Correlation of Stagnant Wetlands Depth and Their Ecological Status in the Central Tamilnadu District, Tamilnadu.

Varunprasath Krishnaraj (varunprasath@psgcas.ac.in)
PSG College of Arts and Science https://orcid.org/0000-0002-8880-6046
Subha Mathesh
PSG College of Arts and Science

Research Article

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Abstract

Background The wetland stagnation is the premise of the wetland depth (WD) but is lacking in detail. The research looks into correlation of stagnant wetland's depth and their ecological status in the Central Tamil Nadu district (CTN) because of few studies. Seventy-five chosen stagnant wetlands are hydrologically isolated, depths were categorized into less than 5 feet, 6 to 10, and above 10 feet, surveyed by the range of methods from districts as Karur (KD), Namakkal (ND), and Tiruchirappalli district (TD). The human disturbance score (HDS) categorized as least impacted (0-33), moderately impacted (33-67), and highly impacted (67-100).The impacts of LULC changes over nine years (2010–2019) through the maximum likelihood method. Overall, wetland depth (WD) showed that 54% (less than 5 feet), 25.6% (5-10 feet) 20.2% (100 feet). District-wise, wetland degradation was the utmost in the TD, followed by ND and KD. Except In KD, the remaining district wetlands were MI category with diverse HDS. The correlation test revealed a positive relationship between WD against the alteration of the buffer zone, habitat, hydrology, and HDS. However, a negative relation between landscape alteration and wetland pollution. The impacts of LULC changes confirm that severe decline in wetlands habitat and water bodies' area due to built-up area, cultivated land expansion and, increasing population. Our study supported that the WD is associated with quantified impact on wetlands conditions, but further research will need due to limited surveyed wetlands with similar geographical locations.

Introduction

Wetlands are seen everywhere and range from open water to covered with forests ecosystems, or just from near the surface stable lakes to short-term ponds. Wetland ecosystems perform numerous essential features or provide a diverse set of services, such as storing water, flood prevention, agriculture, climate regulation, and soil depletion regulation (Zhang et al. 2014; Chatterjee et al. 2015; Beuel et al. 2016). Inspite of ecological processes and human homes and lives, between 30–90% of the globe's wetlands were drastically altered or destroyed. (Junk et al. 2013; Reis et al. 2017), but most still exist challenged and spoiled as a result of high population explosion and urbanisation (Central Pollution Control Board, 2008; Bassi et al. 2014). The depth, length, probability, and period of flash floods (which include water logging) are most crucial hydrological factors that have an impact on all physiological, chemical, and biological attributes of different wetlands (1995, B. Gopal and M. Sah). Wetlands entail 12.1 km2 and account for 40.6% of biosphere amenities (Costanza et al. 2014; Ramsar Convention on Wetlands, 2018). Sum up, 1052 spots in Europe, 359 in Africa, 289 throughout Asia, 211 in North America, 175 in South America, and 79 in Oceania were denoted as Spots or wetlands of worldwide importance (RAMSAR, 2013). Due to population soon started anthropogenic growth, onshore wetlands in aquatic habitats were easily destroyed, and interconnection among wetlands has reduced (Davidson 2014; Gibbs 2000; Mori, Onoda & Kayaba 2018). Water is observed to be highly rare as population expands and amount of water rises, and global warming affects the hydrological processes (World Water Assessment Programme 2012). Despite wetlands being hydrologically concerned ecosystems, an abiotic component (hydrology, water depth, climate, and chemistry) is extensively considered being the most vital controller of wetland biota (Mitsch and Gosselink 2000). The architecture of a wetland's river flows, in conjunction with its physiographic context, determines almost all of its ecosystem attributes, together with soil conditions, water quality, and the form of biota that lives there (van der Valk 2012). Evaporation and monsoon too are important factors in wetland water levels (Van der Kamp and Hayashi 2009; Ackerman et al. 2015). Hydrological variation connected to climatic alteration, such as rainfall variability, is probably to trigger further ecological alteration. Wetland water stagnation is based on individual wetlands characteristics over their stagnation is influenced by seasonal changes. Nearly 50% of wetlands have been gone global and, plenty of the wetlands that stand deteriorated because of hydrologic modification (Zedler& Kercher 2005). Wetland deterioration resulting due to aquifer outflow, river desiccation, and monsoon decline has turned into a gradually urgent predicament (Pattern et al. 2008; Zhang et al. 2008; Johansen et al. 2011). In wetlands, average depth influences the shield and configuration of macrophytes as well as growth of microorganisms on plant communities substrates (Tournebize et al. 2017; Maine et al. 2017; Maine et al. 2007) and also affects the hydraulic performance and vegetation abundance (Guo et al. 2017; Alley et al. 2013; Chen 2011; Liu et al. 2014). LULC alteration by humans since the last few periods is one of the key issues responsible for wetland ruin. Because of overpopulation and associated human induced growth, inland wetlands in aquatic habitats have been easily destroyed, and interconnection among wetland habitats has decreased (Davidson 2014; Gibbs 2000; Mori, Onoda and Kayaba 2018). Understanding and mapping wetland distribution for broadscale valuations is hence a key initial stage concerning crucial and ranking exact conservation requests (Nel et al. 2009, Vörösmarty et al. 2010). Last few decades, Land use land cover changes caused by humans are assume responsibility for wetland deterioration. However, water bodies' dynamics observation is essential for ecosystem valuation (Ahamad et al. 2020) and long-term biodiversity sustainable management (Li et al. 2019). The information acquired about LULC enables a tested awareness of land usage and its perception against farming methods, neighbouring territories, forest lands, fallow land, and ground water bodies through thorough and achievement goal (Suneela and Mamatha 2016; Sreenivasulu et al. 2010). Rainy season in India exceeds 130 cm, and the country's varied geography and climatological regulatory frameworks model helps and distinct wetland eco systems (Prasad et al. 2002). Rapid urbanisation, intensive farming, contamination, high water drawdown, salinization, forest destruction, exotic species, and fish farming all cause degradation of Indian wetlands (Prasad et al. 2002; MoEF 2009; Vikas et al. 2012). In Tamil Nadu, 32 river systems, 11 reservoirs, 2,679 canals and 38, 863 tanks, and 31 aquatic habitats cover the ground of 58,068 ha and 20,030 manmade wetlands with an area of 2, 01,132 ha (SACON,2006). Wetlands called In TamilNadu by many vernacular names such as small ponds mostly called Storage water (Ilanzi), Drinking water tank (Oorani), Irrigation tank (Eri) Reservoir (Kammai), Smallpond (Kuttai), Large pond (Kuttam), Small pool (Kundai), Pool (Kundu), Bathing tank (Kulam). 18.05% of wetlands topographical area in Ramanathapuram District and as less as 1.08% in Coimbatore. In Kancheepuram district, the highest wetland area of (80445 ha, 8.91%) and Chennai is least of (917 ha, 0.10%). Almost all districts Lakes, Ponds, and Tank are the dominant wetland types in Tamil Nadu. In Central Tamil Nadu, in Namakkal District, the wetland area of 7687 ha with a percentage of 2.29% of wetlands. In Karur district contains 16383 ha of a wetland area with 5.66% are wetlands and, in the Tiruchirappalli district, the wetland area of 18626 ha of wetland area which comprises 4.23% are wetlands (TNSWA, 2020). In CTN, some of 510 wetlands were available in diverse sizes but, few studies have investigated the wetland depth influence the key ecological states. Also, the local people's perception of wetland management remains poorly studied. Various studies on the wetlands ES and ES but correlation the wetland depth is in a few papers. The association of the stagnant wetland's depth versus the ecological condition (EC) and their land use, land cover (LULC) changes in the Central Tamil Nadu district (CTN), Tamil Nadu (Fig. 1). The Specific objectives such as

To examine the ecological state of wetlands in relation to human impact.

