International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-7 Issue-4s, November 2018

Urbanization Effects on the Surface Water Resources and Land Use in Udumal Petregion using RS & GIS

V. Chelladurai, P. Karthikeyan, S. Thangamani

Abstract: ***The continuous increase in population and the urbanization resulted in over exploitation of natural resources which directly affects the land use pattern and use of water. A study was framed to assess the changes in the land and water resources management in the Udumalpet taluk region during 1991-2009. The changes in land use pattern, growth and reduction in surface water body area in the region was analysed using ArcGIS 9.3 software.The land use pattern analysis results showed that the cultivable land and build-up land level increased during the study period (1991-2009), and a trend of decrease in water holding structures and uncultivable land area. The growth of area with buildings was 82.64%, in this region and in the urban area switch of land to buildings was 2.16 times of overall build up area increase. The area of surface water bodies at the urban and rural areas were declined by 7.31% and 4.78%, respectively during this study period (1991-2009).The portable water demand forecast analysis showed that the portable water requirement in 2041 would be 2.31 and 1.63 times higher than the portable water requirement in 2011 at the urban, and rural areas, respectively.***

Keywords: Land use pattern change, land cover change, Urbanization, portable water requirement

I. INTRODUCTION

Due to increasing population and industrialization, the urban areas are expanding day by day. For the urbanization, the land from various different land use classes like cultivation land, water bodies are taken up throughout the country. The population increase and industrialization also create stress on water resource management since water needs for most of the activities of economical growth like agriculture and manufacturing industries. The huge increase in urbanization over the last three decades resulted to overuse all the water resources and also it reduced the area of water bodies like ponds, lakes, and canals. The Food and Agriculture Organization's study shows that the share of urban population will be around 54% in 2050, and the domestic demand will be around 90 km^3 [1] (FAO, 2007). In India, the population had increased by17.64 percent from 102.7 to 121.01 crores, while the population of Tamil Nadu had increased by 15.60 percent from 6.21 to 7.21 crores during 2001-2011. During the same period, the proportion of urban population had increased by 31.80%, and 27.16% in India, and Tamil Nadu, respectively. Presently urban population share in India is 31.16% while it is 48.45% in Tamil Nadu [2](Census of India, 2011).This growing population and rapid urbanization create insufficient potable water supply[3](Montgomery and Elimelech, 2007).With rapid urbanization and industrialization in recent times, the area of surface water bodies like lake and river network systems are shrinking in a rapid phase. Similarly, rapid urbanization also reduced agricultural production area as well as changing the land use pattern in a disorderly manner[4](USEPA, 2008). The changes in land use pattern are directly affecting the environment as well as the productivity of land [5] (Vink, 1983). So, a detailed research on the increase in urban area and the management of water resources will help to develop optimal land and water use policies [6] (Chowdhury and Rahman, 2008). Rationalize the water use for portable water supply, irrigation, and industrial use is the major challenge for the policy developers and the application of Remote Sensing and Geographic Information System (GIS) technologies for studying land and water management is getting popular in recent times since they are cost effective and accurate[7] (Chaudhary, 2003).

Till date, there were not many studies on the urbanization effect on land use and surface water changes in Amaravathi River Basin on a large scale [8] (Latha, *et al.*, 2010).The Amaravathi watershed in the Udumalpet region is situated in Tiruppur industrial region which is the most progressive region in Tamilnadu in terms of both agricultural modernization as well as urbanization. The changes in the land use pattern, expansion of urban population, development of manufacturing industry sector and the climate and weather pattern in this region is causing environmental as well as ecological changes of this Amaravathi watershed region [8] (Latha, *et al.*, 2010).

This research study aims to analyse the urbanization pattern, total future water demand and to detect the land use changes of Udumalpet region (Amaravathi watershed) using the data collected from remote sensing and GIS techniques. To develop an efficient water use policy, the land and water area data of twenty years (1990-2009) was used in this study.

