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Lake Inventory Between 1970 and 2016 in Neyveli Hydrological Basin and Generation of Digital Data Base Using Geospatial Technology

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Abstract
Taking care of tanks is essential for the preservation of the several functions of the ecosystem. Therefore, a digital database of surface water and lakes/tanks is critical. Consequently, it is necessary to identify the potentially favorable lakes/tanks useful in irrigation activities and supplement the groundwater rejuvenation. This study took the initiative to digitally document the lakes/ tanks within the Neyveli Hydrological Basin (NHB). Modern techniques like Remote sensing and GIS have been utilized for the present study to generate the digital database about the surface water system in the NHB. This study comparatively examines the 1970s lake map developed from the Geological Survey of India toposheet and the 2016 lake map from NRSC -RESOURCESAT-2 (LISS IV) and CARTOSAT-1 satellite image. The study tracks down that the NHB bounded with 4,492 lakes/tanks with the size ranging from 0.0000447 to 24.14607 sq. km. These lakes/tanks were reclassified into five categorized according to their size by using Arc GIS. The study reveals that 3,231 lakes are defunct, and only 1261 exist, which indicates that 72% of the surface water bodies have vanished within 46 years at the rate of 70 lakes per year. The present study will form the essential information for further analysis and future studies. It can provide an estimation of the water reserves for agricultural production and evaluate the impact of climate change / global warming.

Keywords: Lake Inventory, Neyveli Hydrological Basin, Geographic Information System, Remote Sensing, Change detection, Normalized Water Index.

INTRODUCTION

Lakes have always attracted man, being the source of freshwater supply, but their interference often creates severe problems resulting in an imbalance in the natural system. Lakes are an inseparable part of the landscape as they benefit humankind with many economic and scenic gifts (Jasleen Kaur Dhillon et al., 2012). GIS provides a flexible environment for collecting, storing, displaying, and analyzing digital data necessary for change detection (Yomralıoğlu et al. 2002; Wu q et al.2006). Small water bodies are usually called ponds – a term that also implies the artificial confinement of water (Andredaki et al., 2015). In the central Asian region, the primary source for irrigation is the surface flow from rivers and man-made reservoirs (Rakhmatullaev et al., 2010). Increasing population, industrial development, and expansion in agriculture harm water bodies all over the world (CV Nishikanth et al. 2018). Lake is a formation of a small earthen dam in valleys and local depressions to store runoff from its catchment or diverted from nearby rivers/streams. In Tamil Nadu, about 5,250 rain-fed Public Works Department (PWD) lakes are available and irrigating about 5.12 lakh hectares. It is about 30% of the total irrigated land in Tamil Nadu. The importance of conservation and restoration of lakes has been presumed through everyone's belief that if there is a world war again, it may be for water only. As in Tamil Nadu, more than 75% of people depend mainly on agriculture. It is essential to conserve and restore the irrigation lakes in a technological way with the much-needed social approach. It is calculated that water will be one of the strategic resources in the fourth-coming year (21st century) (Vijayakumar et al.2010). Surface water is a vital resource of water globally; it is considered one of the irreplaceable strategic resources for human survival and social development (Ridd and Liu 1998). However various natural, and anthropogenic activities such as Industrial, Reclamation, Agriculture activities lead to defunct and degradation in quality and quantity of water bodies (Moshen et al.2016). Normalized Difference Water Index (NDWI) can be applied to differentiate non-water from water zone (McFeeters.1996; Sener et al.2016).

STUDY AREA

Neyveli hydrogeological Basin area falls in parts of Cuddalore district of Tamil Nadu state, India, and is located 35 km inland from the Bay of Bengal and 197 km south of Chennai. The town was developed in 1956 after the establishment of Neyveli Lignite Corporation, a public sector enterprise. The study area falls between the co-ordinates of 11°4'1.64" N to 11°51'49.36" N latitudes and 79°9'54.31" E to 79°51'30.11" E longitudes (Fig.1) in the part of SOI Toposheets 58M/1, 2, 3, 4, 5, 6, 7, 8, 9, 10&14, 11, 12, 13, 15 and 16. The total geographical area covered by the Present study is about 6170 sq. km. The Gadilam and Ponniyar river marks the Northern limit. In contrast, the Vellar and Coleroon rivers keep the Southern, Cretaceous-Tertiary contact zone (Vridachalam – Palakollai) marks the western boundary, and the Bay of Bengal forms the Eastern limit of the Study area.

MATERIAL AND METHODS

The prime objective is to generate a digital database of lakes/tanks between 1970 and 2016. The Survey of India (SOI) maps and digital topographic maps are used at a better / large scale (1:50,000). The representative satellite images were chosen by identifying the path and row of the study area from the satellite reference map. Satellite imagery for the present study was obtained from the National Remote Sensing Centre (NRSC), Hyderabad. The satellite data used for this study is RESOURCESAT-2 (LISS IV) and CARTOSAT-1 digital data in Geo TIFF format for the fly period June 2016 covering the study area with UTM Projection. Digital Elevation data generated by Shuttle Radar Topographic Mission (SRTM) were used for the 3D applications. The SRTM digital elevation models are being developed from the SRTM C-band radar observation for selected regions to satisfy the need of the study and to speed the evaluation of acquisition and processing and application algorithms.

