, reserved forest and some other forest 7.35 % in Cauver river 30 km Buffer zone.

## DECIDUOUS

This applies to the phenology of perennial plants that are leafless for a certain period of the year. The leaf shedding usually takes place simultaneously in connection with the unfavorable season. It also includes tree clad area with tree cover lying outside the notified forest boundary areas that are herbaceous with a woody appearance. In that area reserved in deciduous forest in organized for government.

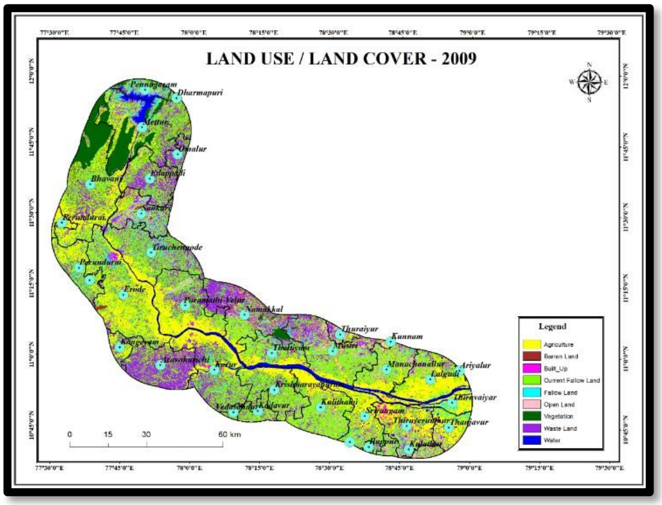



Fig:5

| Sl. No | Pattern | Area in Sq.Km |
|---|---|---|
| 1 | Agriculture | 1813.151 |
| 2 | Barren land | 30.68 |
| 3 | Built-up | 31.98 |
| 4 | Current fallow land | 282.46 |
| 5 | Fallow land | 60.64 |
| 6 | Openland | 132.48 |
| 7 | Vegetation | 210.92 |
| 8 | Wasteand | 150.66 |
| 9 | Water | 38.14 |
| | **Total** | **950.85** |

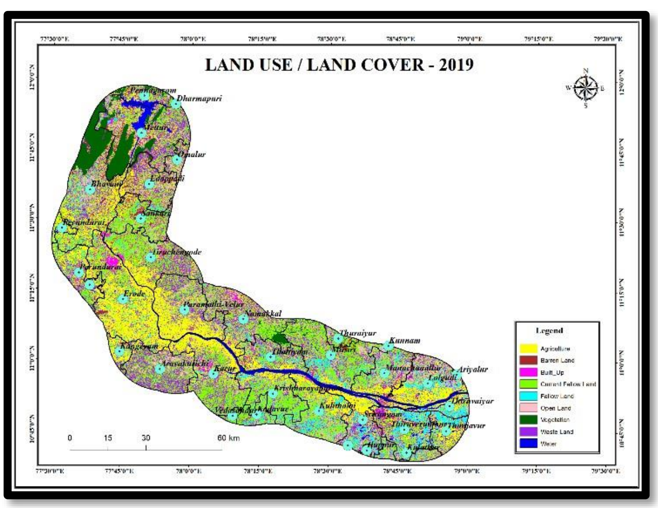



Fig:6

| Sl. No | Pattern | Area in Sq.Km |
|---|---|---|
| 1 | Agriculture | 546.09 |
| 2 | Barren land | 5.15 |
| 3 | Built-up | 40.72 |
| 4 | Current fallow land | 354.57 |
| 5 | Fallow land | 54.02 |
| 6 | Openland | 171.1 |
| 7 | Vegetation | 42.28 |
| 8 | Wasteand | 123.93 |
| 9 | Water | 31.33 |
| | **Total** | **950.85** |

## WATER BODIES

All submerged or water-saturated lands, natural or man-mad, permanent or temporary, static or dynamic, vegetated or non-vegetated, which necessarily have a land-water interface, are defined as wetlands. It consists of drinking for supply waters. In this area seasonally flowing in water bodies totally cover in 1.92% (2019) and 3.20 %( 2009) nowadays reduced of water bodies, in the area having water during rainy seasons.

