LAND USE/LAND COVER CHANGE DETECTION AND EFFICACY OF ARTIFICIAL RECHARGE STRUCTURES IN VANIYAR SUB BASIN OF THE PONNAIYAR RIVER, SOUTH INDIA USING REMOTE SENSING AND GIS TECHNIQUES

S. Venkateswaran[1], S.Satheeshkumar[2], R.Kannan[3]

[1]*Hydrogeology lap, Department of Geology, Periyar University, Salem – 11, Tamil Nadu, India*
[2]*Hydrogeology lap, Department of Geology, Periyar University, Salem – 11, Tamil Nadu, India*
[3]*Hydrogeology lap, Department of Geology, Periyar University, Salem – 11, Tamil Nadu, India*

Abstract

Spatial-temporal changes in land use (LU) and land cover (LC) using remote sensing and GIS buffer analysis techniques were carried out in the Vaniyar sub basin of the Ponnaiyar River in South India. Land uses within buffer distances from Artificial Recharge Structures (ARS) were calculated to quantify the effects of artificial recharge structures. Generally, some land use types were decreased with the increased ARS distances. The objective of this work is to notify the significant changes caused by artificial recharge structures and quantifying land use, land cover changes in the Vaniyar sub basin. Most importantly, the growth of population and domestic product accompanied by the growth in industrial and agricultural activities which led to LULC changes with increased built up land and cropland 20% and decreased water body from 2005 to 2015. Furthermore, the simulated based on results land use scenarios in 2005 and 2015, respectively, for assessing the impact of ARS on LULC change detection analysis were carried out in the sub basin. The results shown that land use pattern changed greatly after ARS construction. Since forest land and cropland are two main types of land use in the study area, the forest land occupied over 35.4% in the study area, during the year 2005-2000, water body had 16 % in the year 1985 and 8% in 2000 decreased. In the major check dam shows that indirect effect within 500 m buffered based on temporal, changing aspects of land use. This interpreted result was derived with the help of satellite data for the periods before and after the construction of artificial recharge structures. Generated land use/cover maps in and around the structures for both pre and post ARS with special reference to vegetation changes. The results reveal that, accompanied by climate change, the LULC changes and human water consumption to be the important factors contributing to the significant changes in the sub basin.

Keywords: *Land use, Land cover, Buffer, Check dam, Remote sensing.*

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1. INTRODUCTION

Artificial recharge structures are important to conserve natural resource like, water and soil, which is reducing day by day at alarming rate. Spatial-temporal change of land use and land cover between 2005- 2015 based on the application of remote Sensing and GIS buffer analysis technique. Land uses within buffer distances in centre of artificial recharge structures were calculated to quantify the effects of artificial recharge structures construction. The results showed that land use structure changed greatly during and after ARS construction. Forestland and cropland were two main types of land use, the forest land occupied over 35.4% in the study area. Built up land was much larger than water body are not equally balanced. Water body had the 16 % in 1985 and 2000 about 8% decreased. Further studies showed that in direct effect was limited in the 500 m buffer region based on the land use patterns including temporal changing aspects of land use and tendency. Generally, three types of land use decreased with the increased off-dam distances. The significant changes caused by land use and land cover (LULC) Bruce D.R (2000)[3] ; Gao (2009)[4]; Jayakumar S (2003)[1];Sundarakumar K et al (2012)[1];Tamilenthi S et al(2011)[1];Vanum, G et al(2012)[1];Venkateswaran S et al (2015)[1]; Ganasria B P(2015); Gunasekaran S et al.,(2014)[1]; Ehsan Sahebjalal et al(2013)[1] ; Ardavan Ghorbani et al(2012)[1] and to quantify the impacts of the observed changes in Vaniyar sub Basin. Most importantly, the growth of population and gross domestic product accompanied by the growth in industrial and agricultural activities, which led to LULC changes with increased built up land and water body decreased from 2000. The simulated based on results land use scenarios in 2005 and 2015, respectively for assessment the impact of LULC changes on the Spatio-temporal distribution in the Vaniyar sub Basin. The results suggest that accompanied with climate change, the LULC changes and human water consumption. The interpreted satellite data for the periods prior to and after the construction of artificial recharge structures generate land use/cover maps in around the structures for both the periods with special reference to vegetation changes. Finally, GIS data generated and carry out change detection analysis to quantify the changes in and around artificial recharge structures.