Manuscript published on 30 November 2018.
***Correspondence Author(s)**
Dr. V. Chelladurai, Associate Professor, Bannari Amman Institute of Technology, Sathayamangalam, Erode (Tamil Nadu), India.
Dr. P. Karthikeyan, Assistant Professor (Sr. Grade), Bannari Amman Institute of Technology, Sathayamangalam, Erode (Tamil Nadu), India.
Dr. S. Thangamani, Assistant Professor (Sr. Grade), Bannari Amman Institute of Technology, Sathayamangalam, Erode (Tamil Nadu) India.

II. MATERIALS AND METHODS

The Amaravathi watershed is situated between 10°41’23” N and 10°13’55” N latitude and 77°05’54” E and 77°25’11” E longitude. This watershed covers a 650.33 km^2 in area Udumalpet region, Tiruppur district, Tamil Nadu, India. The Soil & Land Use Survey of India code for the Amaravathi watershed is 4B2A6, and this water shed has altitudes from 320 to 2220m (MSL). Since the major upper reaches lying in the southern part of the watershed are covered with reserve forest, that portion was not included in this study. So the Upper Amaravathi Watershed (UAW) excluding reserve forest area has been chosen for this study, and Udumalpet, the main urban area in this watershed was selected to analyse the effects of urbanization. This UAW region has average altitude of is 368 m (MSL), and the temperature range of 15°C-39°C. The annual average precipitation is 650-750 mm, of which most of the precipitation falls during the northeast monsoon [9] (Kandasamy and Chellamuthu, 2012).

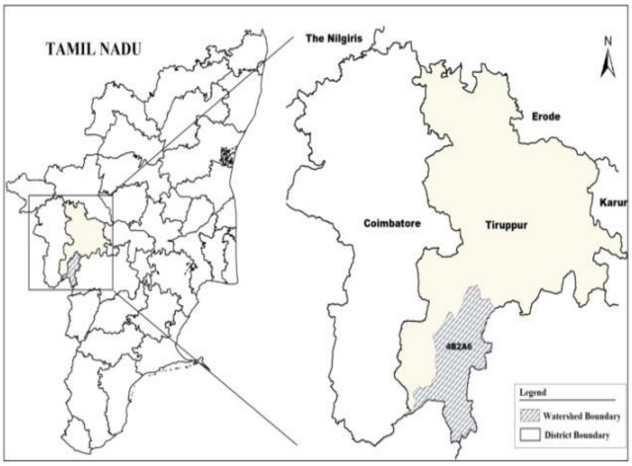

Fig.1. Map of the Amaravathi watershed

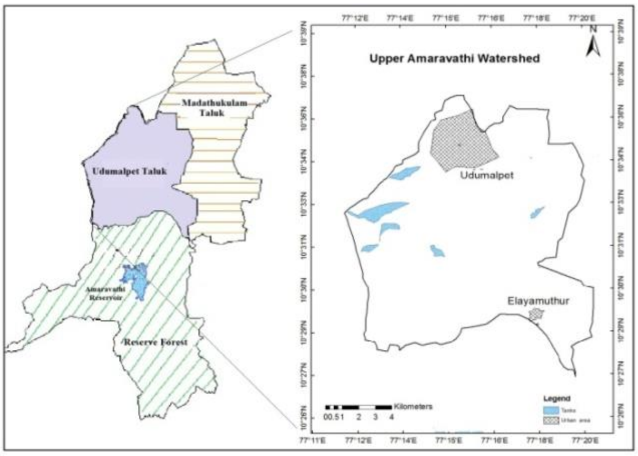

Fig. 2. Map of the current study area

III. MATERIALS

For land and watershed management analysis, Toposheets were collected from the Survey of India and to analyses the growth of urbanization the city maps were collected from municipal authorities. For RS and GIS analysis the satellite images for the study area were downloaded from the USGS Earth Explorer, and then processed using Arc GIS 9.3.

A. Change Detection Analysis

The experimental methodology described in the Fig.3 was used to analyse the changes in land and water cover area in the region.

