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SATELLITE IMAGE PROCESSING AND HEADS-UP DIGITIZATION METHOD FOR THE ASSESSMENT OF WATERBODY ENCROACHMENT USING GEOSPATIAL TECHNOLOGY

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Abstract-** Water bodies like lakes or tanks or ponds play a significant role in preserving and restoring the ecological stability. They are in existence for several centuries, serving the water needs of communities. Encroachment of water bodies for development human settlements and farming has been increased due to population growth and public attitude. This research focused on the water bodies encroachment in Manapparai Taluk, which covers an area of 1090 sq.km that encompasses 108 revenue villages and located in the central part of Tamil Nadu, India. The remote sensing techniques were used to assess the land-use land cover (LULC) changes, The visual interpretation techniques were used to prepare the LULC map and investigated the changes between topographic sheets of 1976 and Quick Bird satellite imagery of 2019. The vector layers of LULC were created by using heads-up digitization method in open-source geospatial software environment i.e. QGIS and GRASS. The LULC changes were assessed according to revenue villages, also predicted the total number of water bodies encroached by the public. The results of LULC layers between 1976 and 2019 confirm that the extent of human settlement increased from 3.52% to 5.98% of the total area, while vegetation cover also increases from 1.38% to 2.12%. Besides, the lakes and ponds decreased from 4.11% (44.94 sq.km) to 3.82 % (39.14 sq.km). The research has demonstrated the advantages of QuickBird satellite imagery to provide an exact, cost-effective contribution to prepare a map and investigate LULC changes over an interval.
***Keywords:** Land-use land cover change, Image processing, visual interpretation, google earth, water bodies encroachment, QGIS.*

I. INTRODUCTION

The lakes and ponds play a vital role in arid and semi-arid regions. Ancient kingdoms developed it, which were well maintained by consumers. More than a century ago, surface water bodies such as lakes and ponds were the primary source of water. Besides, ponds and lakes increase the groundwater level rise. Tanks and ponds are reservoirs usually constructed by earthen soil to capture rainy season runoff in the arid zones by the ancient kingdom of Tamil Nadu (Chola and Pallava kingdom). There are many ancient pieces of evidence to show that rulers had built reservoirs and lakes and ponds in their respective kingdoms (i.e., King Karikal Chola was constructed the Grand Anaicut across River Cauvery, Maravarman Arikesari was built a check dam across Vaigai River, Parakrama Pandiyan was built a check dam Sitranai, etc). They are found in all soil types except sand, located in all socio-ecological, agro-climatic and rainfall areas of Tamil Nadu. The rulers collected a corpus fund to desilt the lake, appointed guards to stop people from contaminating. Recently, various studies show that many of the water bodies were encroached to convert human settlement or agricultural or industrial area. In this research focus on the encroachment of water bodies through analysis of LULC changes in Manapparai Taluk of India.

The encroachment of water bodies was assessed very large scale, according to sub taluk level i.e. revenue villages. The ability to monitor the encroachment of water bodies is necessary by the local government as well as the president of the revenue villages [45]. The LULC requires to manage the natural resource management [10], [41] wildlife habitat protection [25] urban growth model and municipal area development [8]. Transportation network planning and routing of power transmission lines. The LULC was used to evaluate the various disaster like landslides, tornadoes, flood inundating, and volcanic eruption and forest fire. The LULC change plays a vital role such as baseline mapping for much scientific research like site selection for a wind farm, solar farm, solid waste disposal and groundwater recharge [4], [9],[15], [16],[37].

The human settlement development poses an enormous risk to the government properties like forest, river, tanks and ponds, they decrease victim to the process [30]. A large number of LULC changes have been analyzed to various part of Tamil Nadu, India [15]-[17]. Frequent interval, precise, and conversant land-use planning is required to monitor the human activities, risk assessment, environmental resources management and sustainable development [6]. However, Monitoring of LULC at national scales or regional scales face several challenges, including cloud-free data acquisition, the very high price of creating national products for developing countries like India. Previous researchers have used various satellite imagery such as LANDSAT [18],[19] and Sambath 2006; [21], [22], SPOT [43], IKONOS [29], KOMPSAT [9], Quickbird [43] and Sentinel[34] aerial photo [14]. but, the precision of change detection of LULC using geospatial techniques strongly depends on the resolution of the imagery i.e. spatial, spectral, and radiometric resolution of the sensors used [2].