2. STUDY AREA

The study area situated in Salem and Dharmapuri districts of Tamil Nadu. The ephemeral stream Vaniyar has its source along the northern slopes of Shervorayan hills and originating at Kombur and takes a course along the northeast in the valley and emerges out as the main artery of Dharmapuri district with northeast gradient and small portion of catchments area falls in Salem district. The Vaniyar sub-basin has 128 total revenue villages. The study area is agriculture based and water supply is met mainly by dug wells and bore wells. The study area is mainly underlined by Charnockite and followed by Epidote-Hornblende-Gneisses.

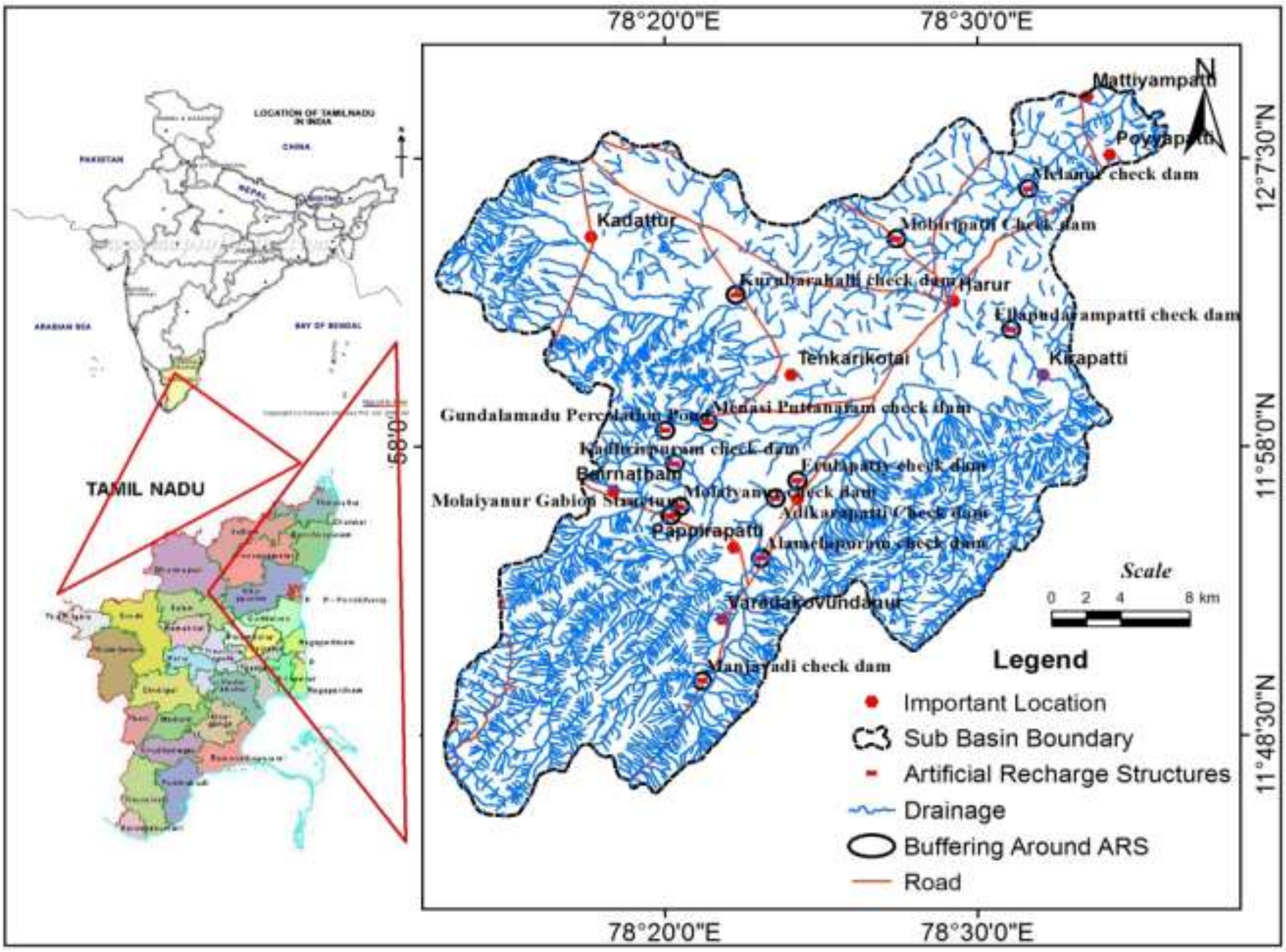

Fig.1. Base map showing Artificial Recharge Structures in the sub basin

2. MATERIALS AND METHODS

The satellite Data have been collected from Landsat.org and USGS their website (http://earthexplorer.usgs.gov) for two periods of time such as before and after construction of artificial recharge structures. The chosen satellite images have been digitized before construction of ARS 2015 and after construction 2005. The satellite images have helped to assess the impact of artificial recharge structures by comparing vegetation changes and land use/land cover (Fig.1). Topography map collected from Geological survey of India and also Google Earth <5 m resolution images are used for primary data collection and to locate ARS in major stream.

The flow chart for the methodology adopted was given in Fig. 2.

