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Spatio-Temporal Analysis of Wetlands of Thrissur District, Kerala, India: A Study Based on Remote Sensing and Geographic Information System

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Abstract: Wetlands are crucial ecosystems that are temporarily or permanently covered by water. The aim of this study was to analyse the spatio-temporal changes in wetlands of Thrissur district from 1973 to 2020. Remote sensing and geographical information system were employed for the analysis. Inland wetlands comprise of paddy wetlands, reservoirs, rivers/streams and canals, lakes and ponds/tanks and pits waterlogged due to mining. Coastal wetlands encompass estuaries, backwaters and mangroves. Results of the study revealed a declining trend in total wetland area. Total wetland area reduced from 79,209.50 hectares in 1973 to 46,313.62 hectares in 2020. From 1973 to 2020, total area under inland wetlands decreased from 76,714.73 hectares in 1973 to 56,337.2 hectares, 43,158.96 hectares and 43,059.20 hectares in 1995, 2008 and 2020 respectively. The disappearance of paddy wetlands was the main reason behind the decline in total wetland area, because paddy wetlands constituted more than 70% of total wetland area. The total area under coastal wetlands increased from 2,494.77 hectares in 1973 to 2,711.66 hectares and 3,298.71 hectares in 1995 and 2008 respectively. From 2008 to 2020 coastal wetlands reduced slightly by 44.29 hectares.

Keywords: Wetlands, Reclamation, Land use, Geospatial technology and Ecosystem.

Introduction

Wetlands are productive ecosystems that deliver numerous ecosystem services to man and other species on earth. According to Cowardin et al (1979) "WETLANDS are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water". The Ramsar Convention (1971) defines wetlands as "areas of marsh, fen, peat land or water, whether natural or artificial,

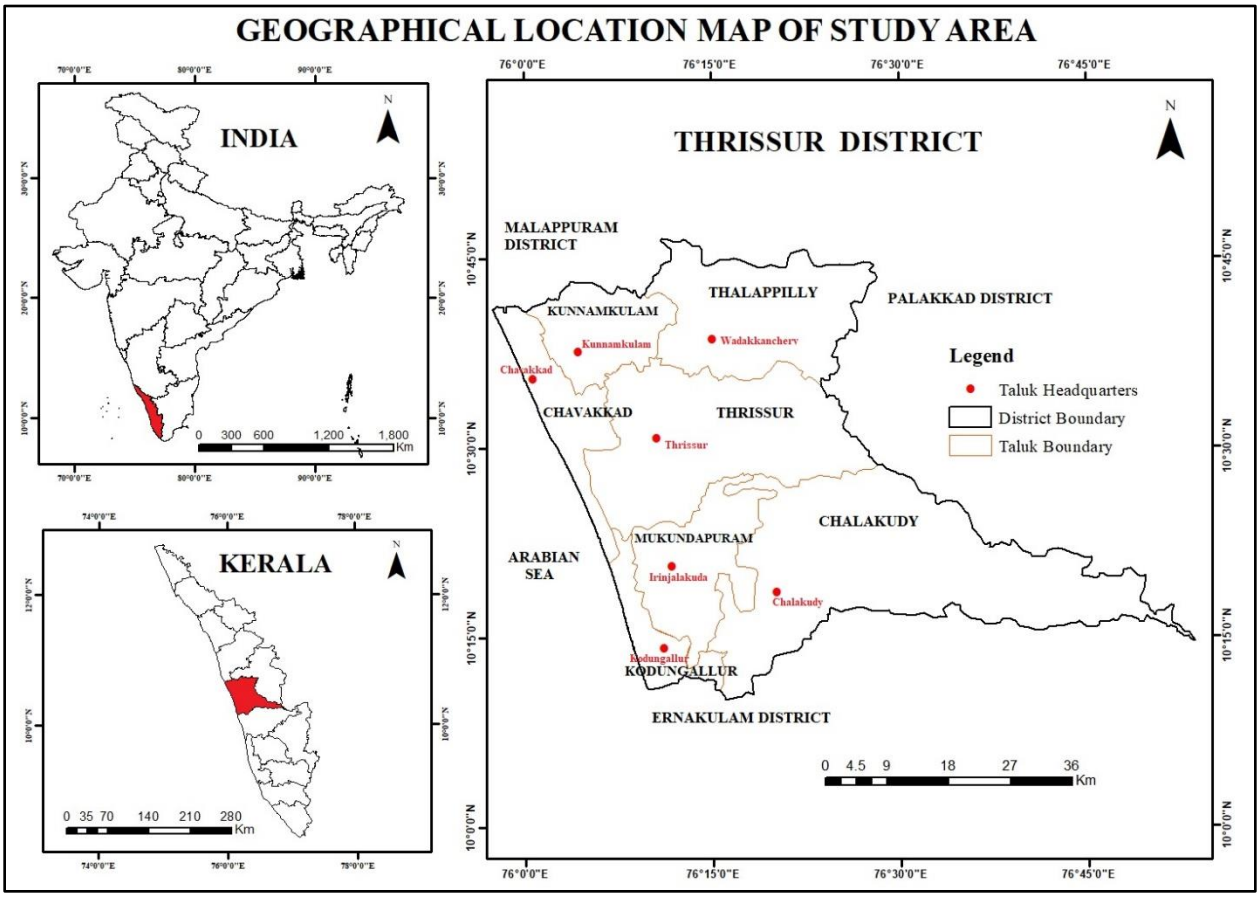
permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". Wetlands are "natural infrastructure" because they contribute to human welfare (Barbier, 2011).They are diverse depending on their origin, geographical location, water regime, soil, sediment characteristics etc. (Space Applications Centre, 2011). The unique geographical characteristics of Thrissur district coupled with abundant rainfall led to the presence of a diverse variety of wetlands such as paddy wetlands, rivers/streams, reservoirs, canals, estuaries, backwater, lakes, ponds and mangroves. These ecosystems are intertwined with the lives of the people as they provide a vast array of ecosystem services including coastal protection, provision of livelihood, groundwater recharge, water purification, recreation etc. These valuable ecosystems are under peril as they are under the threat of human developmental activities. Wetlands are subjected to reclamation, pollution and deterioration. During the past 300 years, there has been an 85% loss in the wetland extent of the world (UNESC, 2022). Therefore accurate and timely identification and mapping of wetlands of a region will aid in monitoring, conservation and sustainable management of wetlands.