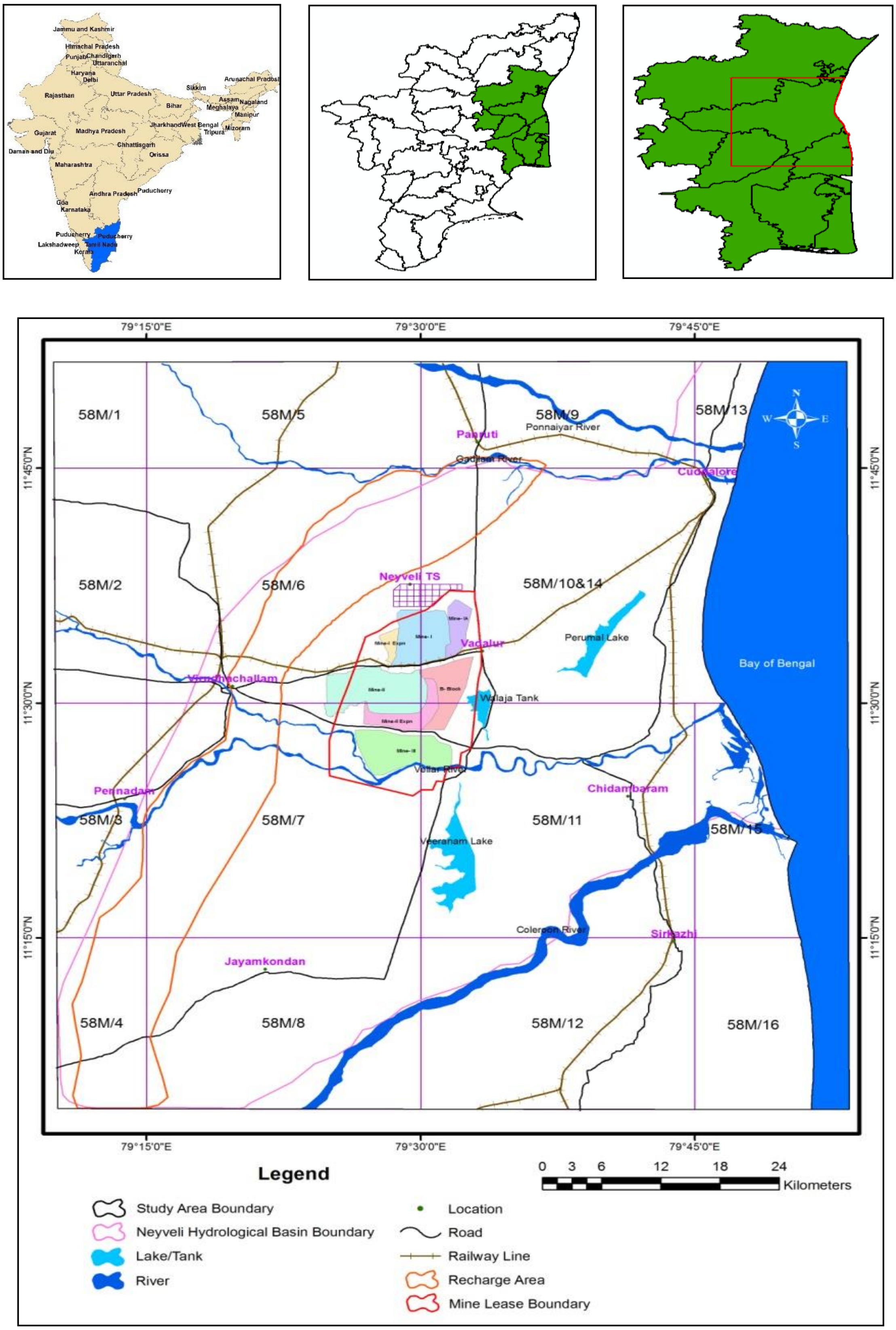


Figure:1 Location map of Study area

ESRI ArcGIS 10.1 is used for the GIS (Geographic information system) based analysis. It provides contextual tools for mapping and spatial reasoning to explore data and share location-based insights, and the software ERDAS Imagine 2014 was used for image processing techniques. Pre-fieldwork was done for a better understanding of the natural and driving phenomenon of the study. Particular locations with longitude, latitude, and corresponding pictures of all water bodies were augmented for better satellite interpretation.

RESULT AND DISCUSSION

Inventory of lakes

The inventory of the lakes was carried out for 1970 and 2016, the current inventory considering the existence of lakes/tanks in the Neyveli Hydrological Basin. The remote sensing and digital image analysis integrated with the GIS techniques complement the better understanding of the surface water and subsurface water system.