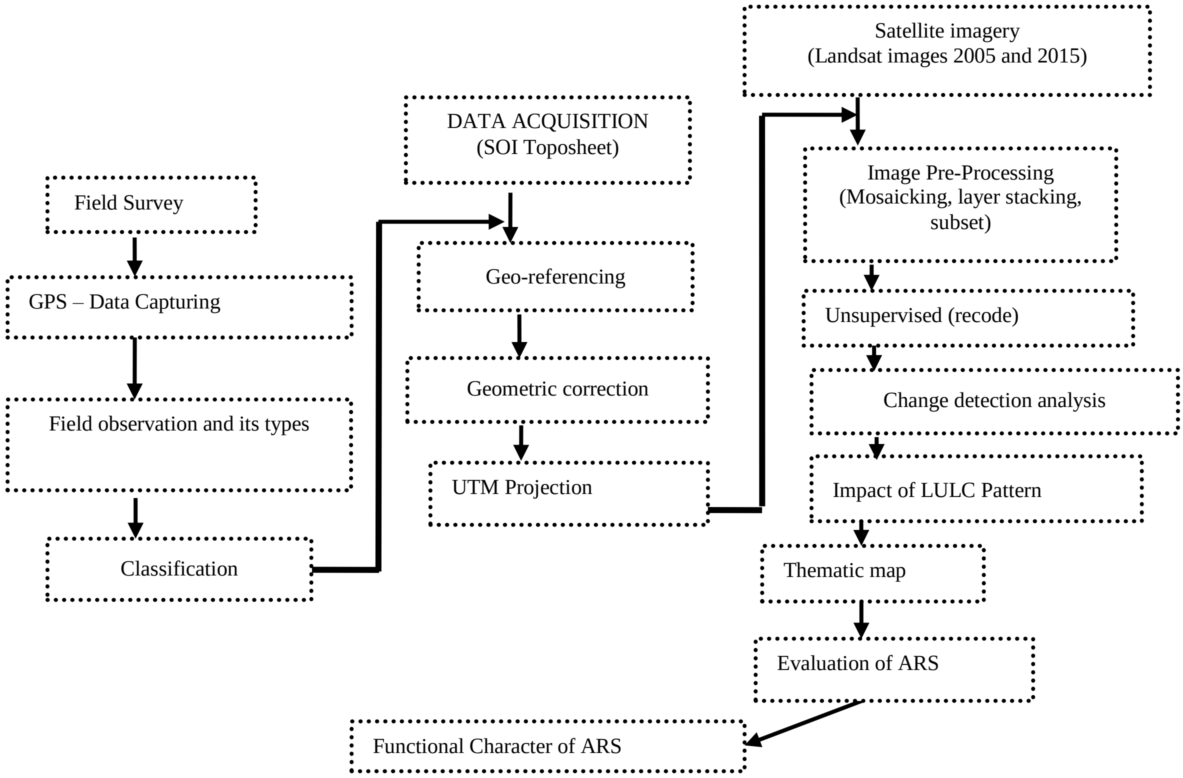

Fig.2. Flow chart showing methodology for the present study

3. RESULT AND DISCUSSIONS

3.1. Change Detection Analysis

The Normalized Difference Vegetation Index (NDVI) method is used for detecting and monitoring LULC changes in the sub basin. In agricultural land changes Compared from 2005 to 2015.The NDVI method is relatively easy tool and simple to interpret, but it cannot provide complete matrices of change directions (Lu et al., 2004)[1]. According to the results the barren lands area are decreased from 2005 to 2015 around artificial recharge structures. In fact, the sparse vegetation has been increased exactly 22.5 % of the whole area during the last 15 year. The functional characteristic of Artificial Recharge Structures in the sub basin of total number as check dams-10, Gabion structure-1, Percolation pond-1 (Fig.1) have been identified by field evidence and confirmed by comparing field data with artificial recharge. The artificial recharge structures constructed the various departments like government and Non-government Organization. Furthermore, the unsupervised classification of satellite imagery data is a proper tool to derive land cover-land use changes. Classified images of pre and post periods provide the basis to discern those areas that depict changes of land cover-land use (Fig 3,4) in the sub basin. Results of this study indicate the impact of artificial recharge structures provided satisfactory results. The vegetation covers around artificial recharge structures have been notified in the Table.1,2 and 3. The main changes observed for the periods of 2005 to 2015 because the increase of agricultural areas due to artificial recharge structures in the sub basin that period indicates the increase rate of about 25% in vegetation (Fig.5, 6). In this regards, increase of population growth and low rainfall are the major factors behind the LULC changes. Hence, the results of this study confirm that, change detection including NDVI and LU/LC unsupervised classification using satellite data offer a good potential tool for characterizing and understanding in and around artificial recharge structures in the sub basin.

3.2. Assessment of Land Use and Land Cover Changes