To identify the wetland degradation factors by using human Disturbance score (HDS) from the three districts of CTN,

To explore the link between wetland depth and wetland ecological ailment.

To evaluate the LULC types and changes over the periods in the CTN.

Materials And Methodsstudy Area

NAMAKKAL DISTRICT: Namakkal district is called Transport city or Egg city in (N; 11.36, 78.30 East) the state of Tamil Nadu, India. (Fig. 1) and separated from the Salem district with Namakkal town from 01 to 01-1997 onwards function independently. The district has two Revenue Divisions, Namakkal and Tiruchengode, and has 7 Taluks viz., Namakkal, Tiruchengode, Kumarapalayam, Rasipuram, ParamathiVelur, Kolli Hills, and Sendamangalam. Namakkal district had bounded on the North by Salem; Karur in the South; Tiruchirappalli, Perambalur district, Salem in the East and West by Erode district. This district is under the North Western Agro-climatic zone. The Namakkal District has 3,363 areas (sq. km) in the total area with a population of 14.96 lakhs. Namakkal District comprises a good forest area with moderate precipitation. The climate conditions such as hot during summer start from March to May and, winter is cold and misty (November to February). The annual precipitation is approximately 900 mm, and the mean temperature from 18°C to 40°C.

TRICHY DISTRICT: Trichy district at latitude 11o 20’ N,longitude:78o 10’E in the central region of Tamil Nadu, bounded to the north by Perambalur district, Pudukkottai district in the south, in the west Karur and Dindigul districts, and in the east by Thanjavur district. Trichy district comprising eight taluks, viz. Thuraiyur, Lalgudi, Musri, Trichy, Thottiyam M. nallur, Srirangam, and Manapparai. The Cauvery delta begins 16 km west of the city and is among the river systems that runs across Tamil Nadu. Cool Months December to February followed by Hot Months from March to May, Windy Months - June to August, and Rainy Months from September to November. The winter months were Maximum temperature 37.7° C and a minimum of 18.9° C. Rainfall varied from 778 to 821mm. The critical amount of rain earned in during Northeast Monsoons, which lasts from October to December. Southwest monsoon started in June and was an over-dominant force till the August end. The utmost population was in the Trichy Taluk comprises 45% of the total population. The total geographical area of 4, 40,383 hectares. Nearly 6% of the lands were under forest coverage.

KARUR DISTRICT: Karur Taluk merged with the Tiruchirappalli district in 1910. Karur district between 10°37’ N to 11°12’ N of latitudes, 77°46’ E to 78°15’ E of longitudes which on the banks of the Amaravati River. The Karur District is 6187 Hectares of total forest area. 25% population is present in the town areas. Precipitation receives from the Southwest and utmost in Northeast monsoons. The Southwest monsoon rains is erratic and, summer rains are insignificant. In the Karur district, the temperature ranges from17°C to 39°C and, the average temperature is 28.7°C. The Southwest monsoon onset from June, the Southwest monsoon onset and lasting till August brings scant precipitation since Karur is a rain shadow region. The majority of the rainfall is received in during summertime (late April and May), with the North-East monsoon arriving in October, November, and December. The average annual rainfall is 590–600 mm. Major river Cauvery is flowing on northern and eastern boundaries.

SATELLITE IMAGES

Mapitute Variant 2020 application had been used to establish Landsat satellite imageries compiled on 22/12/2020 regard to quality and clearness (just under 20% clouds) and used India Vavteq2012 for their picture. The map - based relation is 1:1,313,972 (Fig. 1a, and I b).

Method

From June 2019 to April 2020, wetland surveys and questionnaire inquiries were in the community inside one one-kilometer radius of each water body.

Wetland Selection.

We consider that the Temporary wetlands are dried out completely during the summer season (discover by field visit and with the questionnaire survey), an area less than 8 ha, and also included dryness duration per year. Wetlands are defined and classified differently in different countries, owing to their diverse variety of forms, sizes, and dispersion but followed Ramsar classification. There are many definitions of wetlands like water presence at the ground's edge or in the root zone during rainy season or distinct (hydric) soil circumstances distinct from non-wetland areas next to wetland areas and plants suited to continually or intermittently wet seasons (Mitsch and Gosselink, 2007).

Water quality analysis

Collected water samples from all wetland and stored in polythene bottles and then analyzed in the laboratory by using APHA method (APHA, 1985).

HUMAN DISTRUBANCE SCORE

A number of methodologies (interviews, ecosystem services (ES), human disturbance (HD), and physical parameters) were used to calculate the wetland's ecological and biological state. Wetlands are further classified as having a low, medium, or high impact on human disturbance. Water quality is concerned with the physical characteristics of water and the ecological state of wetlands. The Human disturbance score (HDS) protocol approach was used to assess the level of human disturbance to the wetlands (Gernes and Helgen, 2002). Using relevant information with the first cluster interview sessions, benefits produced in each wetland or the ecological services (ES) were secured and tested.

A field survey was carried out to investigate the ground impact of wetlands. Ecosystem Services, and the physical state of the wetlands. The collected data included several quantitative criteria to calculate the human perturbation element.

Factor 1: Critical zone-Disturbance within 50 metres of the wetlands -0-18 points

Factor 2: Buffer Zone-Disturbance within 500 metres of the wetlands' margin- 0-18 points

Factor 3: Habitat Alteration-Disturbance within 50 metres of the wetlands' edge- 0-18 points

Factor 4: Hydrological Change-Disturbance within 50 metres of the margin of wetlands-0-21 points

Factor 5: Pollution of Chemical disruption within 50 metres of the margin of wetlands-0-21 points

Factor 6: The presence or absence of fish yields a score of 0-4 points.

The standard enumeration method was used to collect information on wetland types, hydrological conditions, land use patterns, ecological state, and habitat evaluation. Finally, each component was rated and classified (ranked) into one of four categories ranging from best to worst, as previously indicated. Each study wetland's human disturbance gradient score (HDS) was calculated by adding all scored values from each element to a total of 100 percent. According to (Gernes and Helgen, 2002), if the category range of a specific wetland's HDS score falls within 0-33, 33-67, and 67-100. It can be categorised as least impacted, somewhat influenced, and most or strongly impacted. Respondents were asked to assign a value to the ES stated for each wetland based on relative relevance, namely socioeconomic variables, wetland importance, and management elements.

WETLAND ECOLOGICAL STATUS

Household Survey

ES was got from the native peoples by using questionnaire survey methods and field survey observations. From each wetland, a minimum of five household surveys (HHS) were randomly selected from the nearby area. 302 individuals took part in this study. A questionnaire comprising twenty questions structured into four sections: 1) The socioeconomic factors were family size, questioner age, appellant scale of formal qualifications, and sex. 2) The questionnaire comprises a factor-wise wetland degradation. The interview had been pre-tested before being managed in person to 302 respondents. Initial, rapid assessment of the wetland survey was carried out in 2 villages that were not part of the selected sample. The interviewers allowed to do pre testing to gain expertise with the questionnaire and provided an opportunity to apply and review the method. The focus was on considering how respondents assumed our questions and recognizing any problems met in providing solutions. Changes were proposed, reviewed, and incorporated into our final questionnaire. Try to cover all the questions raised by the researcher and In the survey conducted, first most senior accessible user asked.