## NORMALIZED DIFFERENCE VEGETATION INDEX

A vegetation index is a single value that quantifies vegetation health or structure. The math associated with calculating a vegetation index is derived from the physics of light reflection and absorption across bands. For instance, it is known that healthy vegetation reflects light strongly in the near infrared band and less strongly in the visible portion of the spectrum. Thus, if you create a ratio between light reflected in the near infrared and light reflected in the visible spectrum, it will represent areas that potentially have healthy vegetation.
The normalized difference vegetation index (NDVI) is a simple graphical indicator that can be used to analyze remote sensing measurements, typically, but not necessarily, from a space platform, and assess whether the target being observed contains live green vegetation or not.

The NDVI is calculated from these individual measurements as follows:

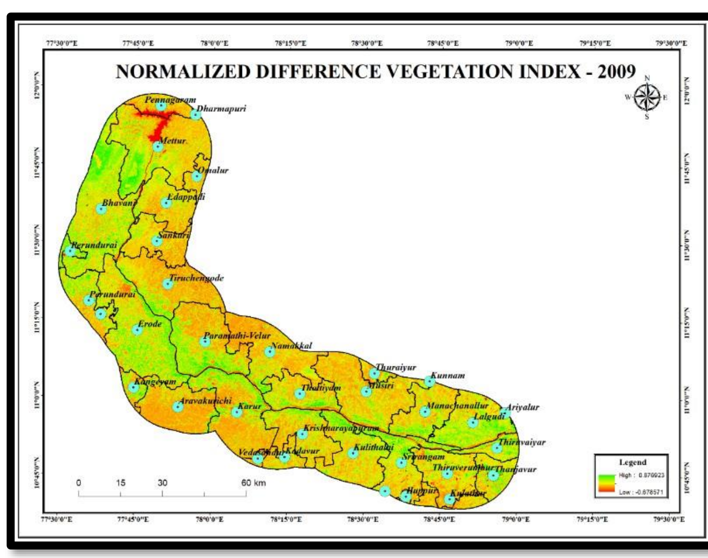



Fig:7 Normalized Difference Vegetation Index -2009

NDVI = -1 to 0 represent Water bodies
NDVI = -0.1 to 0.1 represent Barren rocks, sand, or snow
NDVI = 0.2 to 0.5 represent Shrubs and grasslands or senescing crops
NDVI = 0.6 to 1.0 represent Dense vegetation or tropical rainforest
The NDVI rate can be calculated using raster calculator in Arc GIS.

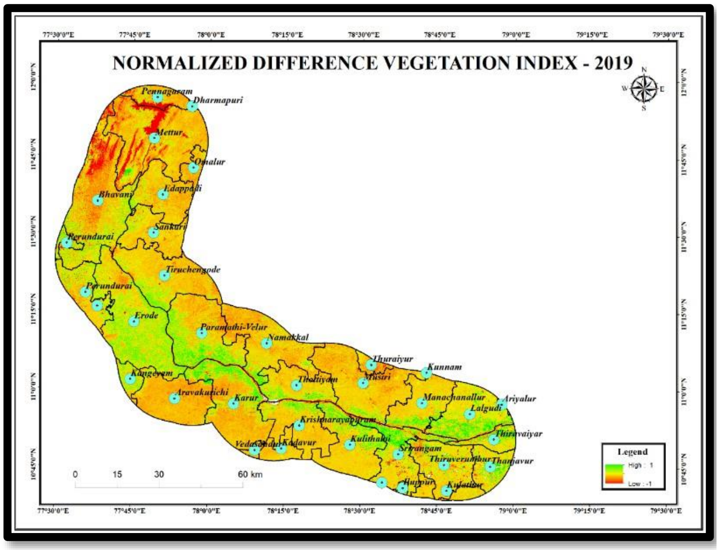



Fig:8 Normalized Difference Vegetation Index -2009

NDVI values range from +1.0 to -1.0. Areas of barren rock, sand, or snow usually show very low NDVI values (for example, 0.1 or less). Sparse vegetation such as shrubs and grasslands or senescing crops may result in moderate NDVI values (approximately 0.2 to 0.5).

