SYNOPSIS

SPATIO-TEMPORAL PATTERN OF LANDUSE CHANGE AND ITS IMPACT ON GROUNDWATER RESOURCES IN DINDIGUL DISTRICT USING GEOSPATIAL TECHNOLOGY

Human activities alter the earth surface significantly in many ways. Man’s presence on the earth and his use of land has a profound effect upon the natural environment, which results in to observable pattern of change in the land use/land cover over passage of time. A modern nation, must have adequate information about many complex and interrelated aspects of activities of earth in order to make decisions. Knowledge about land use and land cover is increasingly important for the country when it comes to planning. To over comes the problems of haphazard, development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat planning is crucial. Land use data are needed for the analysis of environmental processes and problems that must be understood, if living conditions and standards are to be improved or maintained at balanced levels.

‘Land cover’ refers to the physical surface characteristics of land (for example, the vegetation or the presence of built structures). Therefore, land cover is directly observable, either in the field or through remote sensing. Land use, describes the economic and social functions of land, i.e. the purposes for which humans exploit land cover. The major parts of the land surface are used for activities such as agriculture, forestry, settlements and infrastructure.

Land-use models are important tools used to explore potential future impacts on biodiversity and ecosystem services, and evaluate potential trade-offs between different demands for land use, and make decisions. Land-use models can also help to investigate the effects of a combination of drivers at different scale levels, such as population increase, demand for food, commodity prices, water level and global warming, on land-
Use change and its environmental impacts. Essentially, the goals of land-use modeling are (a) to improve the understanding of land-use systems, (b) to explore the behavior of land use systems under changing environmental conditions, and (c) to apply in the scenario analysis and strategy development.

Land use and water resources have a strong relationship with each other, which cannot be separated. The changes together in weather and land use/cover have few impacts on water resources. LU/LC change directly affects both surface and ground water resource, agricultural and economic growth. During this modern era, human activities like deforestation, afforestation, urbanization and farmland reclamation, lead to major agricultural-land use changes. Studying the effects of weather and land use/cover changes is to understand the water resource of an area. Land use/cover changes influence on water resources generally through vegetation interception, evapotranspiration, runoff, surface infiltration, soil moisture status, and so forth.

After the development of Geospatial technology, an “integrated land science” has emerged, uniting environmental, human and remote sensing/GIS sciences to solve various questions about land-use and land-cover changes and the impacts of these changes on humankind and the environment. It has demonstrated pivotal role of land change in the earth system and its complexities that transcend such simplifications as unidirectional and permanent land-cover change caused by immediate population or consumption changes, replacing them by a representation of a much more complex process of land-use/cover change.

Land use and land cover changes are dynamic in nature, which do not homogeneously occur in an area. The changes vary from one place to another irrespective of hill or plain or coastal areas. The present attempt is made to study land use and land cover changes and their impact on ground water resource.

Dindigul is one of the southern districts of Tamil Nadu state. The district has varied topography such as hilly areas of the parts of Western Ghats, namely Palani and Kodaikanal hills; and Sirumalai hill is an extension of Eastern Ghats and large size agricultural lands in the plain area. Spinning mills, Paper, food processing and metal
industries are located in the district. Dindigul city has high concentration of tanneries in and its outskirts. Hence, it is apt to study the land use and land cover change and its impact on ground water resource of Dindigul district using an advanced technique like geospatial technology.

Dindigul district located in the southwestern part of Tamil Nadu. The District lies between 10° 07’ and 10° 50’ North latitude and 77° 16’ and 78° 20’ East longitude. (Fig.2.1) It is bounded by Thiruppur district in the north, Trichy district in the east, Madurai district in the south, Coimbatore district and Kerala state in the west.

The total area of Dindigul is about 6041 sq.km. The district has a density of 345 persons per sq.km and has a sex ratio of 998 per 1000 males. Out of the total population 1351735 persons are classed as rural population and 808040 persons are living in urban settlements. Dindigul city is the administrative head quarters of the district. The study area is divided into 8 taluks, 14 blocks, 34 Town panchayats and 362 villages.

AIM AND OBJECTIVE OF THIS RESEARCH

Aim

To forecast the future pattern of land use and land cover of the study area based on the past and current situation. To compare the result with the latest existing classified image and to analyze the impact of land use changes and their impact on groundwater water level of the study area.

Objective

The following are the major objectives of the present study

1) To study the land use and land cover changes for the selected time points of 1991, 2001, 2011 and 2018.

