Chapter 10
Urbanisation and Tank Systems Adjoining Hyderabad—A Rapid Assessment Using Remote Sensing Techniques

K. Ramesh Reddy, P. Narender Babu and E. Srinivas

Abstract Hyderabad in the Deccan plateau forms a distinct socio-cultural and natural setting and is known for its water bodies such as tanks and reservoirs formed with a long history that still continue to influence the livelihoods of many. Hyderabad's urbanisation with drivers such as rapid industrialisation, surge in IT industry, housing for different classes of population, real estate boom, etc., have exerted tremendous pressure on the tank systems. The present study taken up in Sangareddy district, Telangana, with a prime objective to bring out effects of urbanisation on tank systems and map the spatial and temporal changes of tank catchments, submergence and command area using the Remote sensing techniques. Multi Spectral LANDSAT series and Sentinel 2 data from 2004 to 2016 are used to study the change pattern and understand the changes in terms of plotting, construction and other uncultivated areas. The Satellite data analysed supported by ground truth and relevant secondary data indicates that the tank systems are prone to severe degradation affecting the inflows, storage, irrigation, groundwater recharge and other indirect livelihoods like fisheries. More than 50% of the command area is lost in the last 15 years.

Keywords Tank system · Satellite data · Agricultural land · Urbanisation
Tank ayacut · Irrigation · Change detection

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1 Introduction

Based on the geographic, climatic and topographic back ground, tanks are the back bone of agriculture in Telangana region. Farmers' dependency on tank system has been quite high due to the topography and rainfall pattern in the region. Though the construction of tanks in Deccan region has a long history, since Satavahanas period dated variously from 271 BCE to 30 BCE, Kakatiya reign is known for the technical expertise in the development of tanks system. Similar sprit has been carried by the Muslim rulers of the Telangana region as well.

Hyderabad, having the rich history of 400 years is best known as City of lakes. Nizam's government has taken interest in the tank development in Hyderabad to mitigate droughts. However, with the change in climate, erratic rainfall pattern, improper maintainance of tank system by the community, unplanned growth of urban settlements, surge in the IT industry, housing for different classes of population, real estate boom, etc., gradually affected functioning of tank systems in the region.

The current study focuses on Yenki Cheruvu tank of Sangareddy district, 44 km away from city with a tank command area of 152 acres. The prime objective is to bring out the effects of urbanisation on tank system. Study attempts to map the spatial and temporal changes of tank catchments, submergence and command area using the Remote sensing techniques. Multi Spectral ortho-rectified satellite data of LANDSAT series 5 and 8 for the periods 2004 and 2016 and Sentinel 2 data for the period 2016 are used to bring out the changing pattern of tank system. Trends in land use pattern are mapped to understand the changes in terms of plotting, construction and other uncultivated areas.

2 Materials and Methods

2.1 Study Area

As per the reorganisation of districts taken up in Telangana state during November 2016, selected study tank falls in the newly formed Sangareddy district located in North west direction of Hyderabad city. Yenki Cheruvu in Muthangi village, located 44 km away from Hyderabad city centre lies at latitude 17 32 34N and longitude 78 13 15E. From the secondary data source of Minor Irrigation Department, this tank is selected as it is adversely affected by urbanisation. Yenki cheruvu has a registered ayacut area of 152 acres with a catchment of 3.81 km^2. Total submerged area of tank is 84 acres. Extent of Muthangi village is 8.09 km^2 area with a population of 8777 (Fig. 1).