Objective: The objective of this study is to analyse the spatio-temporal changes in wetlands of Thrissur district from 1973 to 2020.

Materials and Methods

Study Area: Thrissur district is located in the central part of Kerala state (Figure No.1). Positioned between the Arabian Sea and Western Ghats, Kerala lies in the south-western tip of India. Thrissur district bears the coordinates of 10° 10′ and 10° 46′ North latitudes and 75° 57′and 76° 54′ East longitudes and has a total area of 3032 km². Thrissur district accounts for 7.8% of the total area of Kerala and ranks 5th in terms of area among the 14 districts of Kerala. The district is surrounded by Malappuram district and Palakkad district in the north, Idukki district and Ernakulam district in the south, Palakkad district and Coimbatore district of Tamil Nadu in the east and Arabian Sea in the west. The length of coastline is 54km. Thrissur district can be divided into 3 physiographic divisions i.e. Highland (elevation greater than 75m), Midland (elevation 7.5m to 75m) and Lowland (elevation lesser than 7.5m). The general climate of the district is tropical humid climate.

Figure No.1: Thrissur District: Geographical Location



Methodology

Landsat imageries (Table No.1) were downloaded from US Geological Survey website (https://earthexplorer.usgs.gov). After necessary radiometric and geometric rectification, the respective bands of the images were layer stacked and subsequently subsetted with the shapefile of the study area. The projected coordinate system is UTM WGS 84, zone 43 N projection. The 1973 Landsat image was resample to 30m resolution to match with imageries of 1995, 2008 and 2020. The bands were set to False Colour Composite.

Table No.1: Satellite Imageries of Thrissur District, Kerala

Satellite	Sensor	Date of Acquisition	Resolution (meters)	WRS_Path	WRS_Row
Landsat 8	OLI_TIRS	2020-01-11	30	144	53
Landsat 5	TM	2008-12-27	30	144	53
Landsat 5	TM	1995-01-04	30	144	53
Landsat 1	MSS	1973-01-23	60	144	53

The wetlands of Thrissur district were categorized into inland wetlands and coastal wetlands. Inland wetlands consist of paddy wetlands, reservoirs, rivers/streams and canals, lakes and ponds/tanks and pits waterlogged due to mining. Coastal wetlands consist of estuaries, backwaters and mangroves. After setting the image into false colour composite, on screen manual digitization following on-screen visual interpretation was performed. Initially

separate shapefiles were created for every wetland. For instance, every reservoir was digitized separately, then all the reservoirs were merged into a single shapefile. The same process was followed for rivers and canals, estuaries and backwaters, mangroves, waterlogged pits, lakes and ponds. This process was done for wetlands of 1973, 1995, 2008 and 2020 separately. The area under each category of wetland and change in area was estimated. The softwares used for this study were ArcGIS 10.3, Erdas Imagine and Microsoft Excel.