However, the price of the satellite imagery is directly proposal to its spatial resolution, in this research used the freely available satellite imagery of Google Earth Pro software (i.e., QuickBird satellite imagery), that has a high spatial resolution of 2.62m of four multispectral bands and 65cm spatial resolution of the panchromatic band[3]. The assessment of LULC is the procedure of classifying satellite imagery in each type of features through a vector or raster analysis at many time intervals. Earlier researchers adopted various image-processing techniques including pixel-based land cover classification, image classification [2],[8],[10], [11], [13], [21], [24], [33], [34],[38].

The accuracy of satellite image processing techniques (i.e., supervised classification, unsupervised classification, Normalized difference in vegetation index, the symmetrical difference of vector analysis) was produced range between 57% to 73% [38]. The previous researcher [2] was used optimal combinations of pixel-based and object-based land cover classification method to get a higher classification and post-classification change detection accuracies. Visual interpretation techniques can be used to prepare the training sites of supervised classification to achieve 96% accuracy [1]. The visual interpretation and head-up digitization is an exact method for changes identification in LULC [32]. We hypothesized that changes in the extent of population growth, as well as booms in agribusiness activities, have caused in major impacts on the ecology, environment, water bodies, and forest from 1976 to 2019 on Manapparai Taluk in Tamil Nadu State, India. In this research, two different data were used, such as topographic maps (1:50000) and QucikBird satellite imagery, to assess the waterbody encroachment and land-use land cover changes in a geospatially explicit way.

II. STUDY AREA

Manapparai Taluk in Tamil Nadu State, India has a small urban extent, covering a proximate area of 1090 sq.km and is bounded by latitudes 10° 17′ 28″N to 10° 44′ 56″N and longitudes 78° 9′ 46″E to 78° 34′ 07″E as illustrated in Figure 1. According to the census, 2011 data, the research area includes both an urban and rural area population was 52355 and 318127 respectively. The total population of the study area was 370482, total families in were 12,620. The population in Manapparai Taluk was, increased from 331255 in 2001 to 370482 in 2011 (https://www.censusindia.co.in). The study area has igneous rocks (granites), which is containing primordial radionuclides activity (Sankaran Pillai et al. 2016). Also, a reedy layer of red sandy soils covers on top of the western and southern parts of the study area [40].

The average temperature in Manapparai is 28.5°C. In a year, the average rainfall is 816mm. the annual rainfall is about 816mm, maximum in October to ending in December due to winds of the northeast rainy season, and from December to February, the climate is a breeze and humid. The Period of hot summer prevails till June when Southwest monsoon sets which bring scanty rains (MINING 2019). Primary activities of rural area are agricultural and pastoral activity. The monetary base of Manapparai is extensively farming, including the cultivation of maize, Paddy, Millets, Pulses, Banana, Sugarcane and Cotton are the major crops cultivated in the study areas well as poultry and swine [35]. Ovine rearing and agriculture are traditional occupations of many of families generating employment, income and subsistence [5].