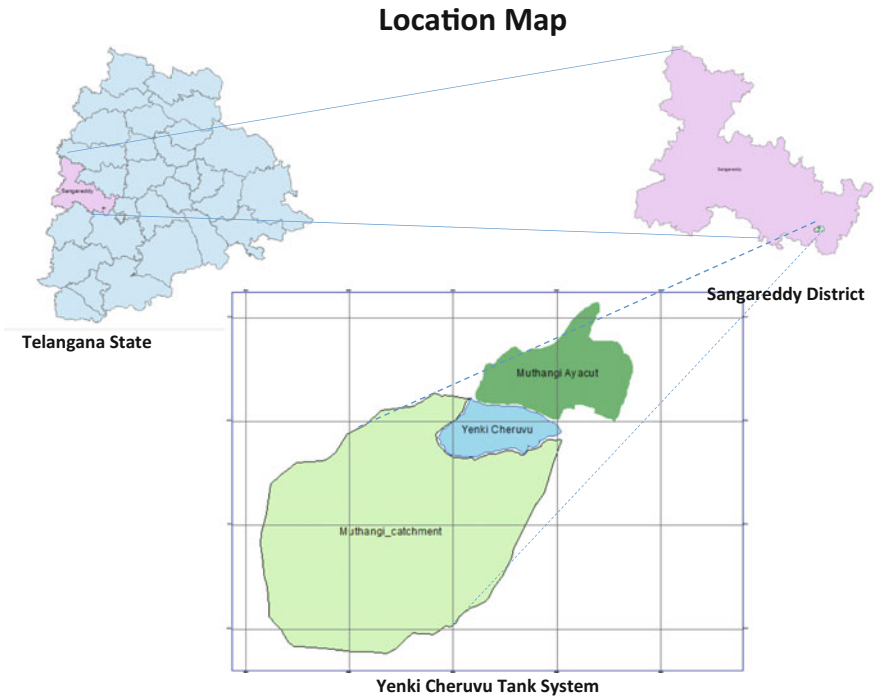

Fig. 1 Location map showing Yenki Tank, ayacut and catchment area

2.2 Datasets

For tracking the spatial and temporal changes in tank catchments, submergence and command area, multi spectral ortho-rectified satellite data of LANDSAT series 5, 7 and 8 for the periods 2004 and 2016 and Sentinel 2 data for the period 2016 were obtained from the public domain service of USGS data centre. Landsat data provide one of the most valuable datasets for mapping and monitoring the earth surface [1].

Cadastral maps from web site http://bhuvan.nrsc.gov.in/governance/twris village Pahanis (land details of farmers) are from http://mabhoomi.telangana.gov.in/GramaPahani_drs.aspx portal.

Landsat-8 has increased capabilities such as new spectral bands in the blue part and cirrus cloud-detection portion of the spectrum, two new thermal bands, improved sensor signal-to noise performance and several developments in radiometric resolution and duty cycle that allows a significant increase in collection of number of images per day [2].

2.3 Methodology

For analysing the effects of urbanisation on tank system, study used GIS softwares such as Arcgis and ERADAS. Cadastral map of the study area is obtained from two different sources, one from the Mandal Revenue office (MRO) and one from Bhuvan web site (http://bhuvan.nrsc.gov.in/governance/twris) to identify the tank ayacut boundary. Village Pahanis were download from http://mabhoomi.telangana.gov.in/GramaPahani_drs.aspx portal for the purpose of identifying the tank ayacutdars (farmers whose land is irrigated by selected tank water). Tank related secondary data has been collected from Command Area Development Authority (CADA) Irrigation department, Telangana and from the stakeholders (farmers) of the tank. Tank ayacut boundary has been marked with the geo-coordinates obtained using GPS instrument with the help of Village revenue officer (VRO)/Neeruganti and overlay of tank ayacut layer on cadastral map was done duly cross checking with the tank ayacutdars survey numbers from village Pahani. Water spread area and catchment area of the tank has been delineated using traverse method along with the GPS and same has been depicted using ArcGIS software.

Remote sensing satellite sensors record digital numbers (DN) of ground features at different wave lengths based on the reflectance capacity of the ground features. All the DN values are stored in the form of bands. The Landsat Thematic Mapper (TM) sensor carried on Landsat 4 and Landsat 5 consists of seven spectral bands with a spatial resolution of 30 m for Bands 1 to 5 and 7. Band 6 was acquired at 120 m resolution, re-sampled to 30-m pixels. Landsat 7 consists of eight spectral bands with a spatial resolution of 30 m for Bands 1 to 7. The resolution for Band 8 (panchromatic) is 15 m.

Sentinel-2 mission is a land monitoring constellation of two satellites (Sentinel-2a and Sentinel-2b) providing global optical imagery with 13 spectral bands using MSI (Multispectral Imager) instrument [3].