For Landsat 5 data,
NDVI = (Band 4 – Band 3) / (Band 4 + Band 3)
For Landsat 8 data,
NDVI = (Band 5 – Band 4) / (Band 5 + Band 4)

The NDVI value varies from -1 to 1. Higher the value of NDVI reflects high Near Infrared (NIR), means dense greenery. Generally, we obtain following result:

## NORMALIZED DIFFERENCE BUILT INDEX (NDBI)

There are lots of indexes for the analysis of built-up area. Normalized Difference Built-up Index (NDBI), Built-up Index (BU), Urban Index (UI), Index-based Built-up Index (IBI), Enhanced Built-up and Bareness Index (EBBI) are most common indexes for analysis the built-up areas. These different indexes having their own formula, own calculation method. The build-up areas and bare soil reflects more SWIR than NIR. Water body doesn't reflect on Infrared spectrum. In case of greenie surface, reflection of NIR is higher than SWIR spectrum (Fig 1). For better result, you can use Built-up Index (BU). Build-up Index is the index for analysis of urban pattern using NDBI and NDVI. Built-up index is the binary image with only higher positive value indicates built-up and barren thus, allows BU to map the built-up area automatically.

NDBI = (SWIR – NIR) / (SWIR + NIR)

**For Landsat 5 data,**
NDBI = (Band 5 – Band 4) / (Band 5 + Band 4)
For Landsat 8 data,
NDBI = (Band 6 – Band 5) / (Band 6 + Band 5)
Also, the Normalize Difference Build-up Index value lies between -1 to +1. Negative value of NDBI represent water bodies where as higher value represent build-up areas. NDBI value for vegetation is low.

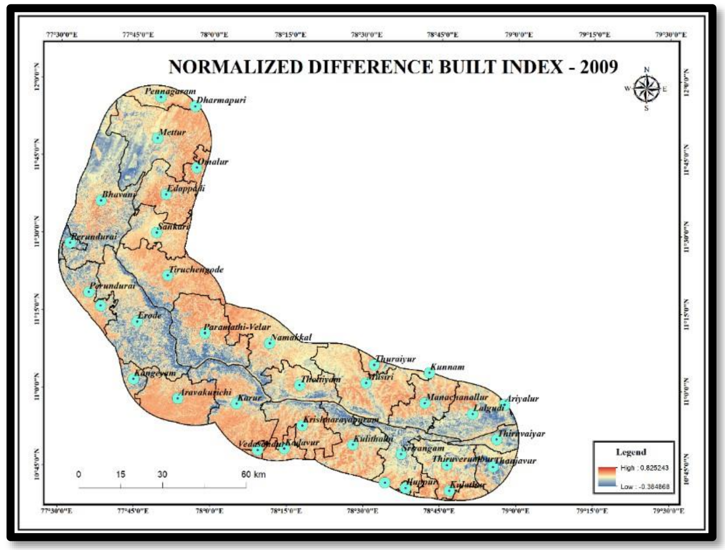



Fig:9 Normalized Difference Built Index -2009

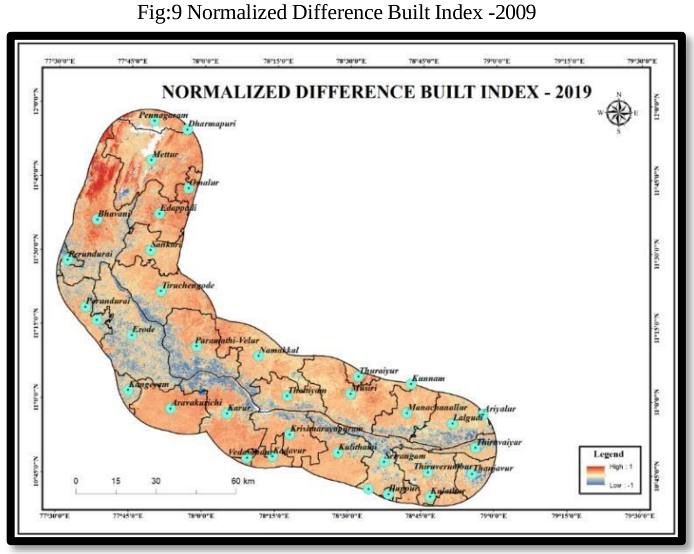



**Fig:10 Normalized Difference Built Index -2019**

## Conclusion

In the present day world, Land Use and Land Cover mapping is of great significance in scientific, scholarly research, planning and management. Regional land use pattern reflects the character of interaction between man and environment and the influence of distance and resources based on mankind's basic economic activities. Land Use Land Cover features have been precisely captured through on-screen visual interpretation and digitally on fused Landsat 5 & 8 satellite imagery. Provision of such maps helps town planners in effective and best possible utilization of its resources besides providing a comprehensive view of the area