Mapping of Lakes/Tanks/Ponds in the Neyveli Hydrological Basin (NHB) was carried out using SOI toposheets on a 1:50000 scale. The water bodies were identified, digitized through on-screen mode with the help of ArcGIS, along with the details of latitude and longitude. The digitized data were stored in different segment files, using the vector operation module; all such segments were combined to get a single final segment map of the entire study area. The attribute like the name of the nearest villages/name of the water bodies, drainage connectivity, etc., were added with the help of SOI toposheets. The study venture that there were 4492 lakes during 1970 in the study area (Fig.2).

In the present study, the mapping of lakes in the NHB has been performed using the Resource sat (LISS IV) 2016. The detection of lakes using multispectral imagery involves discriminating water and other surface types. Delineating surface water has been achieved using spectral reflectance differences. Water strongly absorbs in the near and middle-infrared wavelengths (0.8–2.5μm). Vegetation and soil, in contrast, have higher reflectance in the near and middle infrared wavelengths. Hence water bodies appear dark compared to their surroundings when using these wavelengths. There are various definitions of the NDWI algorithm (Normalized Difference Water Index) that combine different pairs of bands, typically and originally including Green and Near Infrared (NIR) (band two and band 4) to extract various information regarding water bodies. The present study uses the LISS IV spectral bands 2 and 4 for maximum and minimum spectral reflectance of water, respectively, to compute the NDWI algorithm to identify the water spread area. Based on the output generated by NDWI, it is postulated that there were 1261 lakes are present during 2016 (Fig.3)

In the study area, there are around 4,492 lakes/tanks of various shapes and sizes ranging from 0.000447 to 24.14607 sq. km are present. Each lake has been assigned with an ID number for retrieval of the attribute information and eases to locate. It can be observed that a more significant number of smaller water bodies (<0.1sq.km) are present in the Southern part of the study area. The total area of the 4492 lakes in the NHB was around 258.72sq.km in 1972 and1261 lakes with45.61sq.km in 2016 (Fig.4), which shows a rapid growth reduction in the areal extent of lakes in NHB takes place.

Classification of Lakes Based on Size

Neyveli Hydrological Basin holds 4,492 lakes of various sizes. All the lakes are categorized into five classes based on the size of the lake; The first four classes ranging from small (0.1sq.km) to very large (>5sq.km), are suitable for the Irrigation purpose. The desiltation, and restoration could be an identical impact on these water bodies/tanks/lakes. The 5th class representing very small has an area of occurrence <0.1sq.km and contributes significantly less impact for irrigation purposes. In all dimensions, water bodies are needed whether it balances groundwater or it help agricultural usage. According to our focus of studies, the study area, Neyveli Hydrological Basin, has many lakes of various sizes.