As the objective of the study is to bring out the changes in tank ayacut, tank catchment and tank water spread area, unsupervised classification has been used to classify the raster pixels based on the DN value it contains. To perform the unsupervised classification, ISODATA algorithm technique is used that resulted in creation of unlabeled clusters or classes in the satellite image. Using the above method, study area (tank ayacut, tank catchment, tank water spread) is classified into vegetation, settlement and water spread extent. To have image classification accuracy, training samples are created based on the ground truth sample position and create a signature to apply on the images.

Accuracy assessment is an established component of the process of creating and distributing thematic maps [4].

The combined use of Sentinel-2A and Landsat-7/8 poses a number of technical challenges due to the differences in their orbital, spatial, and spectral response functions, and image processing chains. Infact, although the radiometric characteristics of these sensors are similar, they are not identical and can lead to slight differences in surface reflectance and retrieval quantities as confirmed by the

inspection of the data [5]. The study estimate of the encroachment of water spread area of 6.69% was lower than that of the state average of 10% [6], 15.86% in the Kolar district [7] and 20–60% in Tamil Nadu [8].

3 Results and Discussion

The study has facilitated the assessment of effects of urbanisation on tank system resulting in changed land use pattern. Temporal changes in the study area have been brought out using the time series Landsat Thematic Mapper (TM) 2004 and Landsat Enhanced Thematic Mapper (ETM) 2016. Sentinel 2 data of the same period at 20-m resolution is analysed to see the variability of Landsat-8 (30 m) analysed data results. Study focused on vegetation, urban settlements, water spread area in the tank catchment, ayacut and tank areas. Changes in terms of area are assessed separately in the tank system. Study results are presented in Table 1.

3.1 Changes in Ayacut Land Use

The most striking feature observed in ayacut land use change is 149.30% decline of vegetative cover from 2004 to 2016. At the same time, area under urban settlements increased sharply from 4.89 acres in the year 2004 and to 34.92 acres in 2016 which is 6 times of that in 2004. Decline in vegetation during 2016 is a direct result of increase in urbanisation in the ayacut area and indirectly affected by increase of urban settlements in catchment area thus affecting the inflows into the tank (Fig. 2; Table 2).

Catchment area of the tank which is a key land for tank inflows has reduced with increase in urban settlements by 45.12% and there was a decline of 288.27% of vegetation. Even with poor water inflows to the study tank, it is found from the analysis, that there is a slight increase of tank water spread area from 32.04 acres in 2004 to 33.59 acres in 2016. Reasons for the above has found support from the secondary data collected from the irrigation department. Rupees 46.76 lakhs has been spent under Mission Kakatiya Phase I for removal of silt in the tank, improvement of sluices and improvement of channels to the fields etc. (Fig. 3).

As a result of rapid urbanisation, farmers lands in the command area are sold out for real estate plotting with is evident in the satellite image analysis. This can be

Table 1 Percent change in tank system from 2004 to 2016

Tank system	Settlement (%)	Vegetation (%)	Water (%)
Ayacut	85.99	−149.30	–
Catchment	45.12	−288.27	39.76
Tank (water spread)	97.50	−16.36	5.30