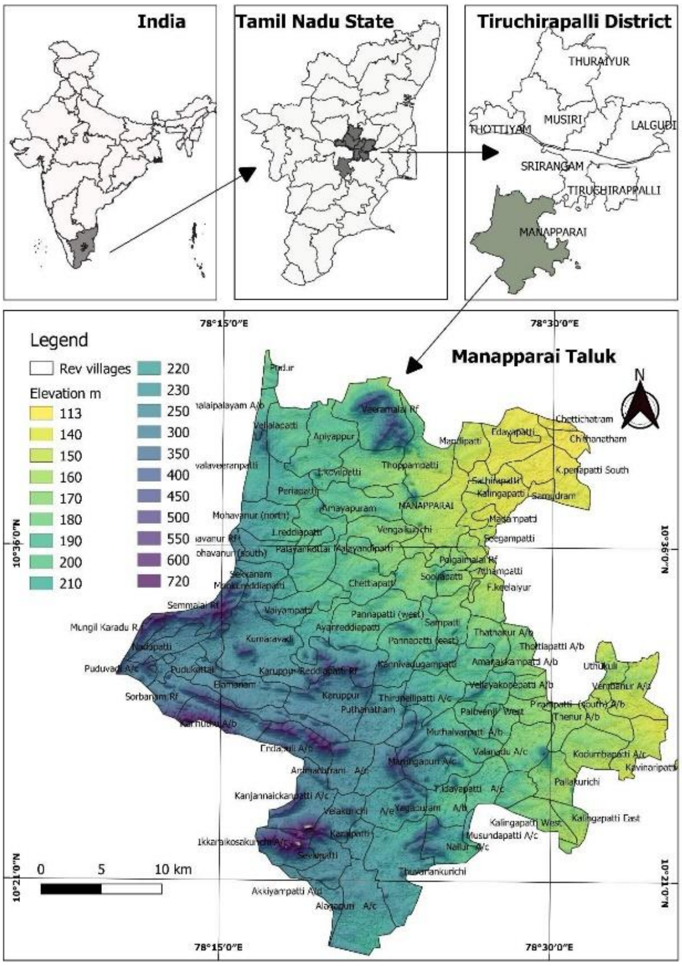

Figure 1. Study Area map of Manapparai Taluk, Tiruchirapalli District, Tamil Nadu (India) overlaid on digital Elevation

Tank irrigation in Manapparai Taluk is a boon often accompanied by wells sunk on irrigated land under the tanks. Poor maintenance of the lakes and the ponds have been facing the most of the problem by the local administration and village panchayats.

Table 1: Description of different LULC classes of study area of Manapparai Taluk, Tiruchirapalli District, Tamil Nadu (India)

Sl. No	**Landuse Class**	**Description**
1	Agriculture	Paddy, and other crops cultivation area
2	Vegetation	Coconut trees, plantation
3	Forest	Reserved forests, scrubs
4	Settlements	Residential, commercial, industrial, institutional buildings, huts,
5	Waterbody	lakes, ponds, dams, reservoirs, and streams

The visual interpretation is quite easy to identify in the Quick bird satellite images, as the details of the individual lakes, ponds and other features can be seen. The area of the waterbody was calculated by using the field calculator tool of attribute table in the QGIS software environment.

III. METHODOLOGY

The study describes four general steps in LULC change analysis, i.e. image geo-referencing, Image sub-setting, visual heads-up digitization, spatial geoprocessing and assessment as illustrated in Figure 2.

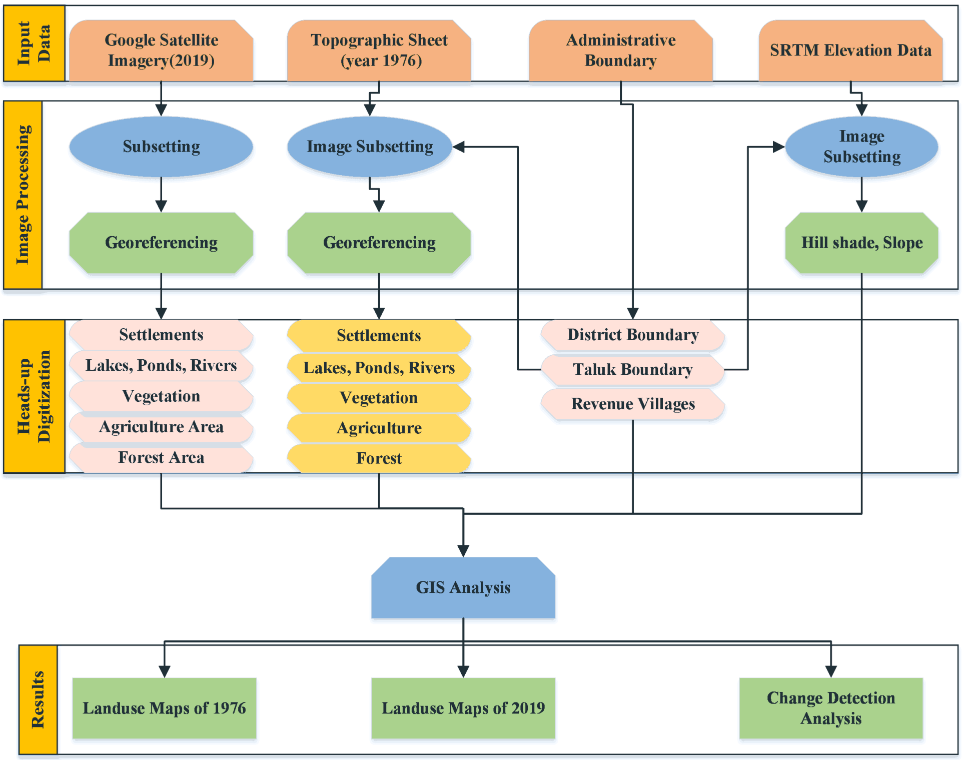

Figure 2. Methodology flow diagram of land-use and land cover change analysis of Manapparai Taluk