Focus Group Discussion (FGDs)

During the focus group talks, the list of ES collected the results of the household survey was verified. During the survey period, Five public focus group discussions (FGD) were hosted in the villages with 5-10 individuals on median at every cluster. Members of the focus groups were chosen depending on their means of subsistence and reliance on the wetland. To prevent some of the recognised issues with focus debate clusters, we restricted group sizes to 5-10 persons and rated the listed ES throughout group conversations.

Key Informant Interviews

Before the survey, representatives from government agencies, non-governmental organisations, research institutes, and researchers were contacted for a list of the wetland's ecological services. During the interviews, the major questions concentrated on income-generating tactics and the causes of alteration in the wetland ecosystem. During the study, 15 delegates from various organisations were engaged, as key informants to assist us comprehend the arrays of variation and the causes for them. The crucial informants were chosen based on their understanding of wetland resources as well as their reliance on and engagement in wetland management.

2.3. Data Analysis

The statistical data were assessed to use regularity table and the Statistical Set (SPSS 25th Edition) for Social Sciences computer software tool, and the Shannon index approach was used to quantify avian diversity. Assess the dependency of a local population and the consequences of various influences on the wetland environment. Based on the study topics, the qualitative information from interviews was first classified and grouped into topics.; related coded themes were then grouped. The rating of ecological services was carried by utilising participative tools. Participants in focus group talks requested that essential ecosystems available from wetlands be identified. Following the listing of key ecosystem services, Scale of 1 to 10, participants rated the designated ecosystem services. (1 is the least preferred, and 10 is the most preferred).The overall ranking was calculated by dividing the total points for each ecological service by the digit of responders. Equally, the reasons of Qualitative approach were used to expose ecosystem transition (focus group talks) as well as household surveys.

LAND COVER AND LAND UTILIZATION

The latest research used ArcGIS to analyse variants in LULC classes in the Namakkal District. Landsat pictures (TM, ETM+, OLIS/TIRS) obtained as from U.s. Geological Survey (USGS, https://www.usgs.gov/) was used for data gathering, image recognition, and time-series classification data of LULC in the work area. Landsat 5 thematic mapper (TM) images containing six bands for 2001with the pixel resolution of 30-120meter, Landsat 7improved thematic mapper (TM) for 2010 with a resolution of 30 meters and 60 meters, and Landsat 8 in OLI operation land image with 9 spectral bands under resolving 114X 112 millimeter were gained from United States Geological Survey (UGGS) and map created by using ArcGIS software. All of the photos were taken between 2010 and 2019 and were cloud-free. The level 1 brands were previously estimated geographically at UTM zone 37N WGS84. The photos were aggregated and eliminated in ArcGIS 10.4 to use the study region boundary shapefile. Subsequent image advancements (typical falsified layout and standard deviation extend) yielded enough instructional polygons to define LULC kinds using ArcGIS 10.4's training design manager (Lillesand et al. 2015). Using the Variational Forest image classification method, the five pictures were grouped into five land-use subgroups (water bodies, rice cultivation, vegetative cover, built-up area, and forest areas). Breiman (2001) predicted unintended forestry, which was progressively adopted by specialists. This is due to the fact that it is more powerful than outdated image grouping algorithms and provides high classification accuracy when using demented and compact training data (Jin et al. 2018). The proportion variability (PC, Eq. 1) and transition probability designs were used to assess the level of different LULC variation (Fenta et al. 2017; Berihun et al. 2019). (Gashaw et al. 2017; Berihun et al. 2019).

PC=Ub−Ua/ Ua

Where PC= LULC rate of changes, Ua= area of start date LULC type, and Ub= area of end-date LULC type.

A land-use transition matrix was used to show how the position and region of various LULC types shift over time. This was accomplished utilising cross-tabulation and coincide passage in ArcGIS 10.4 application. The criterion tables obtained from these assessments were extracted to Microsoft Excel in calculating outer covering and rate of change over the years. The execution classification performance analysis (Kappa coefficient and overall accuracy) using ground Gps coordinates, aerial photographs, team debate, key informant meetings, and source images revealed the performance map precision (Congalton, 1991). The LULC categories of Namakkal district and their descriptions such as agricultural land (Including crops, vegetables, fruits, irrigated land), Barren land (all Barren lands) Built-up area (Including all residential, commercial, roads.), Cultivated land (Including all kinds of cultivation.), Water Body (Including all water bodies (river, lakes, stream, canals, and reservoirs). In 2019, data from the interviews, fieldwork, and Google Earth were used to sequential manner and permit the photograph. Approximately 50 to 60 test dataset points and Google Earth-Pro images were acquired in the ground by each LULC type (Lillesand et al. 2015). Ultimately, there are the categorized pictures of the five LULC classes, namely water bodies, cultivated land, agricultural areas, Barren land, and built-up areas with the help of Arcmap application software. All images covered the area of the Namakkal district. The range of study areas was separated by raster images by the spatial analytical tool in the ArcGIS mask extraction method. Three LULC maps and the distribution area information are presented in Fig 1.b.

LULC accuracy assessment

The categorised results are compared to the reference sets of data, that are believed to be accurate in identifying a classification, for accuracy assessment. Numerous practises are used to assess the accuracy of remote-sensed data and the user (Aronica and Lanza 2005). Change accuracy of LULC is influenced by issues such as sensor aspect issues and data pre-processing practises to use with standard situations during image capture (Morisette and Khorram 2000). In an error matrix, 3 distinct measurements are used in the accuracy processing and analysis on the error of commission or omission, accuracy of the user, producer, and overall accuracy (Coppin and Bauer 1996; Carlotto 2009). The Kappa coefficient, that can be used to calculate the accuracy rate required for all fundamentals, is an extra unit of measure in the illustration classification procedure (Foody 2010). In the latest research, 40 samples were selected for evaluation from 2010 to 2019. We used a stratified sampling method, collecting at least ten ground truth data points from the ground with each LULC class using GIS ArcMap application. The portion of overall accuracy of every attribute is computed using formula 1.

Overall accuracy = cumulative number of valid pixels amplified by the total number of pixels by 100 (1)

Results

302 people, respondents completed the questionnaire survey. The mean respondent's age in males was 41 yrs, and a female was 40 yrs. The respondent's occupations in farming (84%), poultry farming (9%), and others (56%) and the The average mean age, cumulative sample of people, and jobs were documented (Table 1).

Table 1
Description of survey respondents details in Central Tamil Nadu (CTN).

	Karur wetlands N = 102	Namakkal wetlands N = 95	Trichy wetland N = 105	Total N = 302
Male age	30 yrs	45 yrs	50 yrs	41
Female age	35 yrs	41 yrs	43 yrs	40
Female respondent	64	51	59	58
Male respondent	44	43	36	41
Occupation: Farming	19	17	48	84%
Poultry	3	4	2	9%
Others	21	17	18	56%

In CTND, each district 25 wetlands were selected for this study, and the GPS location, size, depth, and individual HDS Score were mentioned in (Supplementary file 1). These wetlands were selected based on easy accessibility and availability. The majority of the wetlands with in districts have elevations of up to 780 feet. The HDS value of each district's wetlands was mentioned in Table 2. The overall size of stagnant wetlands from 20 to a maximum of 665 acres in size was observed in the CTN during this study period.