2) To analyze the temporal changes of land use and land cover from 1991 to 2018 and predict the land use for the years 2026 and 2035.
3) To analyze the annual and seasonal distribution of Rainfall from 1971 to 2018 of Dindigul district.

4) To study the seasonal water level fluctuation for the years 1984 - 2013 and 2018 of the study area

DATA BASE AND METHODOLOGY

The present study mainly depends on secondary sources. Dindigul district administrative map with taluk and block boundaries are obtained from district census hand book. Study area details are collected from District Statistical Office. Data pertaining to total population, population density, sex ratio and literacy rate are gathered from census records. Study area base map and drainage maps are prepared from 1: 50,000 scale, Survey of India, toposheets no 58F/06, 58F/07, 58F/08, 58F/10, 58F/11, 58F/12, 58F/14, 58F/15, 58F/16, 58J/01, 58J/02, 58J/03, 58J/04, 58J/07 and 58J/08. Relief map prepared using SRTM DEM data downloaded from the USGS website.

The following inferences are derived from the present study:

In this present study, an attempt was made here, to know the long term variations of land use and land cover in Dindigul district over 30 years (1991-2018). This study has been made through geospatial technology. The land use/land cover classification is carried out based on SOI toposheets, LANDSAT imageries and GIS, and remote sensing software is used for thematic maps preparation and GPS is used for ground truth verification to check the accuracy of the classification.

NRSC level II classification scheme is adopted to obtain a broad level of classification and to derive various LULC classes such as agriculture land, forest, scrub land, urban settlement, rural settlement, fallow land, agricultural plantation and water body.

Built-up land includes urban and rural settlements have gradually increased in the study area. In the year 1991, the built-up area covered 5% of the total area. Which was increased to 6.33% in 2001, and then 6.7% in 2011 and further increased to 11.66% in
The development of built up land is notable in the Kodaikanal, Palani, Dindigul and Oddanchatram block. Because these are famous tourist and marketing places. The major land cover of Kodaikanal block is forest land.

Water bodies cover insignificant area in 1991 (0.43%) it was reduced to 0.33% in 2001 and the area is maintained as 0.33% in 2011 and 2018. Due to the low resolution of satellite images, small water bodies could not be marked.

In the year 1991, the fallow land was identified as 7.88% of the total district area and it was increased to 10.71% in 2001, and then 27.05% in 2011 and further increased to 45.92 % in 2018. Increasing in fallow land in the study area perhaps associated with inadequate rainfall and irrigation facilities which is reflected upon farmers, occupation and so they have, moved to tertiary or secondary sectors, particularly the small size farmers.

A pronounced change has occurred in the scrubland in all years 1991-2018. In 1991, it occupied 4.85% of the total area, it and increased to 11.23% in 2001and 13.07 % in 2011 and further increased to 17.82 % in 2018.

The change detection shows that agricultural plantation, scrub land and fallow lands benefited, whereas agricultural crop land and forest land lost their aerial extent. From 1991 land use/ land cover 377 Sq.km area of fallow land was converted to agricultural land and 82.95 sq.km area was converted into Scrub land.36.97 sq.km area was converted into rural settlement in 2001. In 2001, 22.97 sq.km scrub land was change into forest, from 1991 land use.26.55 sq.km area was converted into fallow land and 77.65 sq.km area was change into Agricultural land. In addition to that, 3.15 sq.km was converted from rural settlement to urban settlement.

The change detection for the period 2001 to 2011 shows that agricultural land and rural settlement benefited, whereas fallow land, agricultural plantation and scrub lands lost their aerial extent. The land use classes changing into some other class detail their aerial extent. In this period, fallow land 761.86 sq.km changed to agricultural crop land, and about 407 sq.km of agricultural land was changed to fallow land. Also it is
noticed that 181.47 sq.km of fallow land, 117.55 agricultural crop lands have been converted into rural settlement. Scrub lands of 48 sq.km and 46.18 sq.km have been changed to agricultural plantation and fallow land respectively. They derived qualitative changes during the period.