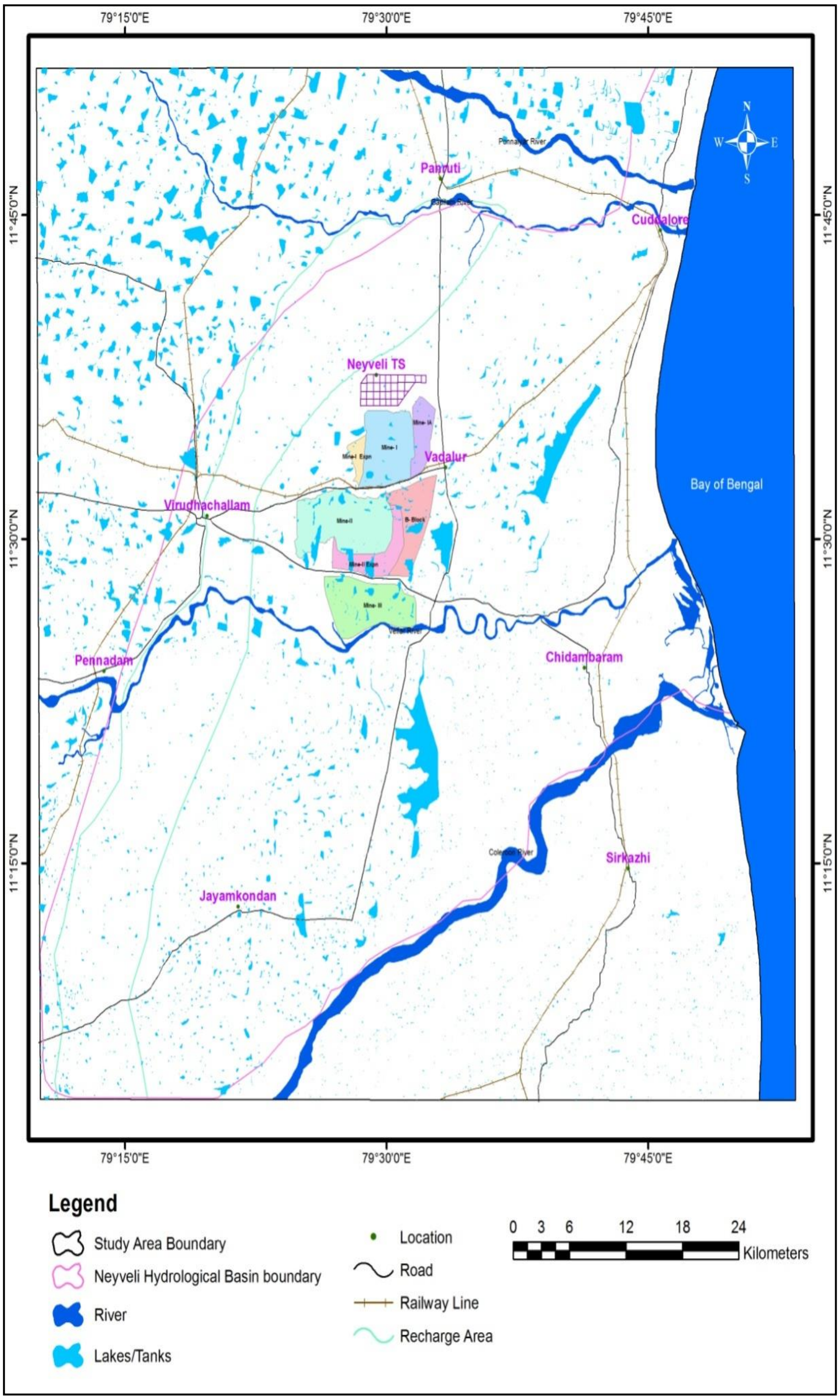


Figure:2 Distribution of Lakes in the Neyveli hydrological basin (1970)

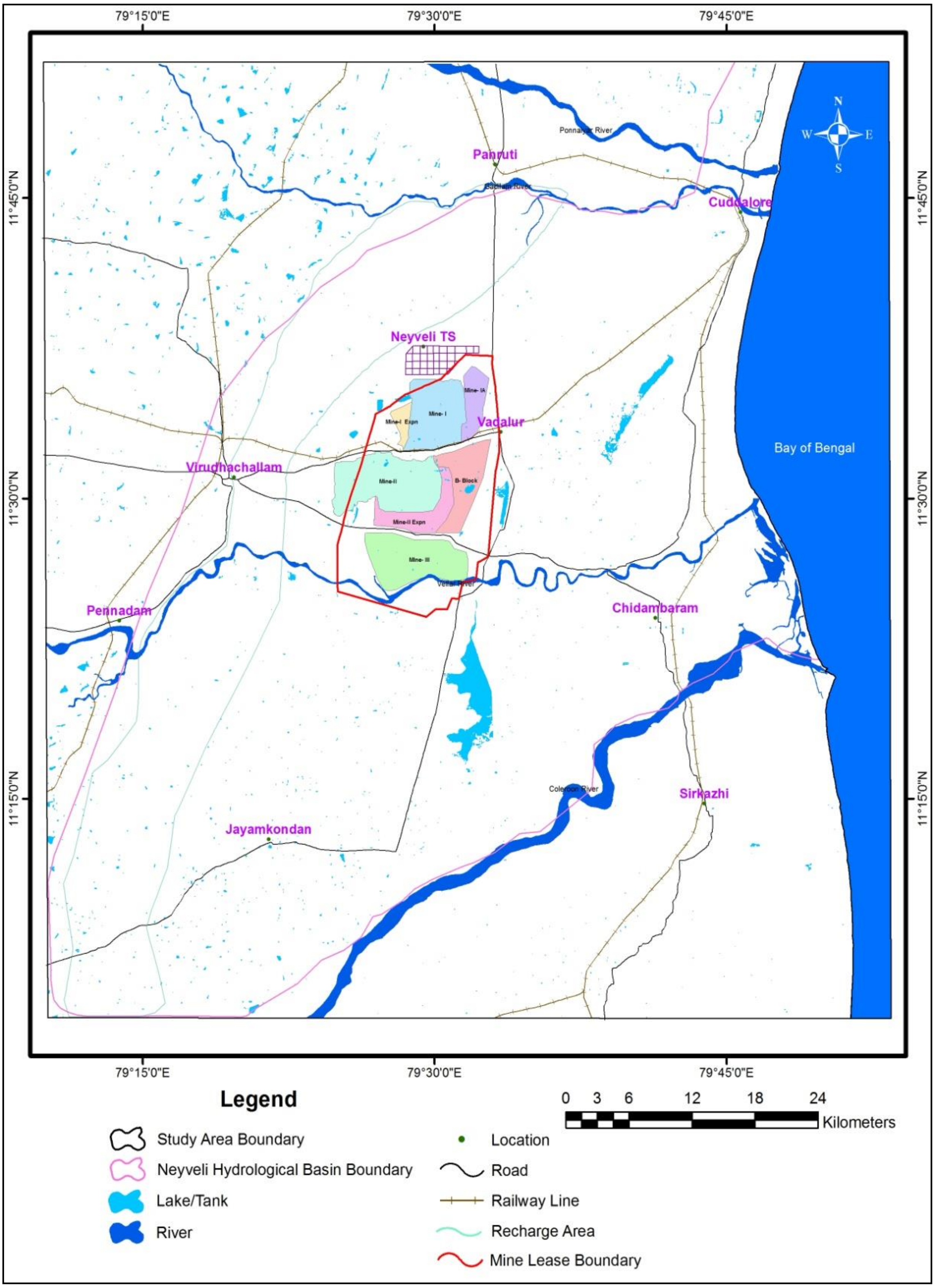


Figure:3 Distribution of Lakes in the Neyveli hydrological basin (2016)