A. Data sets used in research

The geospatial technique is a potential tool in assessing the effects of LULC on different environmental factors including natural disasters and even climate change. Aerial photographs and satellite images are capable of covering large regions and a discriminate variety of land features, which provides change assessment for various land covers like urban area and water bodies [19],[27],[39]. Topographic sheets were collected from the Survey of India. The satellite imagery of Google Earth Pro has temporal inconsistency, does not cover the entire study area (say 1000sq.km) by single image due to clouds, shadows [12]. The high-resolution Quick Bird satellite imagery was downloaded through Google earth pro, acquired on dated 09-09-2019, was originally taken from the QB and have red, green and blue bands with a spatial resolution of 2.6m [14].

B. Software adopted

Quantum Geographic Information System (QGIS) is a GNU General Public License software, which was released as Open source software in May of 2002. The functions of QGIS can function as traditionally expensive proprietary GIS software. QGIS supports several raster and vector data formats.

C. Image Processing

Remote sensing and geospatial technology together can carry out a leap in land-use and land cover mapping [26]. Image preprocessing related works like sub-setting, Geo-referencing, spatial analysis and mapping was performed by using QGIS 3.10 and GRASS 7.8 software. The topographic sheets were georeferenced by Everest ellipsoid and then projected into WGS84 UTM zone 44N. The study area was delimitated using open-source software (QGIS and GRASS software), using a digital elevation model from the satellite of Shuttle Radar Topography Mission launched by the NASA (easily downloadable from earth explorer) The elevation data of Manapparai Taluk was shown in Figure 1. The SRTM digital elevation model can help to understand the terrain condition of the study area. The scanned copy of Topographic sheets of the Survey of India was created. The Geo-referencing and heads-up digitizing of vector data was carried out, then all thematic layers were stored in ESRI shapefile format [23]. Image-to-image registration and geo-referencing were executed on the other satellite images using the QGIS software environment (Freely available online at https://qgis.org/).

D. Heads-up Digitization

The topographic sheets were given more detailed information regarding changes in water bodies and other layers. For LULC mapping of the study area from visual interpretation of satellite imagery and the heads-up digitization of topographic sheets as shown as Figure 3. The spatial database was constructed by adopting the QGIS software environment. The layers that require detecting changes, such as water bodies, settlements, vegetation, forest, and agriculture were digitized using from the scanned copy of topographic maps with a scale of 1:50000. The digital topographic data used mainly for geometric correction of the satellite imagery. The cloud-free Quickbird (high spatial resolution of Google earth) satellite imagery was selected to digitization process of the study area [28], [33]. The entire image processing was performed using open-source software i.e. GRASS GIS (version 7.1) and SAGA GIS (version 8.5). In this research, the visual interpretation procedure was used to acquire the categorized Landuse maps. The LULC features were categorized into five broad types (as illustrated in Table 1): water bodies, agricultural lands, human settlements, forest, and vegetation. These five classes of LULC were interpreted based on the visual interpretation keys. Also, LULC classes of the google satellite imagery were verified by ground truth verification [6], [44]**.** The LULC maps were prepared at large scale (1:5000) by visual interpretation with the use of image interpretation keys such as tone, texture, size, shape, associated features. Visual interpretation technique was used for accurate extraction of lakes and ponds from high-resolution satellite imagery in QGIS software.

IV. RESULTS AND DISCUSSION

The study area had 959 tanks (according to LULC map of 1976), which were helpful to recharge groundwater, regulate rainwater inundations, support ecology and environment, and provide livelihood opportunities to an enormous population. There are a small number of tanks constructed in the recent past two hundred years. The interlinked water bodies were developed for the conjunctive use of wells with ponds, lakes and tanks. The main problems in tank irrigation are the accumulation of silt and poor maintenance of tank bunds that lead from the tank into another type of land-use. According to LULC map of the year 1976, nearly four decades ago, estimated that Manapparai Taluk had 959 lakes or tanks and more than half of them were located south of the Manapparai urban area.