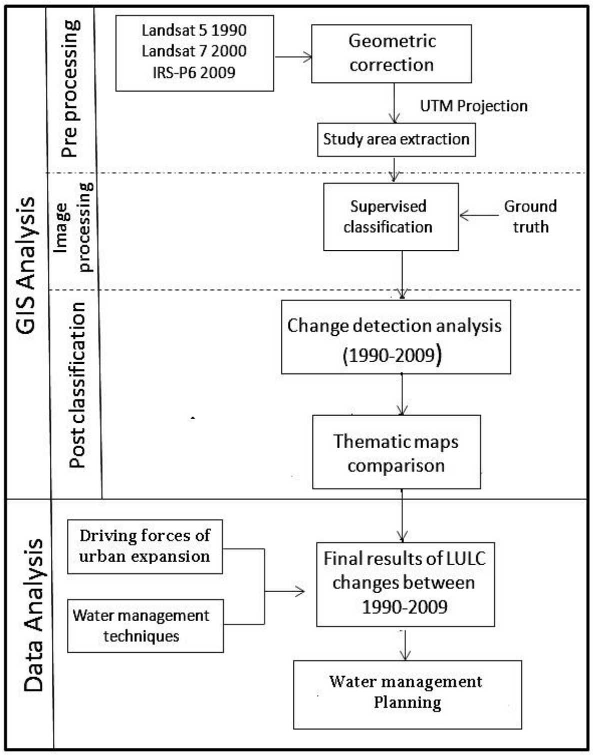

Fig. 3. Process Methodology of the study

B. Satellite Data Used

Satellite data from three different satellites (Landsat 5 with Thematic Mapper (TM) sensor, Landsat 7 with Enhanced Thematic Mapper (ETM+) sensor and the Indian Remote Sensing Satellite (IRS) P6 with LISS III sensor) were collected and analysed in this study using RS and GIS software. For land use analysis the images (cloud-free) captured by the Landsat satellites were obtained from the Global Land Cover Facility (GLCF), Maryland USA website (www.landcover.org), and the details of satellite data collection are presented in the Table. 1. The Landsat 5 (TM) collects data using thermal band, four spectral bands in the visible and near-infrared wavelength regions. Landsat 7 with ETM+ collects data from Blue (0.52-0.6 µm), Green (0.63-0.69 µm), Red (0.76-0.90 µm) bands. The study area is covered in path 144 and row 53 of Landsat satellites [8] (Latha, *et al.*, 2010).

C. Classification using Land Use and Land Cover (LULC) of study area

LULC classification technique was used to analyse how the land area was used and classify the area into different categories depends on the application. Ground truth data were carefully examined by visual interpretation and then five LULC classes were developed for this study (Table 2).

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

The total cultivable land consists of total cultivated area and current fallow land. Image classification technique was used for detecting the changes in the land uses.

S. No	Date	Satellite/Sensor	Spatial Resln.
1	24-01-1990	Landsat 5 – TM	30 m
2	14-01-2000	Landsat 7 - ETM+	30 m
3	24-02-2009	IRS/P6 - LISS III	23.5 m

Table. 1. Specification of satellite data collection

S.N O.	Class	Land use and Land cover included in the class
1	Built-up land	Residential, industrial and commercial buildings/ structures.
2	Water bodies	Reservoirs, Rivers, Tanks, Canals, and streams.
3	Cultivated land	Cropping land, Orchards, and nurseries.
4	Fallow land	Current fallow land, Grazing land, Pasture land and Cultivable wasteland
5	Uncultivable land	Land which cannot be brought under cultivation such as Bare exposed land, surface disturbed ground at building sites, open shrubs.

Table. 2. Land use/land cover classes developed for analysis

D. Image Classification Techniques

The images were pre-processed to remove noises and then analysed using supervised classification technique (maximum likely hood algorithm) based on the signature data collected by field verification process. The areas under the selected LULC classes are calculated by multiplying the single pixel size (m^2) and a total number of pixels in the LULC classes.

IV. RESULTS AND DISCUSSION

For analyzing LULC changes, three satellite images of different periods (1990, 2000 and 2009) were selected and analyzed using ArcGIS 9.3 software. The FCC (False colour composite) of the satellite data were generated by combining information in Red, Green and Blue bands. The satellite images of the study area in the form of FCC corresponding to 1990, 2000 and 2009 were presented in Figures 3, 4 and 5,respectively.