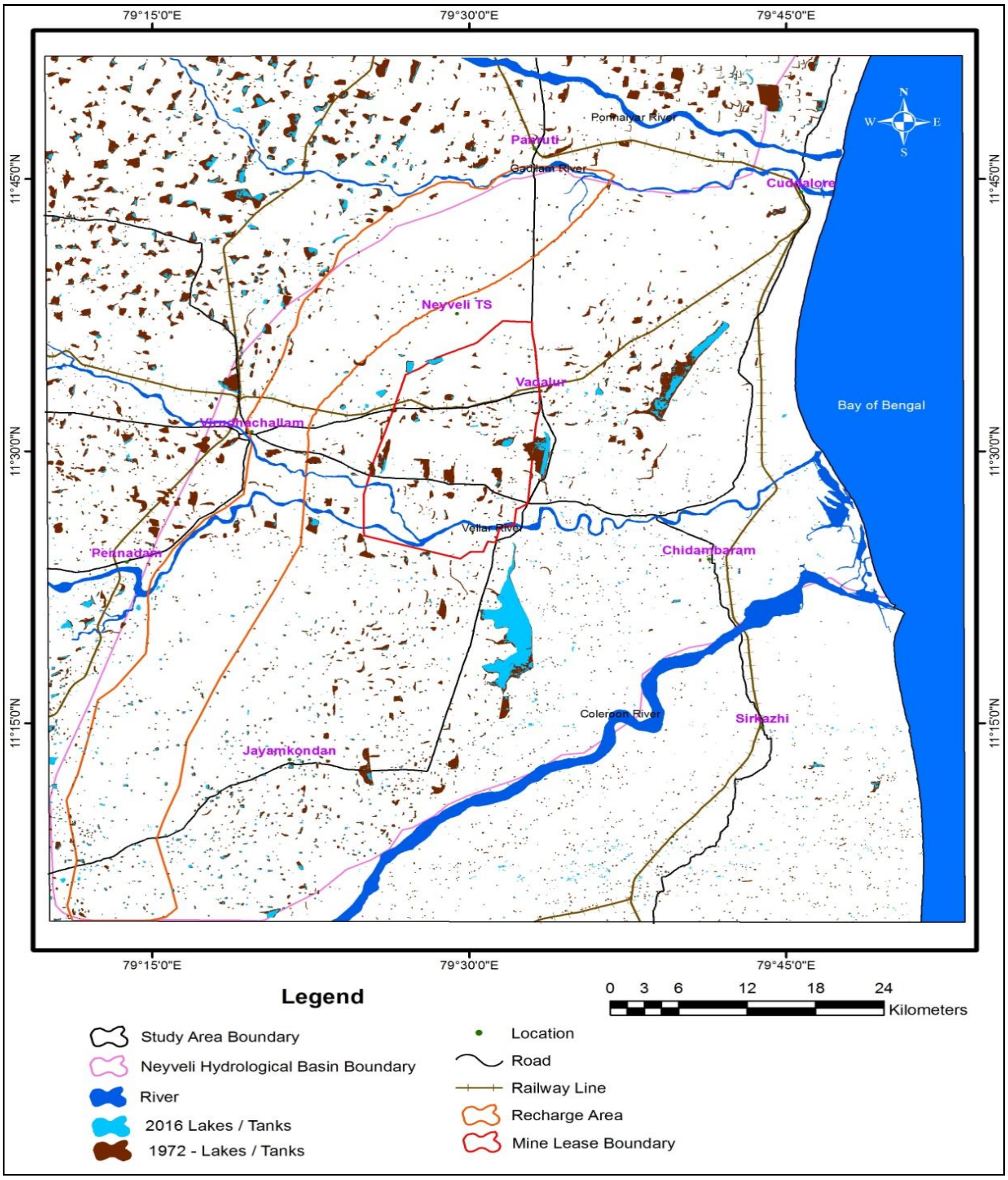


Figure: 4 Comparison of lakes based on SOI toposheet (1972) and Satellite Data (2016)

The size utility of lakes/water bodies is also changed to synchronize and understand; what lakes/water bodies are suitable for desiltation and restorations. The size-wise classification of all 4,492 lakes of Neyveli Hydrological Basins is shown in table.1. In the case of Very Large (>5sq.km) size lakes, there are three lakes, namely Veeranam, Perumal, and Walaja tank, which hold a total area of 42.81sqkm and have an entire perimeter of 94588.64m and contribute 16% of the surface area. In the case of Large (1 to 5sq.km) size lakes, there are 18 lakes which are having a total area of 28.63sqkm, have an entire perimeter of 111281.69m, and cover the geographical extent of 11% within the