The maps showed that between 1976 and 2019 the surface area of water bodies or lakes and ponds decreased from 4.11% (44.94 sq.km) to 3.82 % (39.14 sq.km) of the total area as shown in Table 2. In 1976 compared to 2019 the 43 years, among 959 water bodies, only 871 (according to LULC 2019) of them exist and remaining 88 (112.6 ha area) water bodies have fully encroached. Besides, 232 water bodies (463.4 ha area) had partially encroached which has reduced the size of the lakes as shown in Figure 3. All these menaces had happened because of encroachments on lakes and ponds and major land-use/cover conversions from 1976 to 2019. Also, the list of water bodies encroached partially or fully according to revenue villages was created in QGIS software environment for 1976 as well as 2019 (Table 3). The gradient map of waterbody encroachment was shown in Figure 5 and Figure 6. The area and number of waterbody encroachment according to revenue villages was illustrated in Table 4.

Table 2: The LULC change types assessed from visual interpretation techniques

Class Name	Year 1976			Year 2019			Difference
	Count	Area in Sq. km	total area in %	Count	Area in Sq. km	total area in %	Area in Sq. km
Water bodies	959	44.94	4.11%	895	41.84	3.82%	3.100↓
Rivers	5	6.86	0.63%	5	6.56	0.58%	0.320↓
Vegetation	67	15.061	1.38%	199	23.23	2.12%	8.169↑
Forest	45	198.33	18.13%	39	188.247	17.21%	10.083↓
Settlements	1209	38.52	3.52%	1048	65.39	5.98%	26.870↑
Transportation	1491	36.42	3.33%	1491	36.42	3.33%	
Agriculture		753.869	68.91%		732.013	66.91%	21.856↓

Table 3: Encroachment of water bodies in Manapparai Taluk in Tamil Nadu based on LULC map of 1976 and 2019.

Encroachment in %	**0%**	**<25%**	**26-50%**	**51-75%**	**76-93%**	**100%%**
No of water bodies	638	34	101	74	23	88
Total Area in m^2	31432932	717848	2195840	1299487	421650	1126651
Min area in m^2	1018	2522	2887	1767	4255	2229

Max area in m^2	116390	67443	99468	91575	81864	104579
Mean area in m^2	84473.5	21113.18	21740.99	17560.64	18332.61	12802.85
Meadian area in m^2	84473.5	14746	15892	13485.5	13548	10077.5