The results of LU/LC using remote sensing for interpretation and classification around ARS the radius of 500m buffers were compared with two different periods (Table .2 and 3). The relative ratio of land use in 2005 to 2015 to indicate the change trend after construction of artificial recharge structures. The area of evergreen forest land have been increases about 4 % in and around artificial recharge structures based on their influence of check dam, percolation pond, and gabion structures respectively. The changes of land use are the external functions of the artificial recharge structures, natural eco-systems and human activities. The groundwater table fluctuations are indirect impact LU/LC in pre and post monsoon seasons in the sub basin. The water body have increased rapidly after completion of ARS in the sub basin. The impact variation of land use and land cover before and after construction of artificial recharge structures have been identified in (Table.3) that main changes occurred near the check dams. Distinguishingly, the Cropland from 2005 to 2015 crop land averagely maintained. These changes associated with the impact of ARS constructions, especially when the dam was under construction extremely destructive disturbances had brought to nature ecosystem. A part of forest, grass and farm land were flooded after completion of check dams, therefore, these areas decreased with the increasing of water body.

3.3. Spatial-Temporal Variation of Land use and Land Cover

The ArcGIS tools used for buffer analysis around Artificial recharge structures in the sub basin. The field visited and GPS reading capture, then located artificial recharge structures in a GIS environment and manipulate. There are five types of artificial recharge structures considered for this study such as check dams, subsurface dyke, contour bunding, gabion structures and percolation pond in the sub basin. The groundwater table measured would have been due to the recharge from annual rainfall of 971.24 mm. Selected artificial recharge structure as took in centre as 500m the radius to generate buffers (Fig.1), then analyzed the land use area changes and the transfer area between different land use types during 2005-2015.

Land use and land cover change (Fig.5,7) as to examine around the impact of artificial recharge structure using satellite data considering eight different classes of land use. (i) Deciduous forest land (ii) Evergreen forest land (iii) Crop land (iv) Barren Land (v) Fallow land (vi) Built up land (vii) Crop land (viii) Water Body/stream (x) Road and Railway Network . Land use buffered further classified based on the impact around on artificial recharge structures. Artificial recharge structures are one of the important components of watershed development. There are strong links between soil conservation and water conservation measures in the sub basin.