**Action Plan**

The Cauvery river is one of the sacred rivers of India and also known as the 'Dakshina Ganga' of south India. Agriculture being the main occupation of the state of the Karnataka and the river Cauvery is one of the major sources for an extensive irrigation system, drinking and for hydroelectric power. The river has supported irrigated cultivation for centuries and served as the life giver of the ancient kingdoms and modern cities of South India. The Cauvery River Basin is a highly valuable resource for the people of Karnataka because they directly depend upon it for irrigation, drinking and industrial needs.

Unfortunately during the past decade the tributaries and landscapes within the watersheds of Cauvery river, the 300 m buffer zone on both the sides have undergone tremendous alteration due to increased human activities and unsustainable land use practices by the community. Due to rapid growth of population, increase of urbanization, expansion of industrial activities, intensive agricultural practices, dumping of solid wastes, and untreated wastewater being released to the river has resulted in the loss of natural wetland vegetation and hydrologic characteristics of the landscape that are unique to wetlands.

Conservation of wetlands requires several actions to be taken together. It is necessary to first understand the current status and its ecological elements of the wetlands in terms of its physical, biological, chemical and hydrological characteristics and then determine the objectives and goals for conservation of wetlands.

The secondary authenticated data from various concerned departments/organization and other academic reports and also the data available in the websites were collected and interpreted to know the water quality, the ecology and biodiversity in the study area covering 300m buffer zone on either side of the Cauvery river.

The study reveals that currently, Cauvery river is facing serious anthropogenic pressures from agricultural expansion, expansion of village settlements, increased commercial plantations, sand mining, tourism, etc., that pose severe risk to the vast riparian ecosystem in the region. The use of riparian zones for farming is a predominant activity along the banks of the river that affects the riparian ecology. It is also observed that people from bordering villages/settlements graze their cattle along the river bank of riparian zones due to shortage of land designated for grazing. In addition, the riparian ecosystem in Cauvery has become an integral part of cultural activities with many historic places for worship evident along the bank of the river. Subsequently many research studies show that the water quality of the Cauvery River was reported to be polluted or near to be polluted.

Based on the observations documented during the field visits, GIS analysis and also interpretation of the secondary data, the following management plan has been drawn for the conservation of the wetlands on the both the side of Cauvery river.

**Stopping the Illegal Soil Excavation and Sand Mining:**

The river bed of Cauvery is subjected to soil excavation and sand mining activities in certain areas, though these activities are restricted by the respective department. These activities may cause lowering of riverbed level as well as river water level and also resulting in lowering of groundwater table due to excessive extraction and draining out of groundwater from the adjacent areas. The soil excavation will reduce the thickness of the natural filter materials (Top layer soil), infiltration through which the ground water is recharged. These activities induce soil runoff during monsoon season resulting in siltation in the rivers and also collapse or landslide of the adjacent structures and variation in river slope and flow velocity.

As these activities are posing a threat to the river, concerned departments should take stringent actions against these activities by regular monitoring.

**Preservation of River Beds by removal of seasonal Encroachments of River Bed:**

River beds in some places appear to have been encroached by seasonal agriculture. The revenue Department should duly survey such areas and verify the records and remove such encroachments of river beds etc.

**Control of Industrial Effluent Discharge into the River Course:**

Water footprint of Indian industry is unacceptably high. There is a need to reduce consumption of fresh water through alternative water-efficient technologies or processes, reuse and recycle waste water and make the reclaimed water available for use in secondary activities within or outside the industry and thereby reduce the volume of polluted water discharged into rivers and groundwater. Stringent action should be taken against industrial effluents being discharged into the river course with strict monitoring and enforcement. Also in relation to the industries operating in catchment area a study may be carried out regarding the water usage by the industries, their source and disposal of waste water. The industries may also be asked to contribute under the Corporate Social Responsibility (CSR) for treatment of the industrial effluents by establishing Common Effluent treatment Plants or opting for alternative water efficient technologies and reuse and recycling of water within the industries. This will be highly beneficial in reducing the requirement of fresh water. Tamil Nadu Government in consultation with the local industries should look into the possibility of reuse and recycling of water.