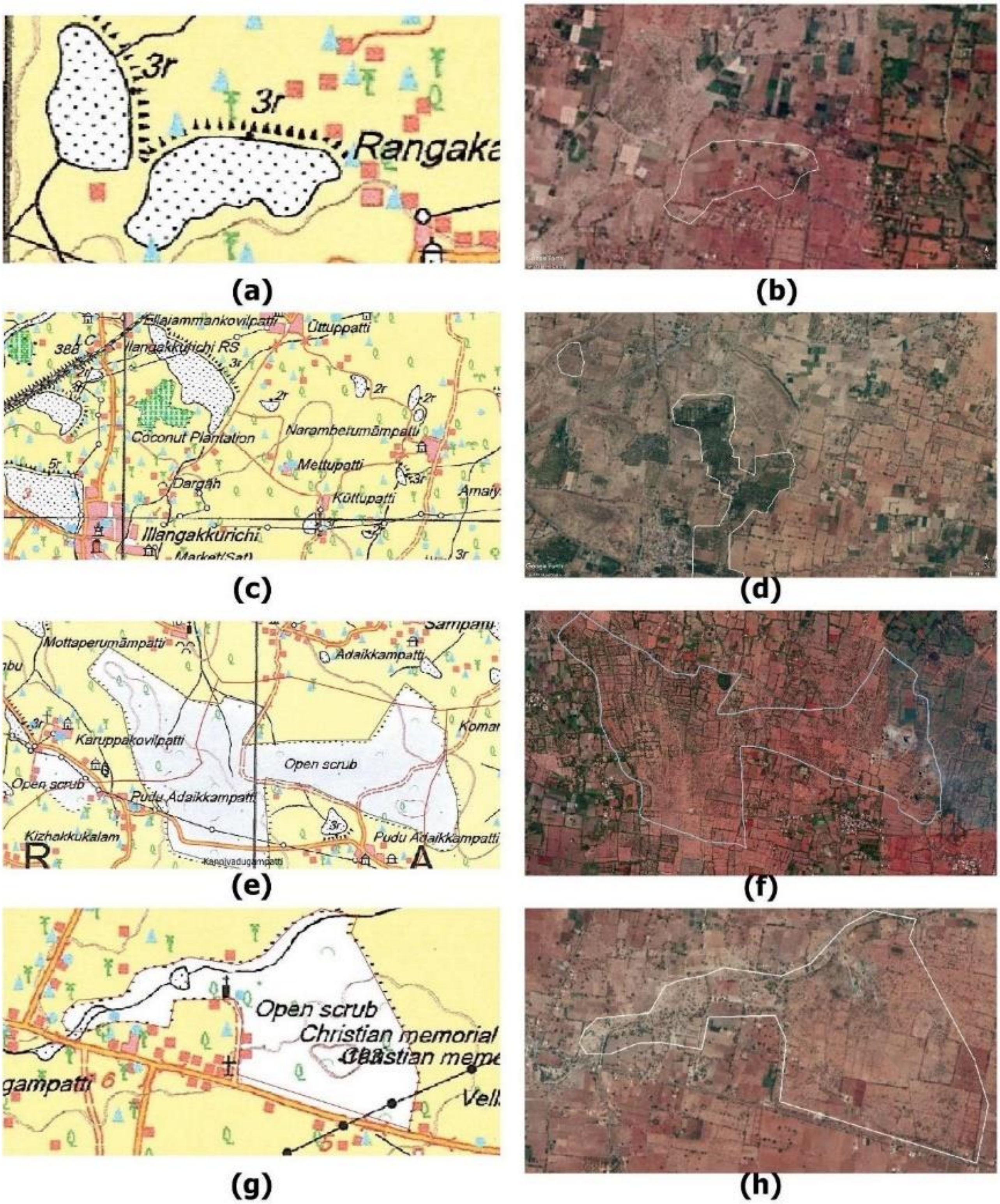

Figure 3. LULC layers heads-up digitization using topographic sheets and satellite imagery, comparison of features between 1976 and 2019 (a) lake, (b) Encroached Lake area, (c)Vegetation (d) expanded vegetation area, (e) open scrub forest, (f) encroached scrub forest, (g) open scrub forest, (h) encroached scrub forest.

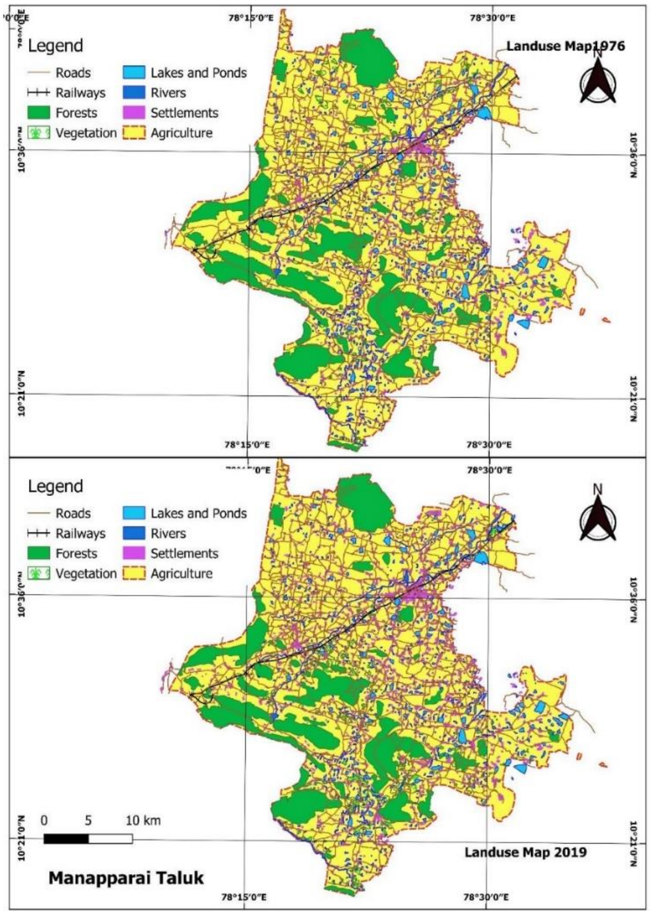

Figure 4: Comparison between the LULC maps between 1976 and 2019.