Table 2
Overall average means, Standard Deviation and Standard error of Human Disturbance Scores in Central TamilNadu districts.

	KARUR			NAMAKKAL			TRICHY		
	AM	SE	SD	AM	SE	SD	AM	SE	SD
Factor 1 **Buffer Zone alteration**	6.5	0.33	1.67	12.00	0.00	0.00	12.00	0.00	0.00
Factor 2 **Landscape alteration**	12.0	0.00	0.00	10.56	0.52	2.62	12.50	0.35	1.69
Factor 3 **Habitat alteration**	2.6	0.61	3.04	10.80	0.85	4.24	7.00	0.47	2.28
Factor 4 **Hydrology alteration**	7.0	0.00	0.00	9.68	0.75	3.73	7.29	0.29	1.43
Factor 5 **Pollution**	7.0	0.00	0.00	7.28	0.28	1.40	8.46	0.59	2.91
HDS Score	28.9	0.70	3.51	50.32	1.37	6.84	47.25	0.88	4.31

In our study, wetlands disturbance due to 5 factors in the CTN. According to the stagnant wetland in a different district, the degradation was utmost in the TD wetlands, followed by ND and Karur district. Overall, factor-wise, wetland degradation is utmost due to landscape disturbance, buffer zone alteration, pollution, hydrological, Habitat alteration. The wetland's average mean, Standard deviation, and Standard Error had mentioned in Table 2.

Overall, the wetland buffer zone disturbance due to lack of protection, road construction and the road passing through the middle of wetlands, cattle grazing, dumping waste, infrastructure development, and damage to wildlife habitat were primary issues. In all three districts, the buffer zone disturbance is the utmost as construction of roads and lack of wetland protection. KD, roads construction (AM: 8.9, SD: 0.66, SE: 3.3) and lack of wetland protection (AM: 7.9, SD: 0.5, SE: 2.8), ND, construction of roads (AM: 7.4, SD: 0.71, SE: 3.5), lack of wetland protection (AM: 6.72, SD: 0.239, SE: 1.9) and in the TD, construction of roads (AM: 8.0, SD: 0.93, SE: 4.5), lack of wetland protection (AM: 6.25, SD: 0.25, SE: 1.2) (Fig. 2).

The factor-wise wetland degradation correlation with the wetland depth was mentioned in (Table 2). The results of spearman's correlation test show that there is a strong potential correlation between the wetland depth and the Buffer zone alteration ($r = 72, .484, p < 000$) and the wetland depth explaining that 23% variation in the Buffer zone alteration (Graph 1). In the Karur district, landscape destruction, like infrastructure development (AM: 9.1, SD: 0.61, SE: 3.0), and lack of protection, cattle grazing were major concerns. In Namakkal Landscape destruction, also the same as buffer zone disturbance, cattle grazing, and garbage dumping (AM: 5.04, SD: 0.44, SE: 2.2) increasing hutments around wetland habitats were the primary concern. In the Trichy district landscape destruction, lack of protection (AM: 6.50, SD: 0.50, SE: 2.4 and infrastructure development and hutment (AM: 5.50, SD: 1.24, SE: 6.1) are mentioned in Fig. 3. The correlation results show test show that there is a no significant negative relationship between the wetland depth and the landscape alteration ($r = 72, .-344, p < 003$) with the wetland depth(Graph 2).

In KD, the habitat alterations like residential buildings (AM: 1.6, SD: 0.55, SE: 2.7 and dumping of municipal waste (AM: 0.96, SD: 044, SE: 2.2), in ND, commercial buildings (AM: 8.16, SD: 0.58, SE: 2.9, and dumping of municipal waste (AM: 5.8, SD: 0.52, SE: 2.6) and Trichy district, cattle grazing and disposal of waste (AM: 3.75, SD: 0.60, SE: 2.9) are vital concerns of wetland degradation were observed and mentioned in Fig. 3. The results of the correlation test by Spearman indicated a strong correlation for both the wetland depth and the habitat alteration of wetlands ($r = 72, .571, p < 000$). The results showed that wetland depth explains 32% of the variation in the alteration of wetland habitat were noted (Graph 3). Pollution is quite less in the KD, but in ND, pollution is burning waste (AM: 6.4, SD: 0.38, SE: 1.9) and disposable wastes. The results of spearman's correlation revealed a non-significant, inverse correlation the wetland depth and the wetland pollution($r = 52, .-142, p < .317$) were mentioned in (Graph 4).

In all three districts, the hydrological alterations caused by size shrinkage, destination, and drought are vital for wetland degradation (Fig. 4). The results of spearman's correlation test show that there is a strong positive correlation among the wetland depth and the hydrology alteration ($r = 72, .475, p < 000$), the wetland depth explaining that 22% variation in the Hydrology alterations (Graph 5). In KD, habitat-wise, the wetland disturbance is caused by a buffer zone and landscape disturbance. The level of disturbance level was more or less similar in all areas. However, the Landscape disturbance, pollution, and hydrological alteration were at the same level in all three habitats. The overall wetland size was above 139 acres was recorded (Fig. 2). In TD, habitat-wise, the wetland disturbance caused by landscape disturbance, buffer zone disturbance is more or less the same in rural and semi-urban areas. The hydrological alteration was the same in all three habitats, but very less pollution damage to the wetlands. The overall wetland size was above 60 acres was recorded in the

Trichy district (Fig. 2). The HDS scores were categorized into three types. The scores were computed with the overall scores of a combination of five parameters of the individual wetlands (detailed mention in the method section) were mentioned in Supplementary file 1. Overall, the wetlands on the rural side were the dominant form, which contains above 84% of the wetlands category. In the KD, one urban wetland, two semi-urban, and the remaining 22 wetlands were rural side wetlands. The HDS scores range from 25 to a maximum of 32 points, and 24 (96%) wetlands were LI categories, and 1 (4%) were MI categories. In the Trichy district, three wetland urban and two suburban and the remaining 20 wetlands were rural side wetlands. The HDS Scores range from 44 to a maximum of 58 points, and all are Mid Impacted categories. In ND, two urban wetlands, two suburban wetlands, and the remaining 21 wetlands were rural side wetlands. The HDS Scores range from 44 to a maximum of 63 points. The 25 (100%) wetlands were MI categories were noted. The results of spearman's correlation test show that The wetland depth and HDS performances have a significant positive relationship (r = 72, .560, p < 000), the wetland depth explaining that 31% variation in the HDS was mentioned in the (Graph 6 and Table 3).

Table 3
Correlation table of factors wise wetland degradation against the wetland depth in the CTN.