The land use categories such as agricultural fallow land, scrub land, agricultural plantation and rural settlement benefited during the period 2011 to 2018. Whereas, Agricultural crop land and forest lands lost in their aerial extent during this period. The details of changing land use classes into other classes with their aerial extent. In this period, 1058 sq.km of agricultural crop land was changed to scrub land (146.84 sq.km), urban settlement (39.93 sq.km) and rural settlement (360.90 sq.km). Fallow lands about 96.95 sq.km, 65.64 sq.km, and 37.91 sq.km have been changed into rural settlement, agricultural crop land and scrub lands respectively. Also it is noticed that scrub lands of 57.43 sq.km, 38.44 sq.km, 27.12 sq.km and 9.41 sq.km have been changed as agricultural plantation, fallow land, agricultural crop land and rural settlement respectively. Also it is observed that 19.20 sq.km rural settlement area has been converted as Urban settlement.

The land use changes during the span of 27 years show that, fallow land, agricultural plantation, rural and urban settlements and scrub lands have increased, whereas agricultural crop land and forest lands have decreased.

Future simulation of land use for the year 2026 and 2035 is carried out through IDRISI software on CA-Markov model. The basic classified land use maps for the periods 1991, 2001, 2011 and 2018 are converted into IDRISI raster format for land use modelling.

In 2026, projected area fallow land is profound (42.42%) followed by scrub land (16.34%) rural (11.59 %) and forest (9.14%). Land use transition probability matrices, together with Markovian conditional probability images for both time periods are calculated in IDRISI-Selva software.

In 2035, projected area of fallow land is profound (36.07%) followed by scrub land (16.91%) rural (12.47 %) and forest (8.91%).
Comparison of different land use categories obtained from the prediction periods 2018, 2026 and 2035 shows that crop lands would decreased as to 450 sq.km and 417 sq.km in 2026 and 2035 respectively. Forest area, would decreased from 552 sq.km in 2026 to 538 sq.km in 2035. Settlements both in rural and urban areas show increasing trends for the three decades. At the same time fallow land decrease from as 2522 sq.km in 2026 to 2179 sq.km in 2035.

The average monthly southwest, northeast, winter, summer and annual rainfall (1971-2018) for the district are analyzed and the season wise rainfall contour maps are generated using ArcGIS software. All rain gauge stations in Dindigul received high rainfall in October and November months and it is reduced in December.

For the span of 48 years from 1971 to 2018 average annual rainfall in the study area is 877.78 mm. The average south west monsoon rainfall is 247.94 and the average north east monsoon rainfall is 448.03mm. The average winter and summer rainfall is 21.30mm and 160.50mm respectively. The north east rainfall contribution is more than 50% in the annual rainfall in the district.

The monthly ground water level data measured from 66 well collected for the period 1984-2013 and 2018 are used for the analysis. The course of groundwater flow indicates information about the movement of groundwater and helps to identify the areas which recharge the groundwater supply wells, streams, lakes and rivers.

The landuse/land cover classification has been carried out for the period 1991, 2001 and 2011,2018 using respective period of satellite data. Landuse change detection analysis reveals that crop land is decreasing while fallow land is increasing over the decade. The occurrence of decrease in crop land and increase in fallow land in the district is mainly due to water level depletion continuously over the decades.

The landuse map of 1991 shows that crop land category in Vedasanthur, Dindigul south, Ayakudi, Devathur, Nilakottai and Sendurai areas are very less as these areas fall in the more than 15 m water level range in the three decadal periods of both monsoon seasons.
Ayyakudi, Chinkkampatti, Kallimanatham, Devathur, Vedasanthur, Eriodu, Dindigul south and Viruveedu area having more than 15 m of water level range during the decadal period 1994 to 2003 spread over less crop lands and more fallow lands as per the landuse map of 2001.

In the landuse map of 2011, it is noticed that in Ayakudi, Odanchatram, Vedasanthur, Eriodu, Dindigul south and Viruveedu areas the crop lands are very less as these areas fall in the water level range is greater than 15 m during the period 1994 to 2013.

The landuse change analysis for the period 1991 to 2001 shows that 1519 sq.km of agricultural land has been changed to fallow land. This change is mainly due to water level fluctuation observed during the period 1994 to 2003 in which more than 1500 sq.km of area fall in the water level range from 10 to 15 m.

The landuse change analysis for the period 2001 to 2011 reveals that more than 400 sq.km of agricultural land has been changed to others. This may be due to 10 to 15 m water level fluctuation observed in the decadal period 2004 to 2013. The landuse change analysis for the period 1991 to 2018 also show that 1934 sq.km of agricultural land has been changed to fallow land in the study area, which may be due to water level depletion observed in the decadal periods. From the landuse change analysis for the period 1991 to 2018 it is observed that agricultural lands in Thoppampatti, Kallimanthayam, Devathur, Eriodu, Silvathur, Sanarpatti, Kambiliyampatti, Ayyalur, Pillaiyarnatham, Viruveedu, Vedasanthur and Vadamathurai have been changed to other lands, since these areas fall on maximum water level fluctuation zones in all decade periods.