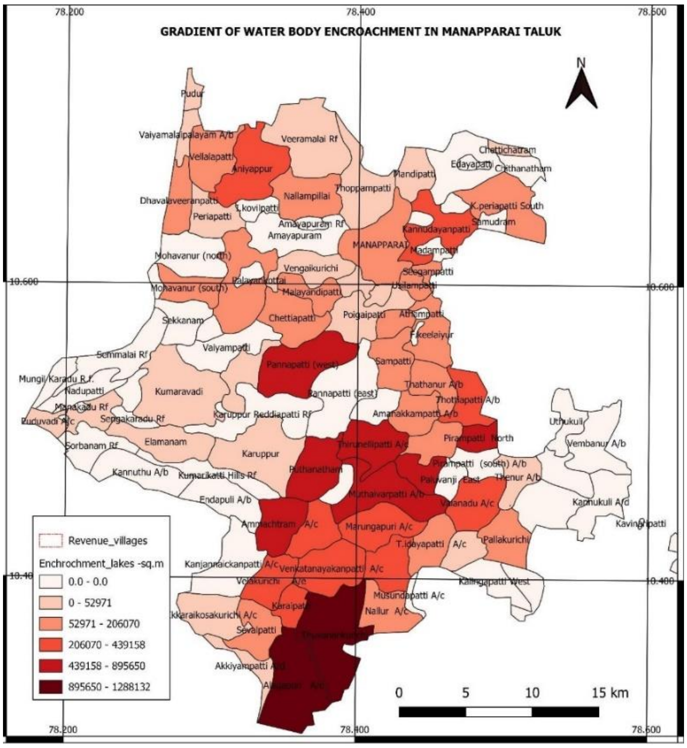

Figure 5. Distribution of Waterbody encroachment in Manapparai Taluk, Tiruchirapalli District, Tamil Nadu (India)

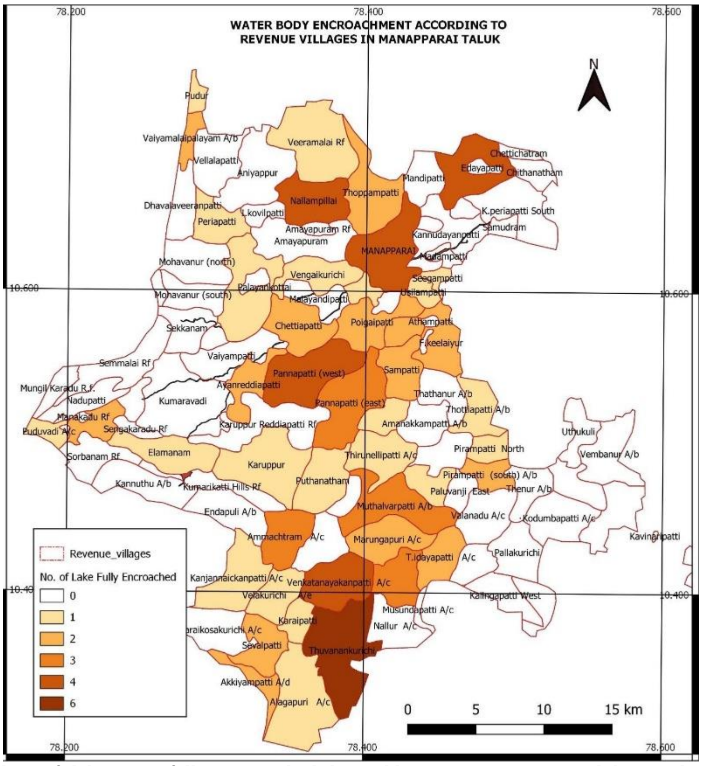

Figure 6: The total number of lakes are fully encroached by public in Manapparai Taluk, Tiruchirapalli District, Tamil Nadu (India)

The advantages of geospatial information technology in LULC change analysis was fully appreciated. The LULC maps were generated for 1976 and 2019 (Figure 4) and the individual class area and change statistics for the four years are summarized in Table 2. The assessment results calculate the LULC changes in the Manapparai Taluk and also demonstrate the proficient of Google Satellite imagery to deliver a precise, viable to map and examine changes in LULC during 1976 to 2019[5], [35], [42]. LULC change can be used as inputs to ecology management and decision making to protect the environment. Figure 4 shows a map of the major water bodies has encroached partially or fully in 61 revenue villages.

The surface area of waterbody decreased from vegetation and forest, representing 19.51% of the research area, are the three most important LULC categories in the Manapparai Taluk, while vegetation cover types of plantations increased from 1.38% to 2.12%. The increase of human settlement lands in the study area was 3.52 to 5.98% relative to the whole landscape. However, the duration of 43 years (LULC period 1976-2019), 21.856 sq.km area was altered to human settlements from cultivated land, distressingly, 10.083 sq.km (18.13% in 1976 and 17.21% in 2019) forest cover decreased. Table 4. List of revenue villages in Manapparai Taluk and its area of waterbody encroachment.