**Alternative Technologies for Treatment of Wastewater:**

The discharge of sewage water into the river is a serious environmental concern and potential health hazard. The Sewage Treatment Plants under the control of concerned department should be maintained and utilized in optimum condition. The water should be collected and treated before releasing into the river, so that such sewage water does not have impact on water quality. Alternative technologies including eco-filtration, soil-scape systems etc., may be adopted to tackle the problem of untreated sewage entering directly into river.

There are villages adjacent to the Cauvery river stretch, which are not connected to a sewerage system. The sewage from such places is to be collected in soak pits. Such cluster of houses/ buildings may be connected to a decentralized sewerage treatment system which is a viable and sustainable alternative approach to sewage, and a well-designed small scale waste water treatment for rapidly growing areas. The advantages of such systems are scalability to any size, adaptability to varying load sizes, and climatic conditions. The water can be safely reused for non-potable end uses.

The State Government and Government of India encourage rainwater harvesting systems through various schemes,

policy and guidelines. It is recommended that guidelines related to Rain Water Harvesting systems should be implemented by the concerned Authorities. Further, the industrial as well as residential buildings should adopt rain water harvesting structures.
The local people should be encouraged to adopt such alternatives at the community level.

**Preservation and maintenance of Storm Water Drains:**

With reference to the problem of discharging wastewater or greywater into the storm water drains leading to the pollution of river, the following is recommended:-

i) Prevent the discharge of any wastewater into the storm water drains with further control on the dumping of solid waste into the storm water drain coming within the vicinity of area having stream, river or lakes.

ii) The storm water drain and wastewater disposal system should be separated.

iii) Diversion of the waste or grey water away from the river, stream and lake.

iv) Regular cleaning and maintenance of the storm water drains.

v)Installation of Gross Pollution Traps in storm water drains to trap the litter, debris, coarse sediments.

**Creation of Tree Plantation along the River Stretches:**

Across the Cauvery river stretch, strip plantation should be created to minimize the pollution in the area. Agro forestry should be encouraged to act as an insurance against crop failures. Forest Department may be asked to come up with a detailed proposal in this regard.

**Forest Cover:**

Improve the forest cover in the river catchment area to prevent soil erosion and siltation of the river beds as a part of River Conservation strategies.

**Creation of Adequate Awareness among the Local People:**

The participation of Central and State government organizations, Educational and Research institutes, Local Community, Citizens and NGOs in the conservation and management of river is very much desirable. Effective participation of local communities in river management accompanied by public awareness and information campaigns is very essential. Moreover, the involvements of local communities are based on understanding and appreciation of the local cultural beliefs, values and norms, which helps in the long term sustainable river management.

Proper implementation and achievement of conservation activities should be done through vigorous community involvement. They should be made aware of the ecological, hydrological, environmental and socio-cultural importance of the river. This can be done through various programs, publications and lake festivals. Erecting a notice board in the river stretches giving details of the river like water spread area, species of fishes, bird fauna, and also on the causes and ill-disposed effects of river pollution to provide information to the visitors and other stakeholders would sensitize them.

Also as explained in the paragraphs above, a number of steps should be initiated by Government to encourage - rain fed agriculture, solid waste management, rain water harvesting, agro-

W – Atmospheric water vapour content

$\Delta$ ε – Difference in LSE

forestry, treatment of domestic waste water, DEWAT systems etc. The local residents should be made aware of all these initiatives and all attempts should be made to implement any Government programme in a participatory manner.

Basin is mostly occupied by irrigated cropland and northern part having some dense forest, middle part of the area lies fallow land, southern part of area is having water bodies. Scrub few places occupied. Over all this land use is mainly concentrated on Agriculture .

Irrigated cropland lies in half of area, for about 47.82% of the Ayyar Basin. Another, northern part of area covers Forest for 13.36%. Un irrigated cropland covers 12.06% of the area, Fallow land 7.43%covers in total area. Scrub land covers in 6.35% land. Barren land, Built up land, Plantation and Water bodies covering below 5% of study area. Finally this area mostly occupied for Agricultural purpose, because drainage facility is good in this region.

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