Table: -1. Size-wise distribution of lakes in Neyveli Hydrological Basin

Surface water extent. In the case of Medium (0.25 to 1sq.km) size lakes, 212 lakes are present, with a total area of 98.20 sq. km, with an entire perimeter of 730459.2m and extent as 38% area. This category forms the maximum areal coverage and has a higher number of lakes next to that of small and tiny size lakes. In the case of Small (0.1 to 0.25sq.km) size lakes, 216 lakes are present, with a total area of 35.34sq.km, with an entire perimeter of 461064.2m, and covers the geographical area of the surface water body as 14%. Finally, in the case of Very Small (< 0.1) size lakes, there are 4043 lakes present, with a total area of 53.73sqkm, an entire perimeter of 1754931.56m, and 21% of the areal extent within the surface water area.

A) Lake with <0.1 sq.km Area

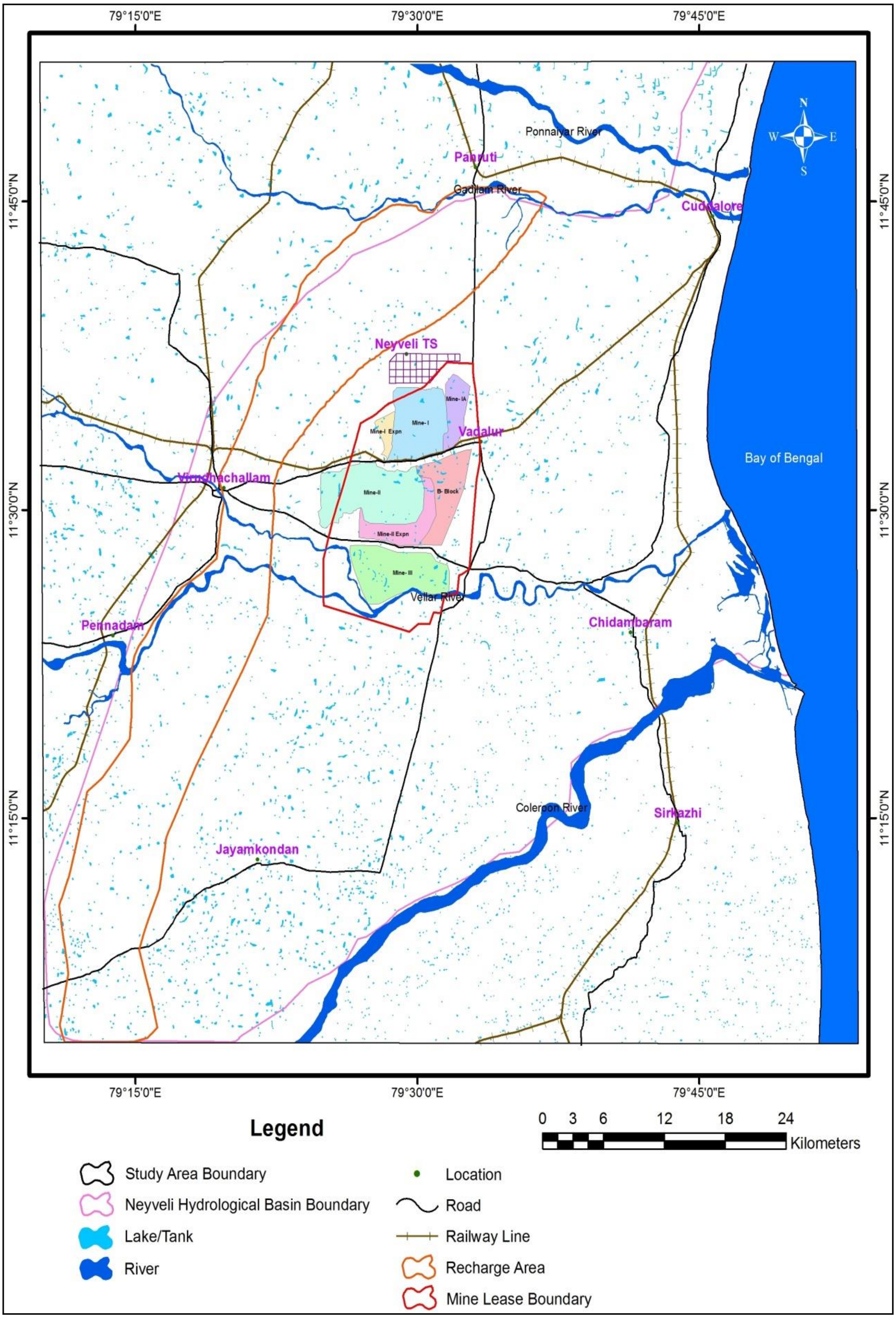
The lakes with the areal extent of <0.1sq.km were categorized as very small lakes. This category represents the highest number of lakes, i.e., 4043 lakes in the study area (Fig .5), and it occupies 57.73 sq. km. These lakes form 90% of the number of surface water bodies present but contribute 21% of the area of the surface water (lakes / tank) present in the study area and contributes 0.93% to the total study area (6170 sq. km). The lake, which has an area of <0.1sq.km, is insignificant concerning the agricultural activities and recharging the aquifer system. These lakes are present in good numbers in the southeastern part of the study area. This is the category having the highest number of lakes present in the study area and occupies