A. Changes of Land Use pattern

The total land use pattern change was analysed during the study period in order assess the effects of urban expansion on different LULC classes and given in Table3.

B. Land Use Pattern Changes During 1990 To 2000

During this period, the urban and built up area in this region increased and a trend of decrease in the water body area. The built-up land area has grown up by 52.36 % in the ten year period (1990-2000), which was the highest change among all LULC classes. At the same time, surface water body areas have declined marginally by 0.68%, most of which occurred in and around the urban area. This result was similar to the findings of [10]*Sundarakumar* (2012), who reported an increase of 372.28% in built up land area, and decrease of 33.22% in water bodies area . Cultivated land increased by 765 ha in this period, which was mostly on current fallow lands. Total cultivable land consists of both cultivated area and fallow land. In this context, the total cultivable land was reduced by 65 ha in this period (1990-2000). These cultivable lands were expensed for urban development.

C. Land Use Pattern Changes During 2000 To 2009

During 2000-2009, the increase in built-up land was 19.87%, which is less when compared with the 1990-2000 period. It is inferred that usage of already developed infrastructure was the reason for this reduction in build up area development and these observed findings are similar to the result that was reported by [10]*Sundarakumar* (2012), and Tan *et al.*, [11] (2005).

D. Overall Land Use Pattern Changes (1990 – 2009)

The results of this clearly showed continuous increment in the built up area development in the Udumalpet region during these two decades (1990-2009). The uncultivable land gradually reduced from 27.94% to 24.92 % as built-up area increased from 6.02 % to 10.95 % of total land cover. Most of the development of built-up area was at the uncultivable land. Fallow land and area of water bodies have also meagrely shared their land for urban area expansion. But, compared to the changes during 1990-2000, the percentage of built-up area expansion was less during 2000-2009. Similar findings have been reported for elsewhere [12, 13, 14] (*Cetin*, 2009; *Ningrui,et al.*, 2010; *Yin,et al.*, 2011). As a whole the built-up land and cultivated land area increased, and the other LULC classes namely water bodies, fallow land, and uncultivable land recorded the overall decreasing trend during the study period 1990-2009.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