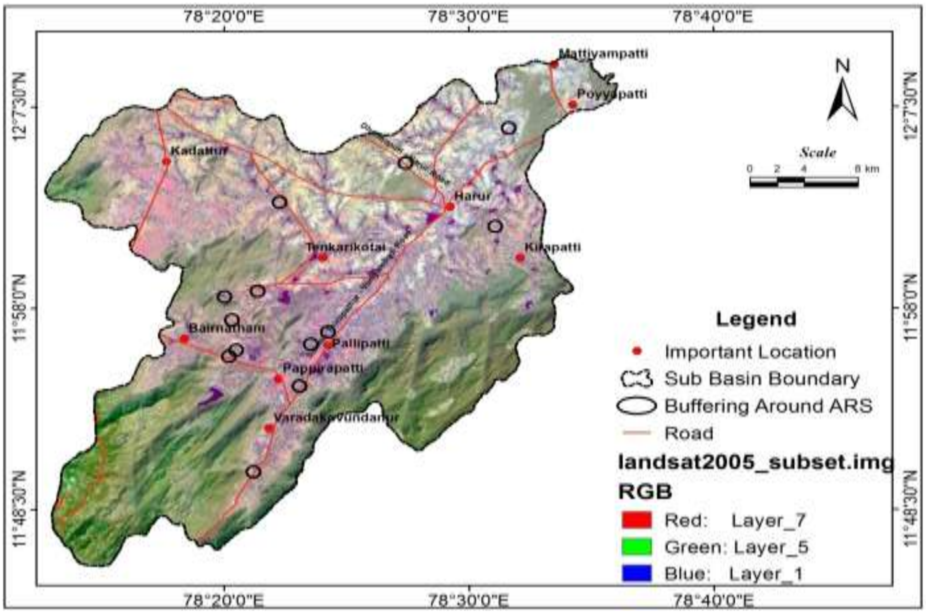

Fig.3. Landsat satellite image 2005

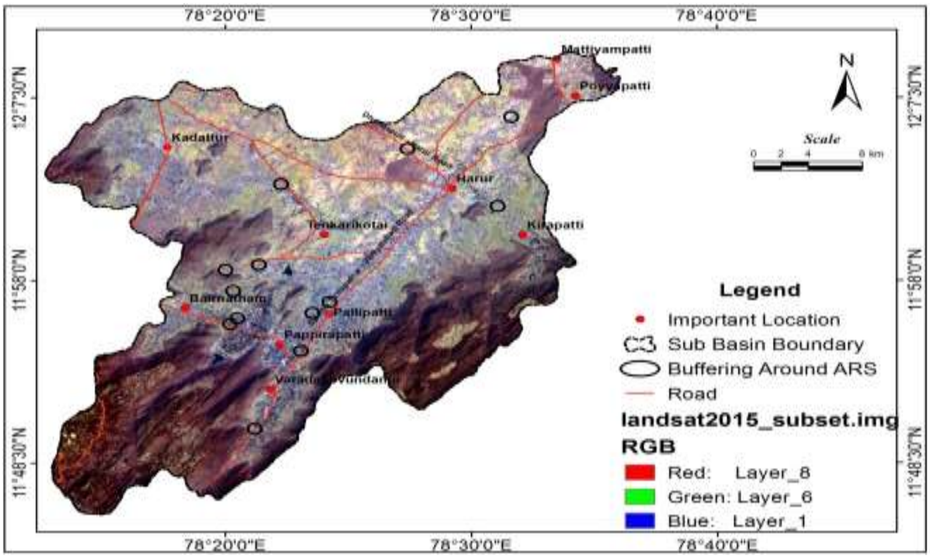

Fig.4. Landsat satellite image 2015

In the sub basin have been Increased irrigation due to check dam construction strongly indicate the crop yield has impacted positively on socio-economic. Due to the presence of artificial recharge structures available water in the wells for the winter crop increased the area under cultivation. The above impact assessment is a strong benefits perceived from the construction of check dams at 500 meter depend upon recharge structures.