Table 4. List of revenue villages in Manapparai Taluk and its area of waterbody encroachment.

Sl.No	Village Name	No of Lakes (1976)	No of Lakes (2019)	No of Lakes Fully encroached	Area Encroached partially/fullysq.m
1	Akkiyampatti	4	2	2	17372
2	Alagapuri	30	30	0	1115142
3	Amanakkampatti	13	13	0	79339
4	Ammachtram	27	24	3	613094
5	Aniyappur	17	16	1	346476
	Ayamporuvai	2	2	0	51614
7	Ayanreddiapatti	19	17	2	19377
8	Chettiapatti	14	12	2	141564
9	Chettichatram	1	1	0	24522
10	Dhavalaveeranpatti	7	7	0	152219
11	Elamanam	6	5	1	23219
12	F.keelaiyur	23	21	2	128295

13	Ikkaraikosakurichi	6	6	0	12094
14	K.periapatti South	8	8	0	133763
15	Kannudayanpatti	23	23	0	276884
16	Karaipatti	14	13	1	325863
17	Karumalai	13	13	0	332102
18	Karuppur	12	11	1	39608
19	Kumaravadi	15	15	0	2522
20	Malayandipatti	4	4	0	138408
21	Manapparai	19	15	4	159846
22	Mandipatti	11	11	0	21360
23	Marungapuri	6	4	2	249466
24	Mohavanur (south)	8	8	0	90027
25	Muthalvarpatti	18	15	3	834973
26	Nallampillai	11	7	4	206070
27	Nallur	7	7	0	87765
28	Palayankottai	18	17	1	114399
29	Pallakurichi	7	7	0	123909
30	Paluvanji West	16	15	1	717683
31	Pannapatti (west)	29	25	4	666237
32	Periapatti	11	10	1	30208
33	Pirampatti North	23	22	1	895650
34	Poigaimalai RF	2	2	0	3050
35	Poigaipatti	9	7	2	52971
36	Pudukottai	2	0	2	51120
37	Pudur	4	3	1	31640
38	Puduvadi	1	0	1	21401
39	Puthanatham	28	27	1	551483
40	Sampatti	15	13	2	158025
41	Seegampatti	7	6	1	69644
42	Sevalpatti	6	4	2	97440
43	Sooliapatti	7	5	2	82444
44	T.idayapatti	9	7	2	180453
45	Thathanur	13	13	0	91942
46	Thenur	11	11	0	21211
47	Thirunellipatti	16	15	1	662920
48	Thoppampatti	15	13	2	8791
49	Thottiapatti	20	19	1	253384
50	Thuvanankurichi	54	48	6	1288132
51	Usilampatti	9	8	1	101110
52	Vadagupatti	3	2	1	14695
53	Vaiyamalaipalayam	2	0	2	51033
54	Valanadu .	14	16	0	235795
55	Veeramalai Rf	3	2	1	50599
56	Velakurichi	13	12	1	298768
57	Vellalapatti	11	11	0	86052
58	Vellayakonepatti	14	15	0	122991
59	Vengaikurichi	4	3	1	34155
60	Venkatanayakanpatti	24	20	4	439158
61	Yagapuram	14	11	3	382432

V. CONCLUSIONS

The present study provides evidence of waterbody encroachment in Manapparai Taluk of India through LULC change analysis using geospatial information technologies. This study was used Google satellite images and in situ data within open-source GIS to map population growth and its resulting influences on land-use changes in the Manapparai Taluk, Tamil Nadu over the last 43 years. LULC is a phenomenon, which is of serious alarm and needs prompt attention in all the growing rural as well as urban areas. The 43 years period shows many extreme changes in water bodies. Particularly these water bodies were converted to agriculture and built-up lands. The increasing population and increasing socio-economic activities are the main reason for LULC change. The water bodies, river, agriculture, and forest have been decreased in the entire study area. The built-up land and vegetation have increased. The study reveals that geospatial information technology has a unique capability to assess the changes that have occurred in LULC over a period. There is a need to develop appropriate image processing or analytical techniques to assess LULC change. It is expected that the revenue village administration would attempt to meet the requirement for developing the tanks and its capacity. The field investigation is required to verify that the water bodies encroached by the public.

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