	Wetland Depth	Buffer zone alteration	Landscape Alteration	Habitat Alteration	Hydrology Alteration	Pollution	HDS Score	Mean	Std. Deviation
Wetland Depth	1							6.87	5.009
Buffer zone alteration	.484**	1						10.14	2.796
Landscape Alteration	– .344**	-0.112	1					11.68	1.959
Habitat Alteration	.571**	.605**	-0.078	1				6.81	4.692
Hydrology Alteration	.475**	.262*	-0.162	.244*	1			8.00	2.586
Pollution	-0.142	0.089	0.072	-0.036	-0.031	1		7.81	2.258
HDS Score	.560**	.852**	0.056	.809**	.463**	.332*	1	42.11	10.782

District-wise, we observed that 37 wetlands were less than 5 feet depth and the (Average Mean (AM) 3.3, Standard Deviation (SD) .96 and the HDS scores (AM: 36.6; SD:10.9), 19 wetlands were 5–10 feet depth with the (AM: 7.61; SD:1.68) and the HDS scores (AM: 47.1; SD: 7.15) and 15 wetlands were above 10 feet depth (AM: 15.3; SD: 3.4) and the HDS scores (AM: 49.87; SD: 6.56) observed.

Table 4
Results of ANOVA Tests in the Stagnant Wetlands at three districts in CTN.

	KARUR	TRICHY	NAMAKKAL
Buffer zone disturbance	df (22,2) = 0.244; P < 0.001:0.969	NS	NS
Landscape disturbance	NS	NS	df(20,4) = .582; P < 0.001:0.815
Habitat Alteration	df(22,2) = 0.1.029;P < 0.001:0.606	df(18,5) = .278; P < 0.001:0.980	df(20,4) = 1.857; P < 0.001:0.291
Pollution	NS	NS	NS
Hydrology Alteration	NS	NS	df(20.4) = 1.841; P < 0.001:0.294

A comparison of stagnant wetlands in three districts of the CTND was assessed by survey respondents. The quantitative tests used to test variations among locations were generalized linear model statistical methods, and the results were given as F value (degrees of freedom), significance value, and effect size n2. N.S indicates that no statistically significant differences were discovered. Table 4 shows the result of ANOVA tests.The LULC maps of the CTN were produced for two reference years (2010, and 2019). The classified areas into classes as water bodies, agricultural land, barren land, cultivated land, and built-up areas. Three land cover maps, distribution area, and class percentage information had presented in Fig. 5.a.b.c and Table 5.

The district-wise wetland distribution area details had mentioned in Table 5. In all three districts, agricultural land areas were dominant in 2010 but, a gradual reduction of area size in 2019 except TD followed by an increase of build-up lands but a decline in water bodies' size nowadays.

Table 5
.Wetland distribution area in the districts of Namakkal, Karur and Tiruchirappalli district (unit: US acre)

Class	Namakkal District (ND)				Karur District (KD)				Tiruchirappalli District (TD)			
	2010		2019		2010		2019		2010		2019	
	Sum of area Us acre	Total %	Sum of area Us acre	Total %	Sum of area Us acre	Total %	Sum of area Us acre	Total %	Sum of area Us acre	Total %	Sum of area Us acre	Total %
Agricultural land	367782.72	43.74	166401.84	19.76	386649.74	63.145	267600.34	37.84	199053.56	25.33	417870.8	44.07
Barren land	25982.49	3.09	2417.93	0.28	35732.273	5.836	27149.976	3.83	152535.36	19.41	710.3167	0.075
Buildup land	144531.14	17.18	413127.99	49.06	121793.84	19.89	274142.51	38.77	108953.05	13.87	104316.6	11.01
Cultivated land	298142.6	35.45	254499.16	30.22	49137.374	8.025	138292.33	19.55	297833.33	37.90	182742.91	19.27
Waterbodies	4397.67	0.52	5509.9	0.65	18982.237	3.10	51.671	0.007	27431.066	3.49	242602.57	25.58
Grand Total	**840836.61**	**100**	**841956.81**	**100**	**612295.47**	**100**	**707236.82**	**100**	**785806.38**	**100**	**948243.21**	**100**

The landscape type 2010 was considered a basic map in all three districts. The two periods of wetland landscape raster maps were overlapped, and intersect maps properties were separated using ArcGIS software 10.7.1. The LULC map initial state of the transition matrix and the area type of classification were calculated from the period 2010 to 2019 were mentioned in (Table 6.7.8). The initial transition matrix was calculated and for mapping and calculation using maximum livelihood type.

Table 6
Wetland type area transition matrix from 2010 to 2019 in Namakkal district (Square miles)

Land class 2010		Land class 2019 (SQ.MILE)					
Row Labels	Sum of area	Agricultural land	Barren land	Buildup land	Cultivated land	Waterbodies	Grand Total
Agricultural land	1.156951	41157.33179	1.408421	2324381.32668	13748.15828	124.52873	2379412.4673
Barren land	654.98944	195903.60201	1.380364	1744089.08750	4556.82968	4.555858	1944553.3282
Buildup land	495029.29951	201879.69122	1.730716	4826585.86350	93460.27459	141.49455	5122069.8454
Cultivated land	17350311.30863	61536.18982	3.046937	3759654.32472	116465.0134	55.934609	3937701.4741
Waterbodies	241.894095	0.34009878	0.010086	55543.11211	64008.40194	93.048533	119644.9507
Grand Total	29415733.49157	500477.20096	7.576527	12710251.3979	292238.7932	419.56229	13503382.4520

The transition data (data depicts the transition of LULC in one form to another. All classes in ND, experienced a progressive percentage of change. The transition matrix showed decreasing agriculture land, cultivation land, water bodies including rivers, barren land, and increasing built-up areas all over the district. Percentage-wise changes in all three districts and overall details were mentioned in Table 5 and Fig. 5.b. The accuracy level of the LULC map, including overall accuracy, producer's and user's accuracy also recorded in all three districts. Also, calculated the Kappa accuracy by using the formula. In producers accuracy and Users accuracy were 100% except for Buildup land (72.7%). The overall accuracy showed that in 2011(95%), and 2019(87%) were noted. The Kappa accuracy in 2010 (0.937) and 2019 was 0.69 recorded.

Table 7
Wetland type area transition matrix from 2010 to 2019 in Karur District (Square miles)

Land class 2001		Land class 2019 (SQ.MILE)					
Row Labels	Sum of area	Agricultural land	Barren Land	Buildup Land	Cultivated land	Waterbodies	Grand Total
Agricultural land	1.669	5.72222	118.2395	2.03057	23086.1252	0.02897	7.9848
Barren land	678.5374	1.86069	582.7608	5.47137	5.2019	0.0399	2.4604
Buildup land	19345.3745	2.431289	222.4736	7.28895	22312.5851	0.0547	3.1827
Cultivated land	4.28515	3.717580	1063.4751	1.03567	17111.1924	0.02277	4.9350
Waterbodies	800.0775	5.065505	2256.5689	9.0313	32156.5248	0.0185	6.3127
Grand Total	1.6763	5.74253	4243.5182	1.6729	1.4668	0.1649	7.5664

The gradual proportion of transition occurred among all classes in Karur District from 2010 to 2019. The results revealed decreasing land for agriculture, cultivation land, water bodies including rivers, barren land, but increasing buildings all over the district. The producer's and users' accuracy was 100% except for buildup land (97.7%), and the overall map accuracy showed in 2010 (95%) and 2019(87%). The Kappa accuracy in 2010 (0.809) and 2019 was 0.74 had observed.