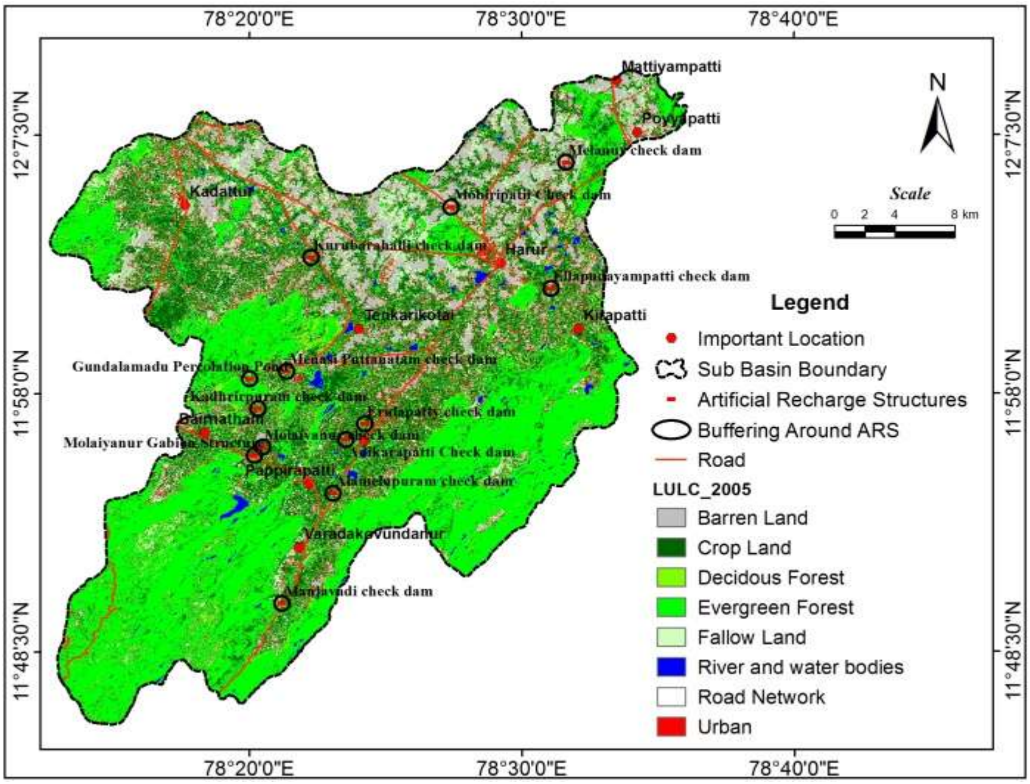

Fig.5. shown LU/LC Pattern 2005

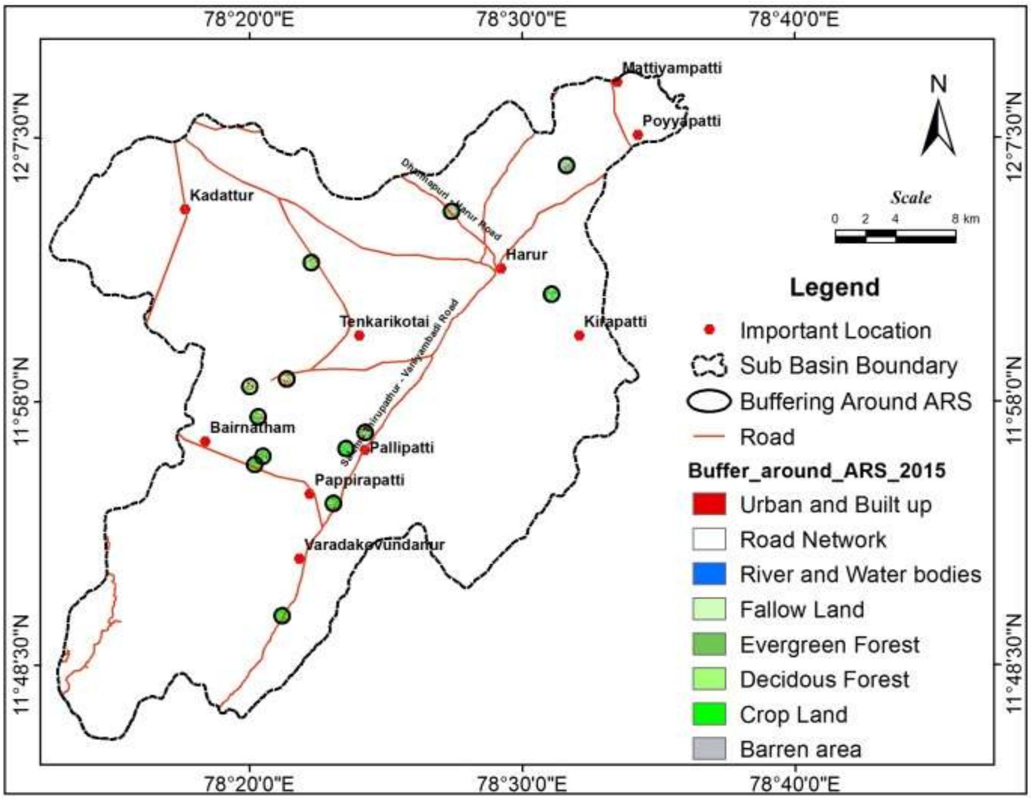