MAJOR FINDINGS OF THE PRESENT STUDY

- When comparing the land use of period 1991 to 2018, 47.57 % of the agricultural land has been decreased to 9 %.
- Forest land decreased from 21.61% to 7.5 %.
Agricultural plantation decreased from 12.64% to 7.79%.

Fallow land increased from 7.88% from 46%

Scrub land increased from 4.85% to 17.82%.

Rural settlement has been increased from 4.78% to 10%.

Urban settlement also increased.

The change detection analysis shows that major agricultural crop land has been changed into fallow land.

In the span of 27 years fallow land, agricultural plantation, rural and urban settlements and scrub lands have increased.

Agricultural crop land and forest lands have decreased.

The decrease in water level, low rainfall during the years 1991, 2001 and 2018 periods and their spatial distribution are the factors for decrease in land use classes such as crop lands and forest lands.

The land use categories obtained from the prediction periods 2018, 2026 and 2035 show that crop lands, fallow lands and scrub lands have increased.

Settlements both in rural and urban area and scrub lands are in increasing trend.

RECOMMENDATIONS

Farmers over exploited in the ground water and Critical blocks should be given training in water management for optimum utilization of both surface and groundwater.

Immediate recharge structures should be constructed in the semi critical blocks so as to improve the category as safe category.
More attention has to be given for augmenting groundwater by constructing recharging structures in the critical category firkas like Dindigul South, Oruthattu and Pillaiyarnatham as these areas got more rainfall during 2018.

All bore wells, dug cum bore wells, dry and not in use, by the farmers will be censured and these wells can be converted as vertical soft for injecting the groundwater in the aquifers for recharging the over exploited areas.

All tanks in the over exploited areas should be protected from encroachments and desilted to restore their original capacity.

Major rivers such as Santhanavardhani Ar, Kodavanar, Varattar, Nanganjiyar and Odakkarai Ar are draining in the over exploited areas in the district. Major rainwater harvesting structures should be constructed across the rivers in suitable places recharging the groundwater so as to improve the groundwater and surface water conditions which would help the farmer community to increase the agricultural productivity.

The practice of ‘Kudimaramathu’ as in the earlier period involved by the local village people for desilting of tanks, strengthening of tank bunds and removal of weeds in the supply channels should be reintroduced by forming self-supporting group with a subsidy from the local body/Government.

As the study of geomatics and modeling show that the crop land would decrease in future. So artificial recharge zones have to be identified and suitable structures should be recommended to improve the groundwater quantity using latest technology like geomatics.

The waste lands such as scrub available in the study area, be converted into productivity lands under waste land management programme. Suitable selected lands can be tilled before monsoon to unconsolidate the soil. To avoid runoff, so that the surface runoff will infiltrate into the unconfined aquifer.

The groundwater regulation act enacted by the Government of Tamil Nadu should be adhered and enforced.
Immediate regulation and a law should be enforced to ban the conversion of the water bodies and crop lands (wet/dry) into housing/ business/institution layouts (including government purpose).

Farmers should be allowed to take the fertile soil from the tanks at free of cost for their crop lands so that the tank get deepen in some extent.

Abstraction of groundwater be regularized.

Water User Association should be formed in the study area to address the needs of various departments.

From the prediction analysis for 2026 and 2035, it is observed that urban expansion is high in Dindigul district, it should be taken by concern authorities, city planners in their future plans and actions for Dindigul district in terms of drinking water facility road networks, infrastructure, and allocating some locations for future services such as, schools, health centers, governmental buildings, public parks, etc.,

The prediction analysis shows that most of future urban expansion substitutes agricultural areas, which could be avoided through future plans and strategies.

As a final point, the study is highly suggested that urban planners and decision makers utilize remote sensing and GIS techniques for effective monitoring of urbanization trends in Dindigul district. Hence, it will improve their expectations and predictions of the expansion and the location of future built-up areas, and enhance the existing urban.

Strategies for better sustainable land management. Future studies should investigate the impacts and the interactions of some spatial variables on urban expansion patterns, To integrate other suitable methods with Markov model to predict future LULC change, and to investigate other socio-economic factors that may play important roles in urban expansion.