Table 8
Wetland type area transition matrix from 2010 to 2019 in Tiruchirappalli District (Square miles)

Land class 2001		Land class 2019 (SQ.MILE)					
Row Labels	Sum of area	Agricultural land	Barren Land	Buildup Land	Cultivated land	Waterbodies	Grand Total
Agricultural land	8.3607	5.17890	0.3994	6278.3389	9.2100	1.4937	5.4266
Barren land	36376.2944	5.285391	1.2305	1979.3548	4.2219	9.6100	4.4256
Buildup land	28590.4417	4.7574	0.7058	2673.8559	5.1204	1.1237	4.9236
Cultivated land	3.7051	3.0671	1.1226	4245.9994	28601.3881	7.5604	3.1756
Waterbodies	3305.7545	1.9225	0.6124	409.6322	13722.3503	4.9769	2.5615
Grand Total	4.6095	1.84811	4.0708	15587.1814	2.2784	4.8322	1.9207

The change matrix analysis shows the transition had occurred among all classes in TD. The transition matrix showed decreasing land for agriculture, cultivation land, water bodies including rivers, barren land, and increasing in the built-up areas all over the district. In producers and users, accuracy was 100% except for buildup land (87.2%). The overall accuracy of the map showed in 2011(96%) and 2019(87%), and the Kappa accuracy in 2010 (0.913) and 2019 was 0.89 recorded.

Discussion

The physical characteristics of the stagnant wetlands had categorized into seven parameters for a better understanding of wetlands. In CTN, physically, there are differences among the wetlands structures. The temperature ranges from 23°C to 29°C according to season, and water temperature is highest in the summer because of the hot climatic season and open nature of the wetland site. Overall, 87% of the wetlands were colorless, Leftover wetlands are indeed green due to abundant phytoplankton and harmful algal blooms; concentration of pollutants and corrosion are typically green. The chemical parameters were not done on all individual wetlands, but the selected wetlands used for drinking and agricultural purposes. There is a correlation between wetland depth and the Buffer zone alteration reported. In our study, in all three regions, the buffer zone disturbance utmost as construction of roads and lack of wetland protection leads to a lack of nutrient accumulation. Evolves in wetland morphology convolution and coalescence as human nuisance levels increase (Liu and Cameron, 2001 and Li et al., 2010). Our study also suggested that all three wetlands were being destroyed by landscape destruction, like infrastructure development, and lack of protection, cattle grazing, hutment was a vital concern. Our study also supported that livestock drinking and grazing were abundant in wetland habitats in CTN and also, provided a negative impact if overused. The negative correlation of wetland depth and the landscape alteration reported, and landscape alterations of human modernization of natural environment within adjoined terrain has had a huge impact. within 500 meters from the buffer zone in most of the wetlands in CTN due to lack of fencing. Human impacts have completely affected surroundings in human-populated areas, and this landform shift has become a significant driver of ecological systems globally (Lofman, Kouki 2001, Naveh 2007). Our study also supported that the landscape alteration of all three districts was because of anthropogenic activities in the CTN. A positive correlation between wetland depth and the Habitat alteration was reported. However, alteration had caused by several factors. Habitat alterations such as residential buildings and dumping of municipal waste are vital issues In the Karur district, which affect the quality, overall health of the ecosystem. Also, the impact was much low because of the lack of water availability most of the year. In ND, Habitat alterations like commercial buildings and dumping of municipal debris are important issues observed. In the Trichy district, Habitat alterations such as cattle grazing and disposal of waste are vital concerns. Pollution-wise, a negative correlation with the wetland depth had reported. District-wise, the Pollution level is less in the Karur district whereas, in Namakkal and Trichy district, burning waste and disposable dumping were general around the Wetlands habitat. Hydrology alteration had caused by several factors but, a positive correlation between wetland depth and the hydrology alteration had reported. Wetland hydrology measurement also enables the identification of local climatic changes (Schuyt, Brander 2004).In CTN, stagnant wetlands had various depths during the flooding period and summer season. The wetlands depth had based on wetland types, locations, and hydrology. Our study has supported the depth and duration of water flowing in different wetlands that can be extremely variable (Rahman Ahidur 2016). In the CTN, the Trichy area receives rainfall during the Southwest and North-East rainfall, rivers, and dams. In Namakkal and Karur areas, the water source is mainly from the annual precipitation itself. Stagnant Wetlands in the different districts had various sizes observed. Our study revealed those wetland conservation projects had based on size and water holding capacity during summer. In the Indian subcontinent, the precipitation concentration over a short period of June-September followed by a hot season over the large variability of Total rainfall ranging from 20% -100% has a significant impact on the wetlands. The water level of river systems, lakes, and waterways varies greatly seasonally and year over year. Maintenance of the buffer strips as a critical factor governing their longer-term nutrient retention effectiveness (Hille et al. 2019).

The positive correlation between wetland depth and the HDS Scores reported and wetland alteration is caused by several factors. In all three districts, hydrological alteration, caused by size shrinkage, destination, and drought, is a vital source for the degradation of wetlands. Our study supported that even with a slight change in hydrologic condition, Transformation in biota richness, species diversity, and ecosystem efficiency may result (Prasad et al. 2002). Overall, the rural side wetlands were the dominant (84%) of the wetlands category. HDS scores were higher in urban side wetlands because of anthropogenic activities. Urbanization has become a critical cause for losing wetland areas in developing countries because of commercial buildings, road infrastructure, and residential development. Our study supported that Wetland ruination in rapid urbanisation weakens wetland careers in long-term urban wetlands (Booth, 1991; Knutson et al. 1999: Lehtinen et al. 1999: Azous and Horner, 2000). Wetlands are evolving due to changes in hydrology, increased nutritional and pollution runoff, overexposure to introduced species, and increased breakdown because of impacts of urbanization. In Karur district, out of 25 stagnant wetlands, 22 wetlands were rural side wetlands under the status of (96%) LI category because of non-usage and less anthropogenic activities. However, in TD and ND, over 20 wetlands were rural-side presence under MI categories.

Our study revealed little information on stagnant wetlands distribution, mapping, and correlation of wetland depth with the Ecological status in the Central Tamil Nadu district. Our LULC evidenced the drastic drop of wetland areas, together with water bodies, in the study area over the last ten years (2010–2019). Many studies have reported that wetland regions are being lost due to urban growth, which our survey endorsed (Belayneh et al. 2020; Hailu et al. 2020). The emergence of built-up areas in CTN was the significant driver for their evolution by discharging, infilling, and vastly increased wetland habitat, as assisted by many other publishers (Mao et al. 2018; Huang et al. 2019). The transition matrix of the CTN district from 2010 to 2019 had created by the maximum likelihood method. The results showed that gradual changes in LULC in all the classes and all districts had observed. The transition matrix revealed decreasing land for agriculture, rivers, and pond, but an increase in water bodies, and few differences in buildup areas. Overall (7%) size reductions were noted from the period 2010 to 2019. The built-up area has been expanded every year because of urbanization. The increase in building is inversely related to increase in population, which disrupts the sensitive ecological integrity by over-using natural resources and exacerbating waste problem. Our research found that newly built infrastructure projects, as well as various market facilities among residences, have attributed to the shrinking of wetlands, water bodies, cultivated land, vegetative cover, and rangeland. Human systems are not complex machines; they frequently have a direct impact on ecosystems, such as expanded particulate pollution, water, and land, as well as biodiversity loss. The built-up area expansion had caused by rapid population growth. In our study area, as per the 2011 census of India, district KD has (1,064,493), Trichy (2,722,290) and Namakkal (1,726,601) and in 2021 is (1,124,822), (1,181,912), (1,824,454) respectively (estimates as per aadhar uidai.gov.in Dec 2020 data). Increasing the population status over the period is impacted by the built-up areas in all three districts. Also, 2011 census, above 47% lives in urban regions of the district. Built-up area increasing trends all over the three districts, especially sudden rise after 2011. Because of monitoring the implementation, there would be a substantial growth in constructed land in the state's southern part in socio-economic development. Rivers, and Ponds gradual reduction of the area from the period to 2019. However, the impact is decreasing from 2011 onwards to 2022. In producers accuracy and Users accuracy were 100% except for Buildup land. The overall accuracy showed in 2010 (96.6%) and 2021(87%) was observed. Drastic changes of increasing built-up area in CTN state because of many reasons. Abolish the system of the joint family (especially matrilineal) and the development of nuclear families. The emerging trends in urbanisation boosted the pace of the housing unit against 2017. A significant rise in remote population movements to neighbourhood locations is because of jobs oriented. Overall, these research findings can offer the water quality in CTN, provide details that can be used to pinpoint pollutants and their impacts. Also, Lulc recognition setting clear lawmakers in the efficient oversight of the land use region.