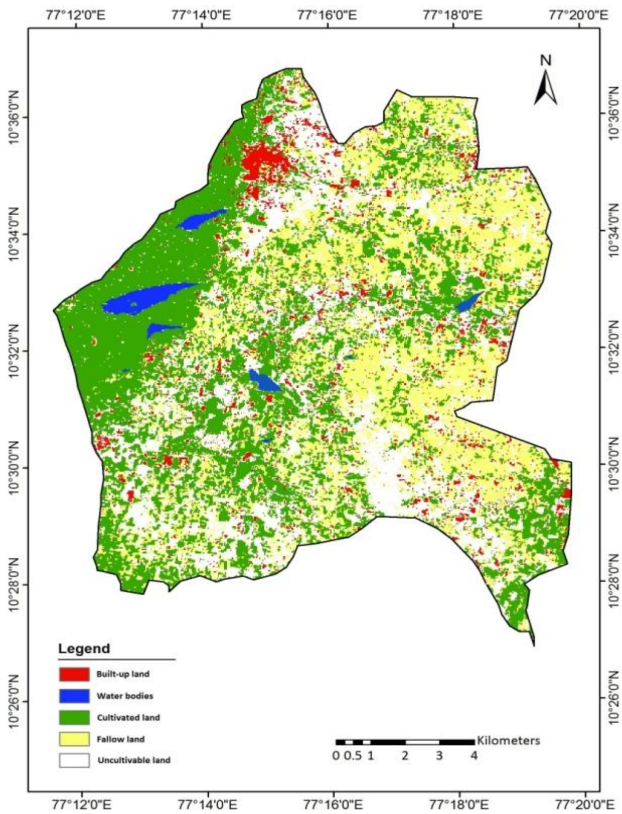

Fig. 3. Map of Land use pattern of Amaravathi watershed during 1990

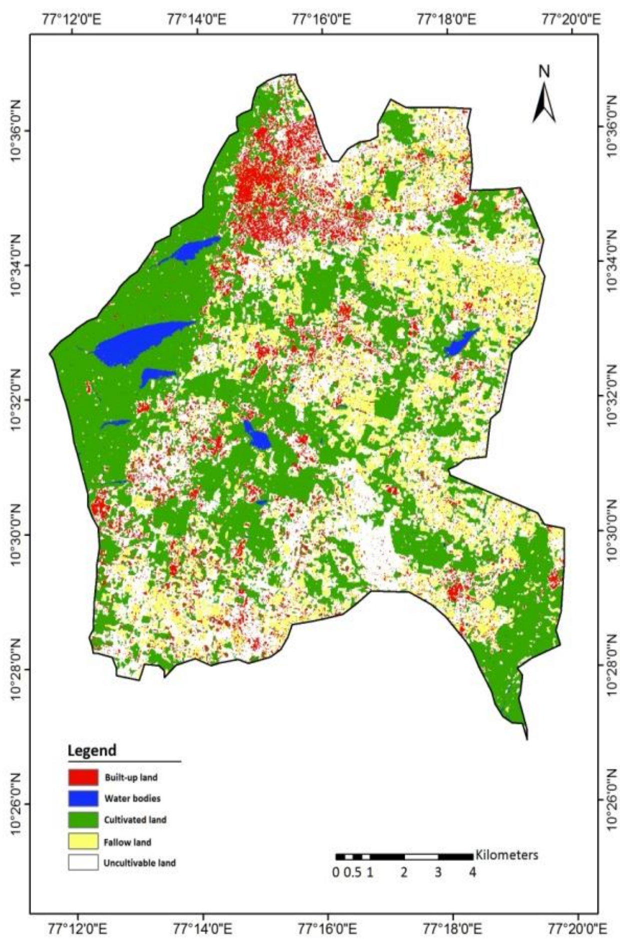

Fig.4. Map of Land use pattern of Amaravathi watershed during1990

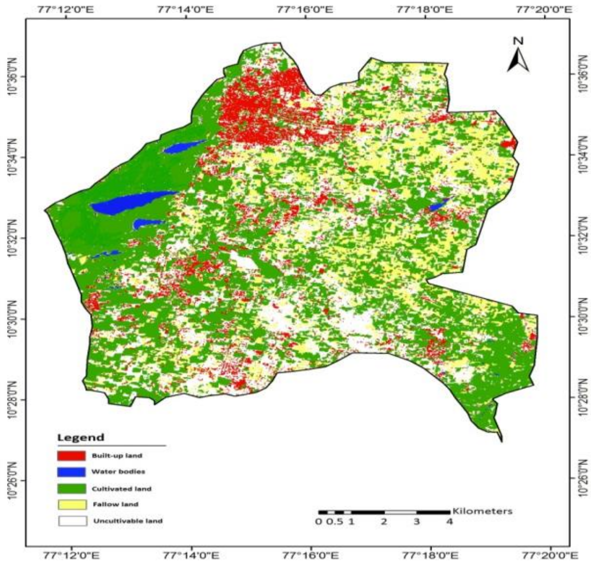

Fig.5. Map of Land use pattern of Amaravathi watershed during 1990

Class	Area						Changes in Area					
	1990		2000		2009		1990-2000		2000-2009		1990-2009	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Built-up land	1037	6.02	1580	9.16	1894	10.95	543	52.36	314	19.87	857	82.64
Water bodies	292	1.68	290	1.67	276	1.59	-2	-0.68	-14	-4.82	-16	-5.47
Cultivated land	6193	35.8	6958	40.25	7433	43.03	765	12.35	475	6.82	1240	20.02
Fallow land	4932	28.5	4102	23.73	3546	20.51	-830	-16.8	-556	-13.5	-1386	-28.1
Un-cultivable land	4830	27.9	4354	25.19	4135	23.92	-476	-9.85	-219	-5.02	-695	-14.3

Table. 3. Overall Land Use Pattern Changes during 1990 – 2009

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Total cultivable land (both cultivated land and fallow land) has decreased over two past decades, the total cultivable land was reduced from 11125 ha (64.36 %) in 1990 to 10979 ha (63.52%) in 2009. Totally 146 ha of cultivable lands were reduced. It indicates that approximately 7.3 ha of cultivable land has been lost in every year and converted for other purposes.