Results and discussion

Wetlands of Thrissur district: Paddy wetlands, rivers/streams, reservoirs, canals, estuaries, backwater, lakes, ponds and mangroves and land left waterlogged due to mining are the wetlands of Thrissur district. Paddy wetlands constitute the largest category of wetlands in the district. They are used for the cultivation of rice and for integrated rice-shrimp farming. The district is also home to a unique wetland system named Kole wetlands, which is a part of the Ramsar site- the Vembanad –Kole. The major rivers of the district are the Chalakkudy, Keecheri, Puzhakkal, Karuvannur and Bharathapuzha. Major reservoirs are Peechi, Chimmony, Vazhani, Sholayar Peringalkuthu, Asurankundu and Pathazhkundu reservoirs. Main lakes are Eanamakkal lake, Muriyad lake and Kattakambal lake. Numerous ponds of varying sizes can be seen in the district which serve the purpose of irrigation, fishing, ground water recharge etc. Thrissur district is home to two estuaries- Azheekode estuary and Chettuva estuary. Kodungallur backwaters is an important backwater systems of the study area. Thrissur district is interconnected with numerous inundation and perennial canals. Canoly canal is part of the National Waterway-3. Mangroves can be found in Chettuva estuary and backwaters, near Eanamakkal lake, Kodungallur backwaters, Azheekode estuary and Mullassery, Venkidangu and Pavaratty panchayats.