Conclusion

The first time, we had surveyed 25 wetlands in each district to determine the wetland depth associated with their ecological status in the CTN. Studies revealed that wetland degradation because by the factors such as landscape disturbance, buffer zone alteration, pollution, hydrological alteration, and habitat alteration. Also, WD is a positive relationship with alteration of buffer zone, habitat, hydrology, and HDS Score, but a negative relation with landscape alteration and wetland pollution. The wetland degradation was the utmost in the district Tiruchirappalli, followed by Namakkal and Karur district. Except In KDW, the remaining district wetlands were MI category. Varied HDS had observed among the regions. Studies supported that WD had based on water availability throughout the year, but SW were facing water shortages because of a hydrological alteration and lack of management activities. District-wise wetland depth showed that 54% (less than 5 feet), 25.6% (5–10 feet) 20.2% (100%) categories and, the rural side wetlands were the dominant form in all districts. Overall, the ES of wetlands against the water depth showed that a strong correlation between them. The impacts of LULC changes over 9 years confirm that severe decline in wetlands habitat and water bodies' size, because of established territory, arable land advancement, increasing urban population, and demand to feed the population. For wetland management, needed the data such as individual wetlands, LULC, and human disturbance scores. Also, expanding the research on other parts of the districts will be useful for the documentation of regional wetlands. Our study suggested that the depth of wetlands leads to some quantified amount of impact on wetlands, and more research will be required to evaluate the influence on wetlands.

Declarations

The authors declare no conflict of interest.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Dr. Varunprasath Krishnaraj: Supervision, original draft writing, conceptualization, writing review, final analysis, and editing.

Subha Mathesh: Data collection, Investigation, Visualization, Formal analysis,

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Not applicable

CONSENT TO PARTICIPATE

Not applicable

CONSENT TO PUBLISH

Not applicable

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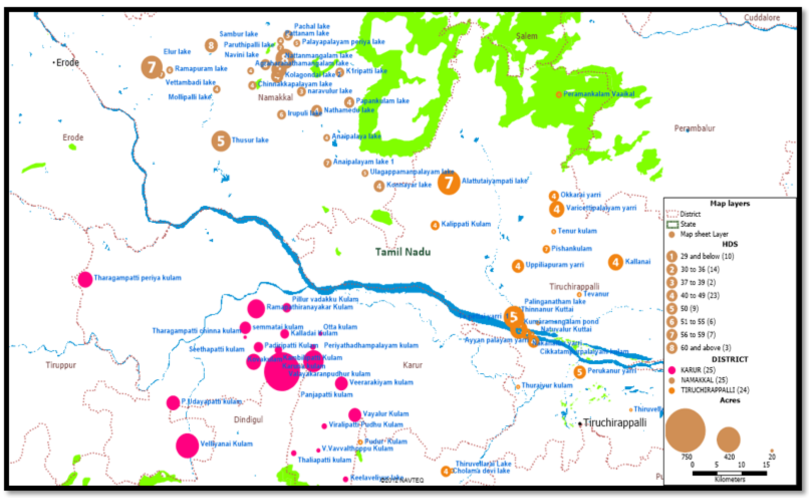
Graphs

Graph 1 to 6 are available in the Supplementary Files section.

Figures



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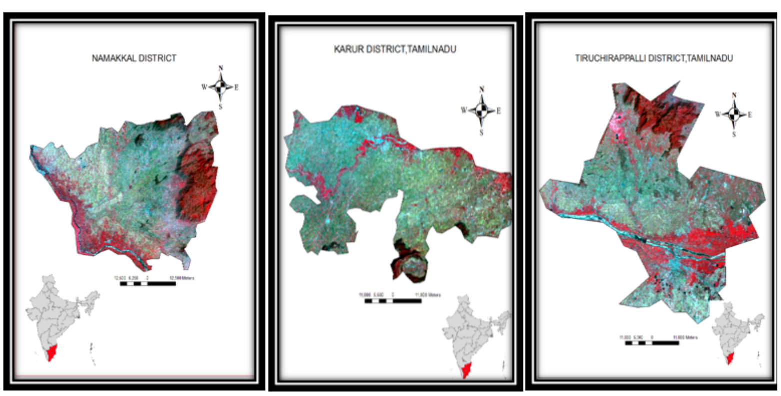


B

Figure 1

a. GPS location of surveyed stagnant wetlands in the Central TamilNadu District (CTN). b) Location map of Central TamilNadu districts as Namakkal, Karur and Tiruchirappalli created by using Arc GIS software.

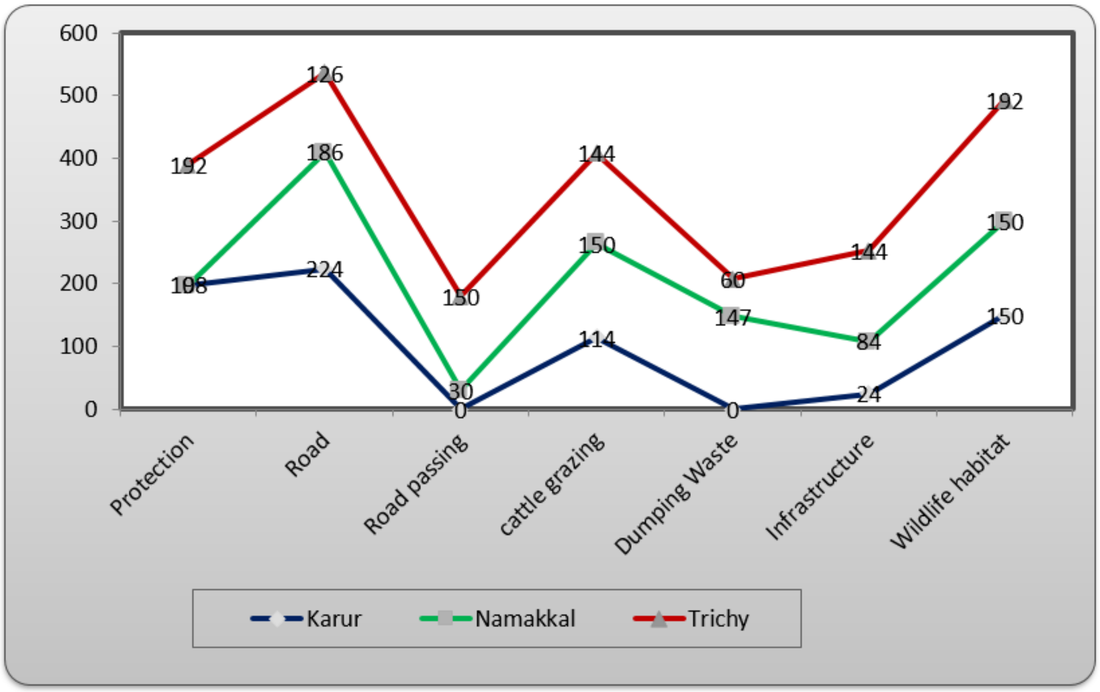


Figure 2

District wise the wetlands degradation in the Buffer zone areas disturbances in the Central TamilNadu district.