S. No	Class	Range	No. of lakes	Area (Sq.km)	Area %	Perimeter(m)
1	Very Large	> 5	3	42.81	16	94588.64
2	Large	1 - 5	18	28.63	11	111281.69
3	Medium	0.25 - 1	212	98.20	38	730459.2
4	Small	0.1 – 0.25	216	35.34	14	461064.2
5	Very Small	< 0.1	4043	53.73	21	1754931.56
	Total		**4492**	**258.71**	**100**	**31,52,325.29**

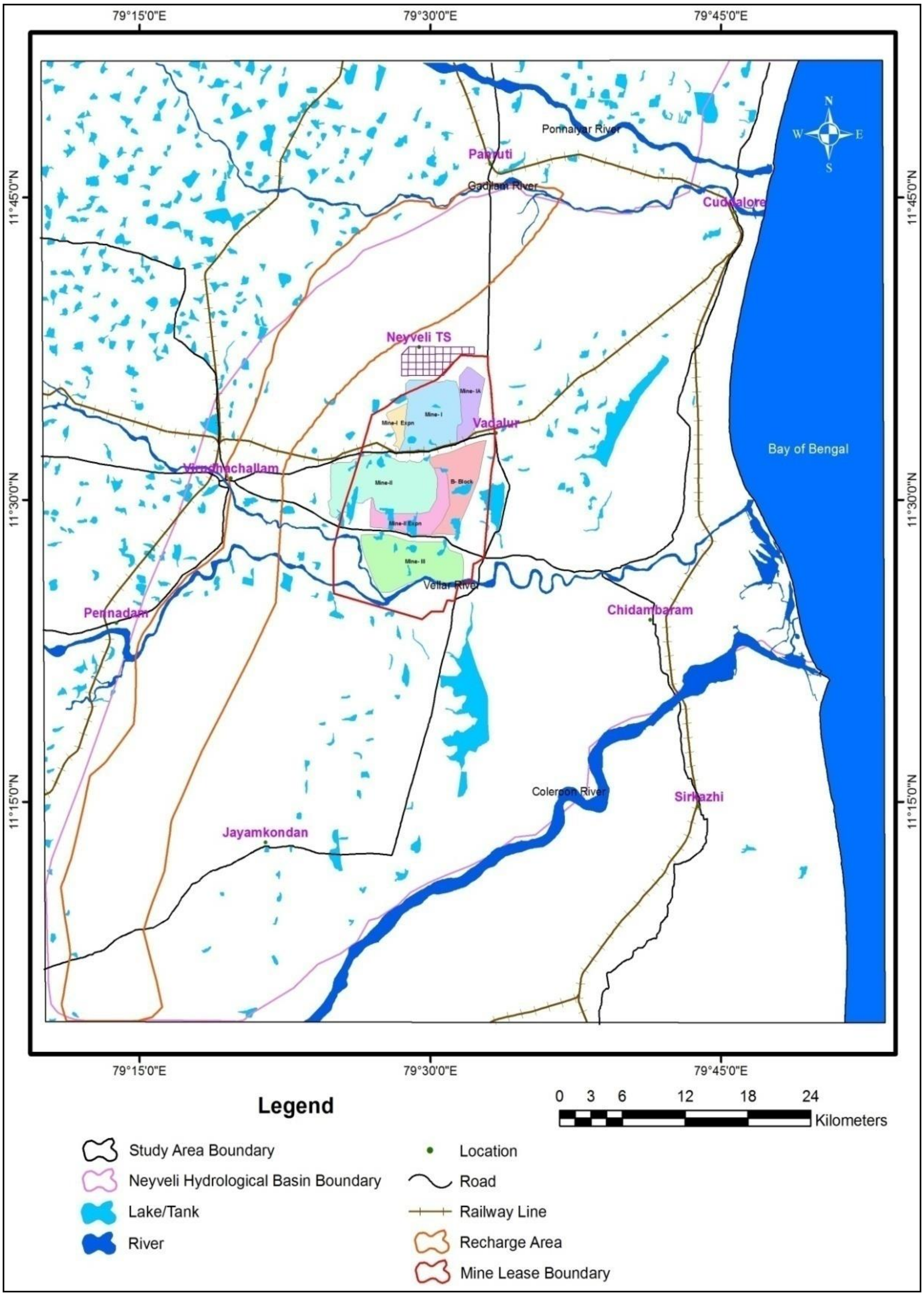
Highest areal coverage next to that of medium-size lakes. The data corresponding to the size variation within the class of small lakes (<0.1sq.km) exhibits that the highest number of lakes (1354) have the areal extent of <0.005 sq.km, next to that 1295 number of lakes falls within the size range of 0.005 to 0.01sq.km. There are about 702 lakes are representing 0.01 to 0.02sq. Km range, the lakes with <0.02sq. Km areal extent in the study area represents 261number of lakes. The lakes with <0.1 sq.km are 4043 in number; amongst this higher number of lakes, i.e., 2649 represent the area's size with <0.01sq.km. The rest of the 261 lakes represent the size of the water body with 0.02 to 0.03sq.km.