Figure. No. 2: Wetlands of Thrissur District – 1973

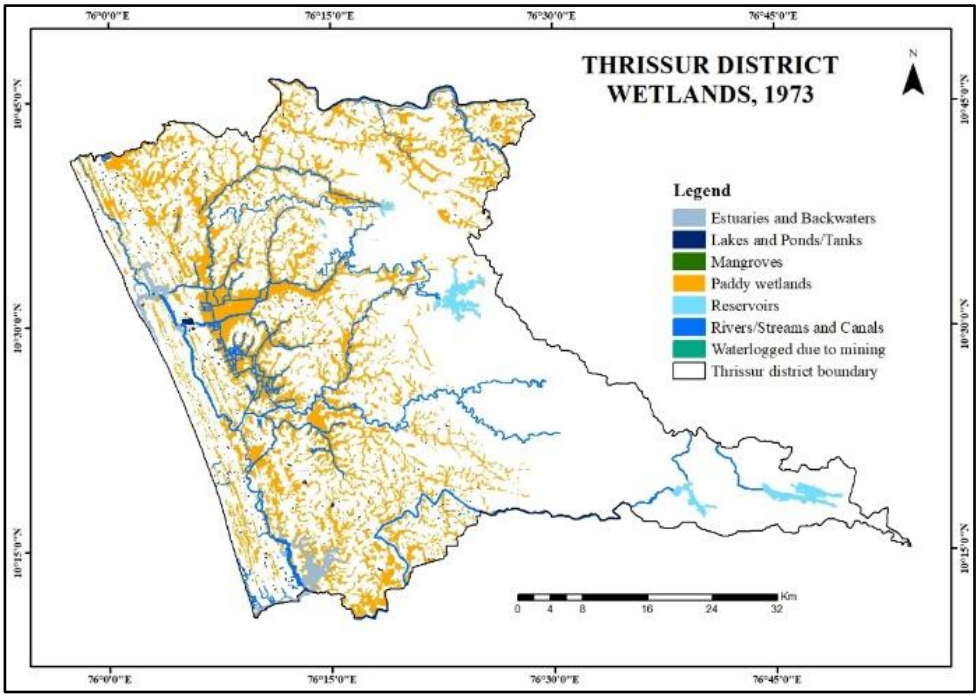


Figure. No. 3: Wetlands of Thrissur District – 1995

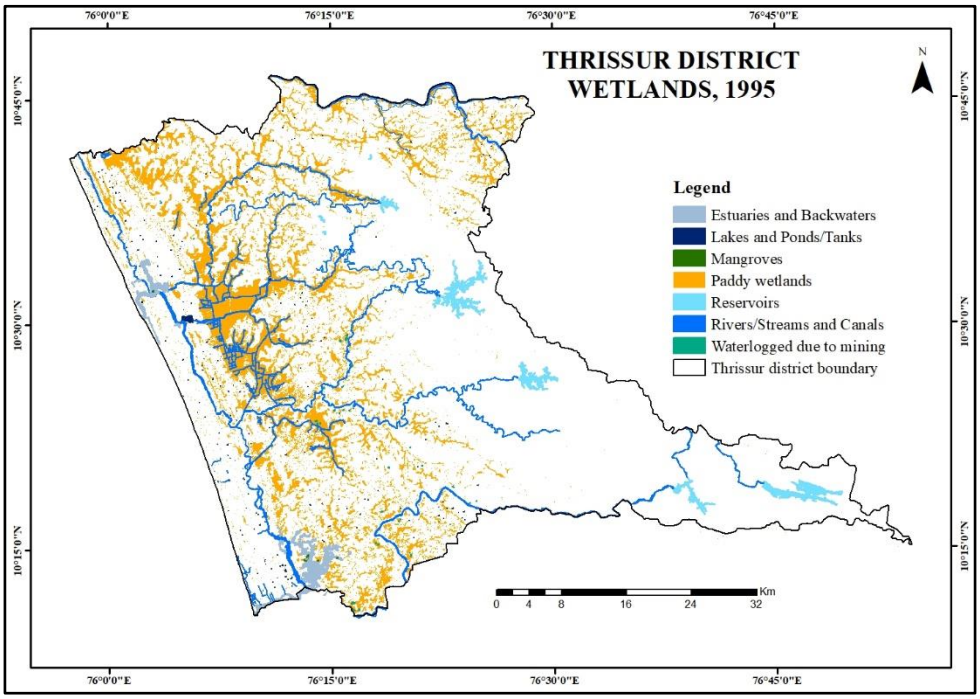


Figure. No. 4: Wetlands of Thrissur District – 2008

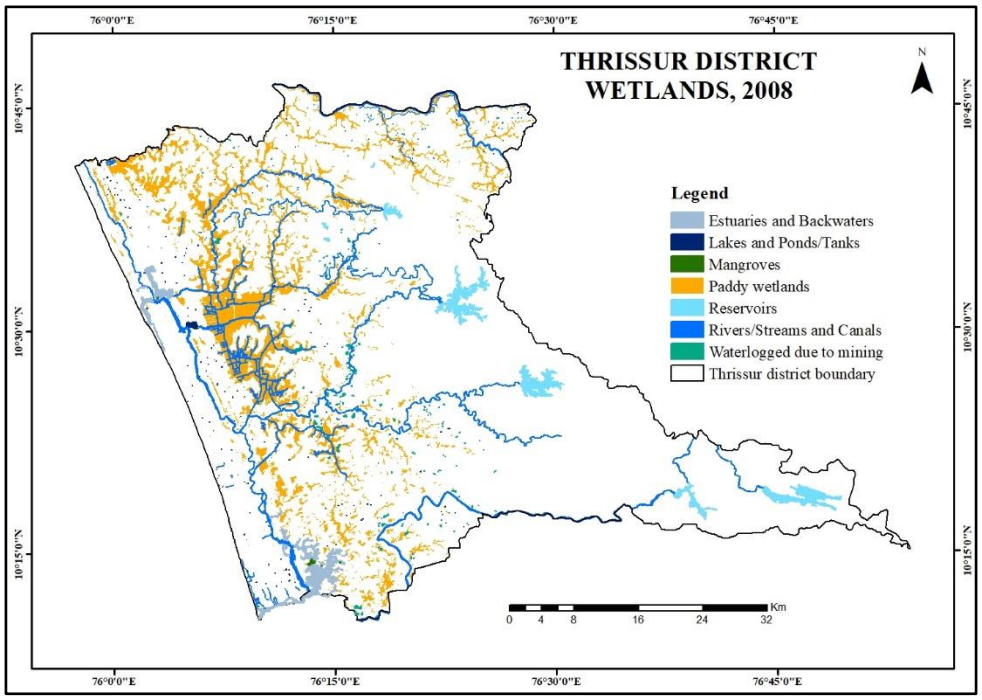


Figure. No. 5: Wetlands of Thrissur District – 2020

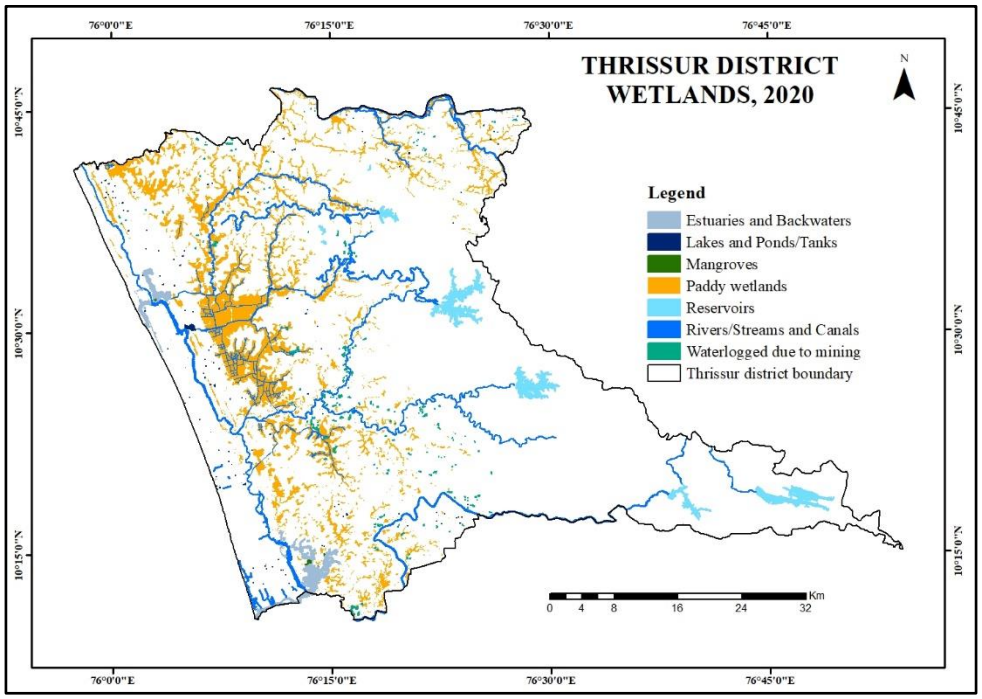


Table. No. 2: Area of Wetlands in Thrissur District - 1973, 1995, 2008 and 2020

Types of Wetlands	Sub-types of Wetlands	1973	1995	2008	2020
		Area (Ha)	Area (Ha)	Area (Ha)	Area (Ha)
Inland Wetlands	Paddy Wetlands	66236.26	45686.08	32688.92	32431.62
	Reservoirs	2071.25	2719.21	3156.29	3402.54
	Rivers/Streams and Canals	7497.51	7043.99	6349.17	6240.76
	Lakes and Ponds/Tanks	897.13	789.91	616.32	512.19
	Waterlogged due to mining	12.58	98.01	348.26	472.09
	Sub-total	**76714.73**	**56337.20**	**43158.96**	**43059.20**
Coastal Wetlands	Estuaries and Backwaters	2411.36	2651.80	3264.46	3205.48
	Mangroves	83.41	59.86	34.25	48.94
	Sub-total	**2494.77**	**2711.66**	**3298.71**	**3254.42**
Grand total		**79209.50**	**59048.86**	**46457.67**	**46313.62**