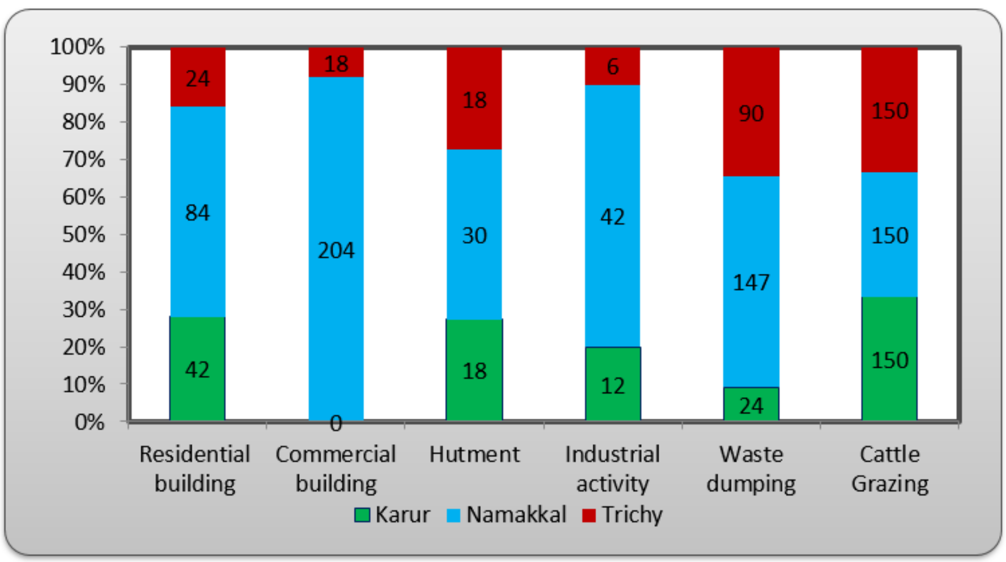


Figure 3

Overall wetlands degradation due to Habitat alteration factors in the Central TamilNadu district.

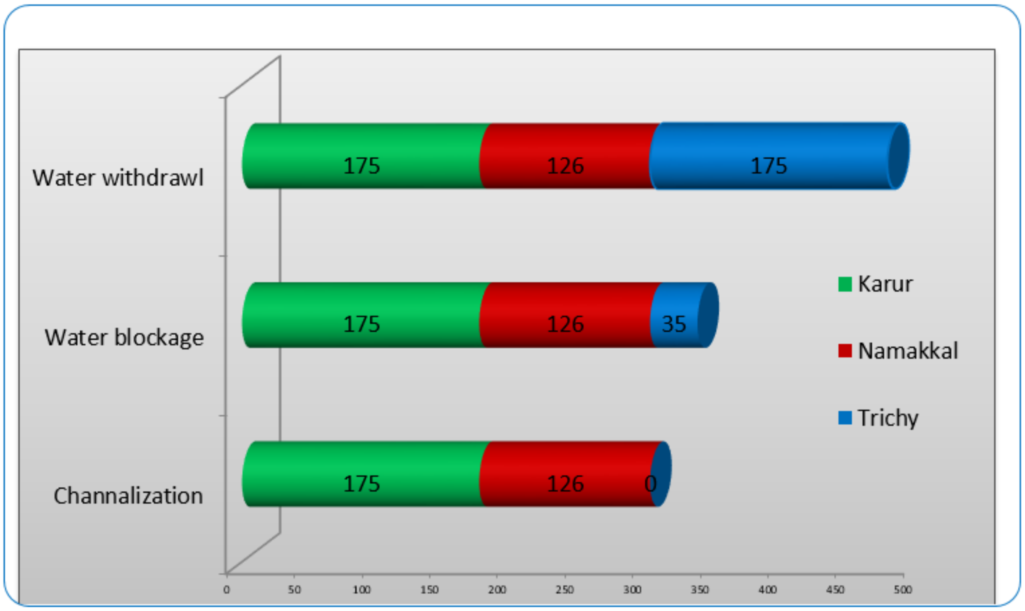
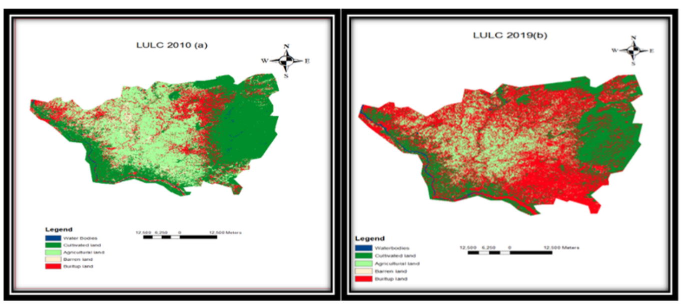


Figure 4

Overall wetlands degradation due to hydrology alteration in the Central TamilNadu district.



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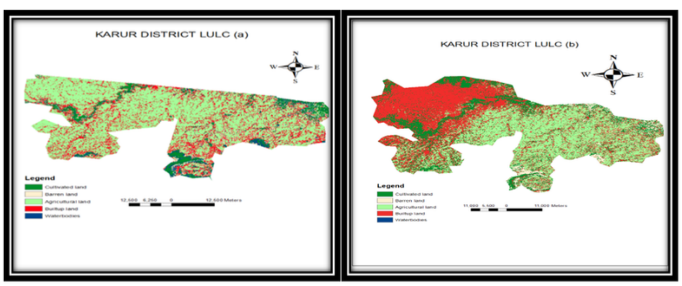

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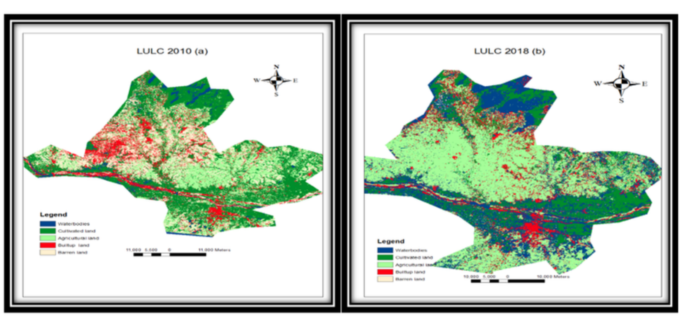

C

Figure 5

a. Land use/land cover classification in Namakkal District in 2010(a) and 2019(b). b. Land use/land cover classification in the study site in 2010 (a) and 2019 (b) in Karur District. c. Land use/land cover classification in Tiruchirappalli District in 2010(a) and 2019(b).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Graph12.png
- Graph34.png
- Graph56.png
- SUPPLEMENTARYFILE.docx