B) Lake with >0.1sq.km area

In general, the Neyveli Hydrological basin has many lakes; concerning its utilization and recharging principle, the lakes with an area of >0.1sqkm have been categorized as applicable for irrigation, agriculture, and many other ways.



Figure; 5 Distribution of Lakes having area <0.1sqkm in the Neyveli Hydrological Basin



Figure; 6 Distribution of Lakes having area >0.1sqkm in the Neyveli Hydrological Basin

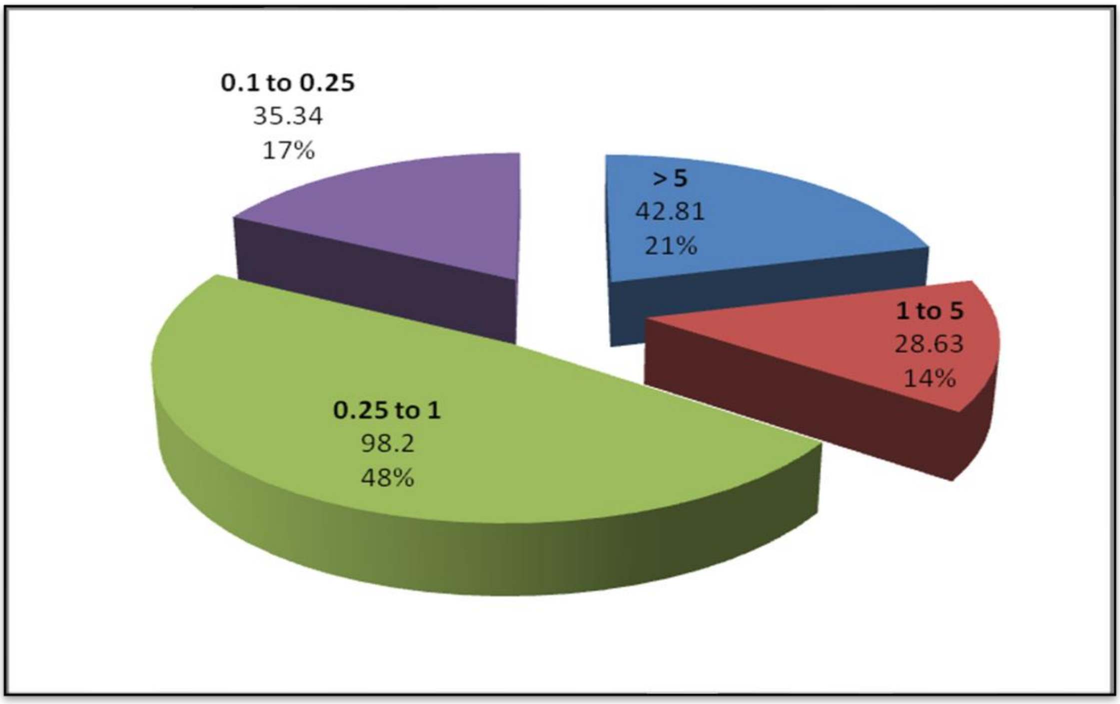


Figure 6 represents the lakes which are having >0.1sqkm area. According to size, lakes/water bodies/tanks were distributed in various ranges with a minimum >0.1sqkm. Only 449 numbers of lakes/tanks/water bodies fall within the study area. According to size and its utility these 449 water bodies has been categorized as Very Large (>5 sq.km), Large (1 to5sq.km), Medium (0.25 to 1sq.km) and Small (0.1 to 0.25sq.km). (Fig.7)

CONCLUSION

The digital base shows there were 4,492 lakes/tanks present in the study area. The ariel extent of the lakes/tanks within the Neyveli hydrogeological basin is reduced at a rapid rate from 258.72 to 45.61sq.km, from 1970 to 2016 at the rate of 4.63 sq. km/yr. The study also reveals that the more prominent lakes can survive for a longer duration and can work for irrigation and domestic purposes. Tanks with a water spread area of >0.1 sq. km were inferred by reclassifying the digital lake layer using Arc GIS. In this category, around 150 lakes were characterized. The study also concludes that the water bodies (>0.1 sq. km) present outside the Neyveli mining lease area have more possibilities for a more extended period. The reclassified lakes with >0.1sq.km and having the drainage network were chosen for further analysis. Monitoring and creating a digital database on lakes/tanks are not only crucial to assess the availability of water resources, as they play a significant role in agricultural activities, but also to understand the phenomenon of groundwater recharge to augment better water management practices. These maps will be helpful to recover and protect the surface water system maintain the ecosystem.

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