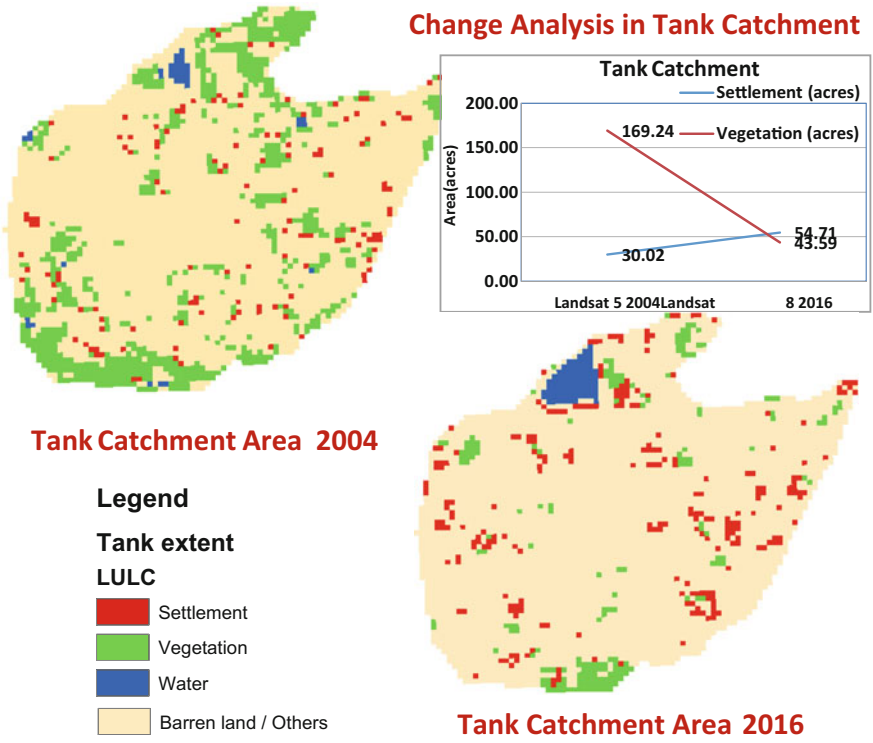

Fig. 2 Change analysis in the tank catchment area

Table 2 Change of landuse pattern with reference to registered tank area, ayacut and catchment

Year	Tank system and Reg. area (acres)	Settlement (acres)	Settlement (%)	Vegetation (acres)	Vegetation (%)	Water (acres)	Water (%)
2016	Ayacut (152)	34.92	22.97	15.79	10.39	_	_
	Catchment (631)	54.71	8.67	43.59	6.91	18.46	2.93[a]
	Tank area (83.9)	8.90	10.60	12.23	14.58	33.58	40.03
2004	Ayacut (152)	4.89	3.22	39.36	25.90	_	
	Catchment (631)	30.02	4.76	169.24	26.82	11.12	1.76
	Tank area(83.9)	0.22	0.27	14.23	16.96	31.80	37.91

[a]Interception by the water bodies in the Catchment

substantiated by the fact that the land values have risen sharply from about Rupees 25 lakhs in 2004 to as high as 70 lakhs to 1 crore per acre in 2016.

From secondary data source, it is observed that around 80 families have been directly or indirectly dependent on fisheries for their livelihood for a period of at least 3 months in a year. Encroachments and change in land use in the catchment, foreshore and water spread area with urban settlements and draining of urban

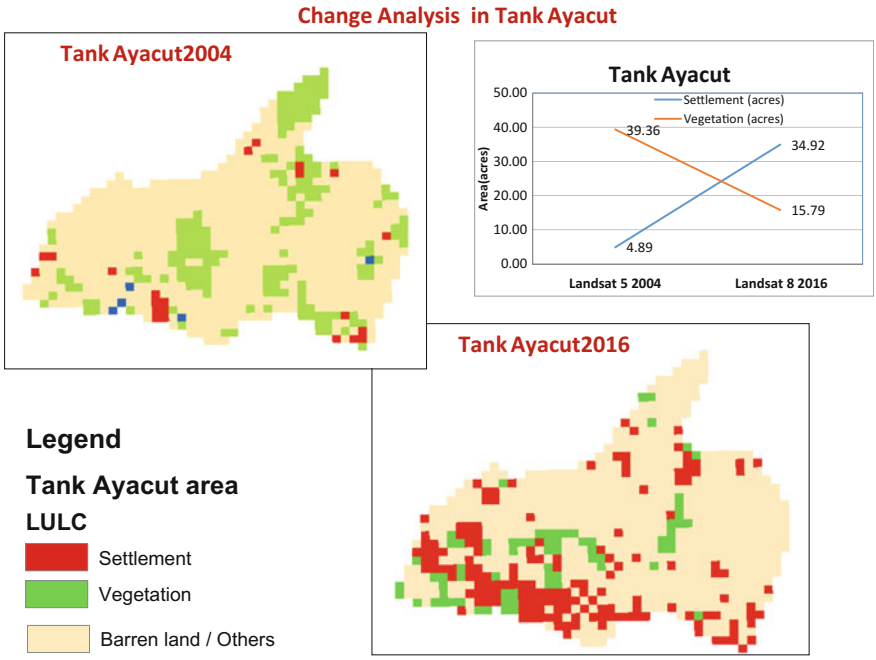

Fig. 3 Change analysis in the tank ayacut area

sewerage to tank area has led to tank water pollution. This adversely affected the livelihood of the families dependent on fisheries directly or indirectly.