Source: Computed by authors from Landsat Imagery

Figure. No. 2: Area of Wetlands in Thrissur District - 1973, 1995, 2008 and 2020

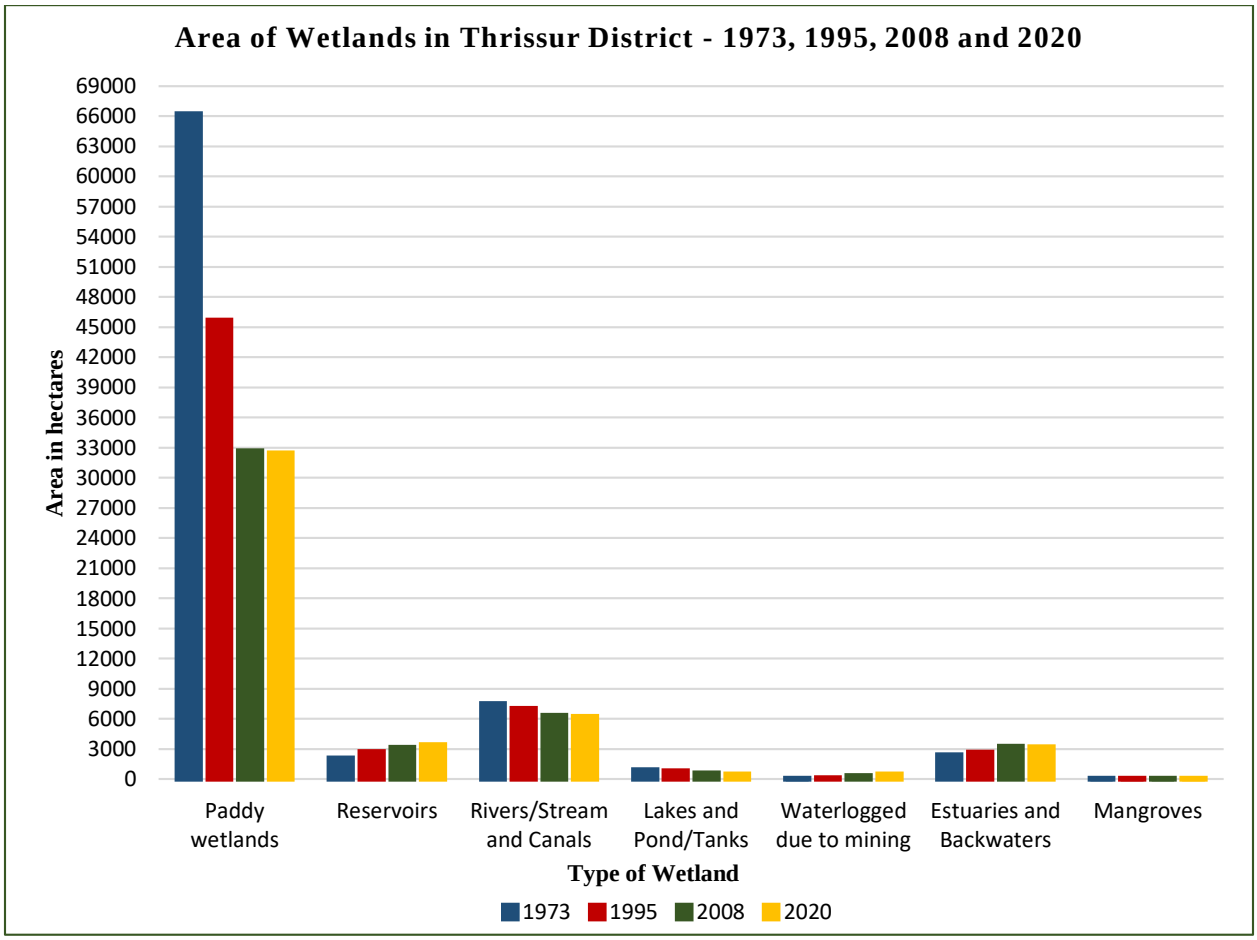


Table No.3. Percentage of each wetland type to total wetland area of Thrissur District - 1973, 1995, 2008 and 2020

Types of Wetlands	Sub-types of Wetlands	1973	1995	2008	2020
		Percentage	Percentage	Percentage	Percentage
	Paddy Wetlands	83.62	77.37	70.36	70.03
	Reservoirs	2.61	4.61	6.80	7.35
	Rivers/Streams and Canals	9.47	11.93	13.67	13.48
	Lakes and Ponds/Tanks	1.13	1.34	1.33	1.10
	Waterlogged due to mining	0.01	0.17	0.75	1.02
	Sub-total	**96.85**	**95.40**	**92.90**	**92.97**
Coastal Wetlands	Estuaries and Backwaters	3.04	4.49	7.03	6.91
	Mangroves	0.11	0.11	0.06	0.11
	Sub-total	**3.15**	**4.60**	**7.10**	**7.03**
Grand total		**100.00**	**100.00**	**100.00**	**100.00**

Source: Computed by authors from Landsat Imagery

Table No 4. Area and Percentage of changes in Wetlands of Thrissur District - 1973 to 2020