E. Effects of Urbanization and Land Use Pattern on Water Resources

The total area of water bodies in the study area have declined gradually from 1990 to 2009. About 16 ha of water surface area has been diminished in the last two decades. Almost all the water bodies around the urban area have been subjected to reduction in area. While most of the rural water bodies remained unchanged.Rapid urban growth requires more water in the future. Thus, potable water requirement in the study area has increased. This condition causes scarcity of water and may lead to the over-exploitation of groundwater resources in future. The further growth of urban areas will lead to targeting cultivable land and surface water bodies for urban development.

V. CONCLUSION

The results of this study clearly show that the urban sprawl is the major reason for the changes in the land use pattern in the Amaravathi watershed region. The satellite data collected from three different Landsat satellites along with the field verification data were used to analyse the land use pattern in this region during 1990-2009 using RS and GIS tools showed that the built up area expansion and reduction of water bodies and uncultivable land during this period. Change detection analysis shows that most of the settlements were built-up at expense of uncultivable land and fallow land.Most of the expansion in human settlements was observed within urban environments, which caused the considerable loss of water bodies in the urban area. This analysis result can be useful in policy preparation in urban development and watershed management. Understanding the rate of land use changes in time and space is useful in planning for suitable management of land and water resources.

REFERENCES

1. FAO, 2007. Coping with water scarcity - Challenge of the twenty-first century, *World water day issue.*
2. Census of India. 2011. Rural-Urban Distribution of Population, *Provisional Population Totals,* Government of India Publications, New Delhi.
3. Montgomery, M.A., and M. Elimelech. 2007. Water and sanitation in developing countries: including health in the equation. *Environmental Science & Technology*. 1: 12–24.
4. USEPA, 2008. *Environment Protection Agency (EPA) Report on Environment*. United State Environment Protection Agency.
5. Vink, A.P.A., 1983. Landscape Ecology and Land Use. *Longman, New York*. 171.
6. Chowdhury, R. K. and R. Rahman, 2008. Multi-criteria decision analysis in water resources management: The Malnichara channel improvement. *International Journal of Environmental Science and Technology*, 5(2): 195-204.
7. Chaudhary, B.S., 2003. Integrated Land and Water Resources Management in Southern Part of Haryana using Remote Sensing and Geographical Information Systems (GIS).*Ph.D. Thesis,* University of Rajasthan, Jaipur.
8. Latha, J.C., S. Saravanan and K. Palanichamy, 2010. A Semi – Distributed Water Balance Model for Amaravathi River Basin using Remote Sensing and GIS. *International Journal of Geomatics and Geosciences*, 1(2): 252-263.
9. Kandasamy, P. and M. Chellamuthu, 2012. Dry Spell Analysis for Water management Planning. *International Journal of Applied Science and Engineering Research*, 1(1): 127-137.
10. Sundarakumar, K., M. Harika, S.K. Aspiya Begum, S. Yamini and K. Balakrishna, 2012. Land use and land cover change detection and urban sprawl analysis of Vijayawada city using multi-temporal Landsat data. *International Journal of Engineering Science and Technology*, 4(1): 170-178.
11. Tan, M.X.L., H. Xie and C. Lu, 2005. Urban land expansion and arable land loss in China - A case study of Beijing-Tianjin-Hebei region. *Land Use Policy*, 22: 187–196.
12. Cetin, M. 2009. A satellite-based assessment of the impact of urban expansion around a lagoon. *International Journal of Environmental Science and Technology*, 6(4): 579-590.
13. Ningrui, D., H. Ottens and R. Sliuzas, 2010. Spatial impact of urban expansion on surface water bodies - A case study of Wuhan, China. *Landscape and Urban Planning*, 94: 175–185.
14. Yin, J., Z. Yin, H. Zhong, S. Xu, X. Hu, J. Wang and J. Wu, 2011. Monitoring urban expansion and land use/land cover changes of Shanghai metropolitan area during the transitional economy (1979–2009) in China. *Environ Monit Assess,* 177:609–621.