As mentioned earlier, Sentinel 2 data for the study area has also been analysed along with the LANDSAT 8 for the period October 2016. Sentinel 2 data analysed at 20 m resolution also shows similar trend as Landsat 8 (Fig. 4).

3.2 Changes in Tank Water Spread Area

It is clear from the analysis that tank encroachment in the year 2016 increased to 97.2% compared to 2004. This is due to the placement of the tank adjoining the busy Hyderabad-Mumbai National highway. Monitoring of the encroachments periodically by the Irrigation Department or by the local body such as Water User Association (WUA) can reduce such activities. Local institution (WUA), which is not active in Telangana may be activated to increase people participation. Tanks are not only the sources of irrigation for the farmers but also serve to protect the local ecosystem through different ecosystem services. In other words, if the land value exceeds significantly downplaying the returns from agriculture, it doesn't necessarily mean the need to do away with the tank systems.

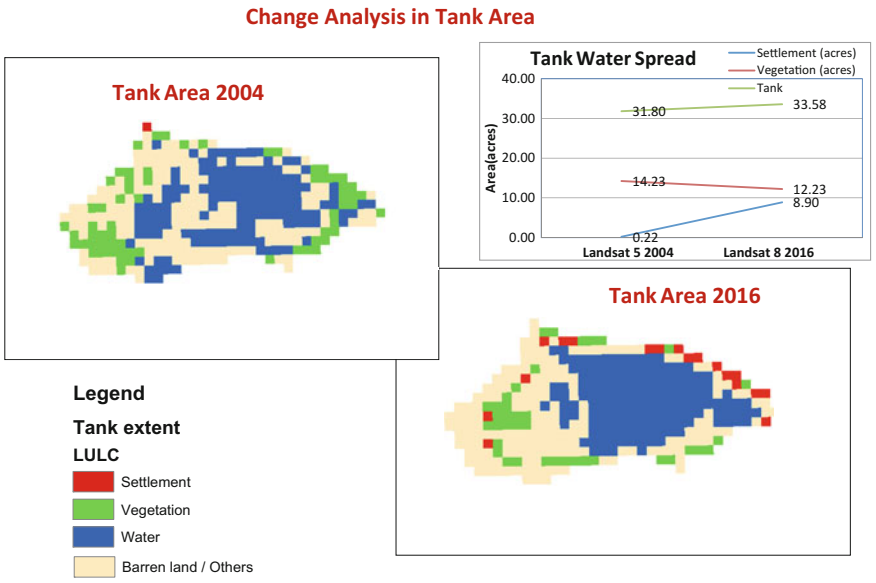

Fig. 4 Change analysis in the tank area

4 Conclusions

Tank systems are traditional means of livelihoods in Telangana that have been ecologically and economically productive since ages. Yenki cheruvu tank system is one such system that has got seriously deteriorated in the last 15 years. Due to the recent developments around Yenki cheruvu such as development of Outer Ring Road (ORR), proximity to the Hyderabad city and tank being adjacent to national highway, there is a huge transformation from agriculture land to urban property along with surge in land values. As tank systems serve much beyond the irrigation needs in the form of ecosystem services including provisioning, supporting, regulating and cultural services, it is important to protect them despite the fall in irrigated area under it. Involvement of institutions such as NGO's, WUA's in the initial phases of tank restoration and encroachments through motivation can give positive results. Government has to use the technology and services of GIS and Remote Sensing experts in mapping the issues around the tanks in the pre-urban and urban areas for sustainable ecosystem management.

Further research can be done using GIS and Remote sensing techniques to map the selected tank systems, which includes catchment, ayacut and tank water spread areas in and around Hyderabad city to bring out the vital statistics about effects of urbanisation on tank system and help in ecological conservation. This kind of study may also contribute to the sharpening of methods and techniques for delineation of

tank system and continuous monitoring. This can be eventually developed into a Decision Support System for the policy makers and administrators. Remote sensing high-resolution satellite data and results can help in framing the regulations for preserving the tank system for future generations.

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