Types of Wetlands	Sub-types of Wetlands	1973-1995		1995-2008		2008-2020	
		Change in Area (Ha)	Change in Percentage	Change in Area (Ha)	Change in Percentage	Change in Area (Ha)	Change in Percentage
Inland Wetlands	Paddy Wetlands	-20550.18	-31.03	-12997.16	-28.45	-257.30	-0.78
	Reservoirs	+647.96	+31.29	+437.08	+16.07	+246.25	+7.80
	Rivers/Streams and Canals	- 453.52	-6.05	-694.82	-9.86	-108.41	-1.70
	Lakes and Ponds/Tanks	- 107.22	-11.95	-173.59	-21.97	-104.13	-16.89
	Waterlogged due to mining	+85.43	+679.09	+250.25	+255.33	+123.83	+35.56
Coastal Wetlands	Estuaries and Backwaters	+240.44	+9.95	+612.66	+23.10	-58.98	-1.81
	Mangroves	-23.55	-28.23	-25.61	-42.78	+14.69	+42.89

Source: Computed by authors from Landsat Imagery

Table No 5. Area and Percentage of changes in Wetlands of Thrissur District - 1973 to 2020

Types of Wetlands	1973-1995		1995-2008		2008-2020	
	Change in Area (Ha)	Change in Percentage	Change in Area (Ha)	Change in Percentage	Change in Area (Ha)	Change in Percentage
Inland Wetlands	-20377.53	-26.56	-13178.24	-23.39	-99.76	-0.23
Coastal Wetlands	+216.89	+8.69	+587.05	+21.65	-44.29	-1.34
Total Wetland Area	-20160.64	-25.45	-12591.19	-21.32	-144.05	-0.31

Source: Computed by authors from Landsat Imagery

Spatio-Temporal Changes in Wetlands of Thrissur district: For analyzing the spatio-temporal change in wetlands in Thrissur district, the wetlands have been categorized as Inland wetlands and Coastal wetlands. Inland wetlands consist of paddy wetlands, reservoirs, rivers/streams and canals, lakes and ponds/tanks and pits waterlogged due to mining. Coastal wetlands consist of estuaries and backwaters and mangroves. Results of the analysis reveals a declining trend in total wetland area. Total wetland area reduced from 79,209.50 hectares in 1973 to 59,048.86 hectares in 1995, 46,457.67 hectares in 2008 and finally 46,313.62 hectares in 2020. But a diverse picture can be seen when each category of wetland is taken into consideration. (Tables No. 2, 3, 4 and 5 and Figures No. 2, 3, 4 and 5)

Spatio-Temporal Changes in Inland Wetlands: The area under inland wetlands decreased from 76,714.73 hectares in 1973 to 56,337.2 hectares, 43,158.96 hectares and 43,059.20 hectares in 1995, 2008 and 2020 respectively. The share of inland wetlands to total wetland area of the district was 96.85 % in 1973, 95.40% in 1995, 92.90% in 2008 and 92.97% in 2020.

The main contributor to the decline in area under inland wetlands was the disappearance of paddy wetlands. From 1973 to 2020 paddy wetlands declined by 33,804.64 hectares. In 1973 paddy wetlands covered an area of 66,236.26 hectares and constituted 83.62% of total wetland area of the district. This reduced to 45,686.08 hectares (77.37%) in 1995 and to 32,688.92 hectares (70.36%) in 2008. Thus from 1973 to 2008, 33,547.34 hectares of

paddy fields were converted for other purposes. The main reasons behind rampant conversions of paddy wetlands were rapid urbanization, population pressure, spurt in infrastructural development and structural changes in agriculture. From 2008, state legislations such as Kerala Conservation of Paddy Land and Wetland Act enacted in 2008 brought down conversions. As a result only 257.30 hectares of paddy lands was reclaimed from 2008 to 2020.

Area under rivers/ steams and canals reduced from 7,497.51 hectares in 1973 to 7,043.99 hectares in 1995 and to 6,349.17 hectares in 2008 which finally reached 6,240.76 hectares in 2020. Thus from 1973 to 2020 there was a total reduction of 1,256.75 hectares in area under rivers/ steams and canals. The main threats to these wetlands were encroachment along river banks, sand mining and conversion of small canals to built-up.

Many ponds of the district was filled with sand and reclaimed for construction purposes, thus causing a continuous decline in area under lakes and ponds/tanks. Area under this category of wetland reduced by 107.22 hectares (-11.95%) from 1973 to 1995. Maximum decline was during the period 1995-2008 when a reduction of 173.59 hectares (-21.97%) took place. From 2008 to 2020 area under lakes and ponds/tanks fell from 616.32 hectares to 512.19 hectares thereby causing a decline by 104.13 hectares. This shows that in spite of the Kerala Conservation of Paddy Land and Wetland Act, 2008, filling up of ponds still continues.

The reservoir area increased over the years. From 1973 to 1995 area under reservoirs augmented by 31.29% i.e. from 2,071.25 hectares to 2,719.21 hectares. The main cause was the construction of Chimmony reservoir and dam, the construction of which started in 1975 and was completed in 1995.The water level in other reservoirs might have also risen. Analysis of satellite images showed that reservoir area again rose to 3,156.29 hectares in 2008 and 3,402.54 hectares in 2020. The reason might be an increase in water level of reservoirs when the satellite image was acquired. Thus the share of reservoirs to total wetland area of the district rose from 2.61% in 1973 to 7.35% in 2020.

Continuous surge in infrastructure development led to mushrooming of numerous mining sites. Mining of clay from paddy wetlands renders the paddy lands unsuitable for cultivation. Granite building stone and laterite building stone are mined from the highlands. After the minerals are extracted, the mines are abandoned. Deep-dug pits get filled with water after rainfall and waterlogged pits are formed. Area waterlogged due to mining increased continuously from 12.58 hectares in 1973 to 98.01 hectares in 1995, 348.26 hectares in 2008 and finally to 472.09 hectares in 2020. Thus waterlogged abandoned mines increased by 459.51 hectares from 1973 to 2020 showcasing the intensity of land degradation taking place in the study area.

Spatio-Temporal Changes in Coastal Wetlands: Coastal wetlands occupy a very small percentage of the total wetland area of Thrissur district. The share of coastal wetlands to the total wetland area of the district was only 3.15 % in 1973, 4.60% in 1995, 7.10% in 2008 and 7.03 in 2020. Area under coastal wetlands showed an increasing trend up to 2008, after which it declined slightly. The total area under coastal wetlands increased from 2,494.77 hectares in 1973 to 2,711.66 hectares and 3,298.71 hectares in 1995 and 2008 respectively. From 2008 to 2020 coastal wetlands reduced slightly by 44.29 hectares (-1.34%).

Area under estuaries and backwaters increased from 2,411.36 hectares in 1973 to 2,651.8 hectares in 1995 and to 3264 hectares in 2008. The main reason was the abandonment of pokkali paddy cultivation in Kodungallur backwaters and these fields were either converted to aquaculture ponds or left waterlogged, thereby increasing the area under this wetland. At the same time reclamations along backwaters did take place, but it was not very significant. Also, as mangroves grow along backwaters, destruction of mangroves during this period caused increase in estuarine and backwater area. From 2008 to 2020 area under this water body declined by 58.98 hectares (3,264.46 hectares to 3,205.48 hectares) mainly due to land reclamation occurring in Azheekode estuary and expansion of mangrove area. When mangroves expand, backwater and estuarine area will reduce. The share of estuaries and backwaters to total wetland area of Thrissur district was 3.04% in 1973, 4.49% in 1995, 7.03% in 2008 and 6.91% in 2020.

Mangroves which occupied around 83.41 hectares in 1973, declined to 59.86 hectares in 1995 and 34.25 hectares in 2008 due to anthropogenic stress. Thus mangroves decreased by 28.23% from 1973 to 1995 and by 42.78% from 1995 to 2008. They were cut down purposefully for infrastructure development as well as unknowingly due to lack of awareness regarding their significance. Thus from 1973 to 2008, 49.16hectares of mangroves were destroyed. A ray of hope can be seen since 2008 as the area under this ecosystem has increased by 42.89% (14.69 hectares) from 2008 to 2020. Though very small, this increase is an indication of change in attitude of the people. They have started recognizing the value of mangroves and measures are being taken by the Government and the masses for conserving and propagating this valuable wetland.

Conclusion: Thrissur district is the abode of a wide variety of wetlands. The importance of wetland ecosystems lies in the fact that they are sources of hydroelectricity, irrigation, fisheries, drinking water and paddy. They facilitate navigation, tourism and flood control. However, rampant changes in land use coupled with a spurt in infrastructure development impacted wetlands negatively. They are subject to threats such as reclamation for built-up, siltation and sedimentation, weed infestation, pollution, waste disposal, and irresponsible tourism. As they are sensitive and fragile ecosystems, they may be irreparable once damaged. At the same time, they are irreplaceable due to the ecosystem services they deliver to mankind and other species on earth. Therefore these valuable ecosystems have to be conserved at all cost for maintaining the integrity of the district. Efforts should be taken to completely stop the deterioration of wetlands. The Kerala floods of 2018 and 2019 were lessons for the people of Kerala as to the situation that will arise if the wetlands of the state are not preserved and conserved.

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