Fig.6. Buffer around ARS 2005

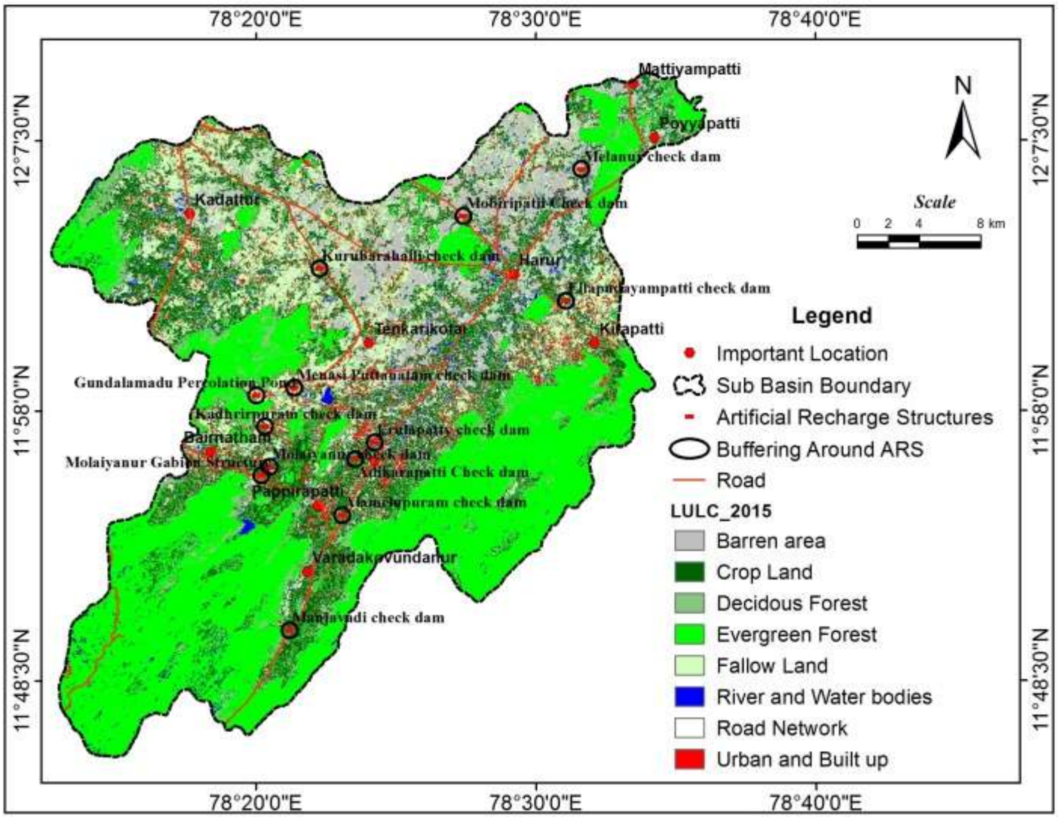

Fig.7.shown LU/LC Pattern 2005

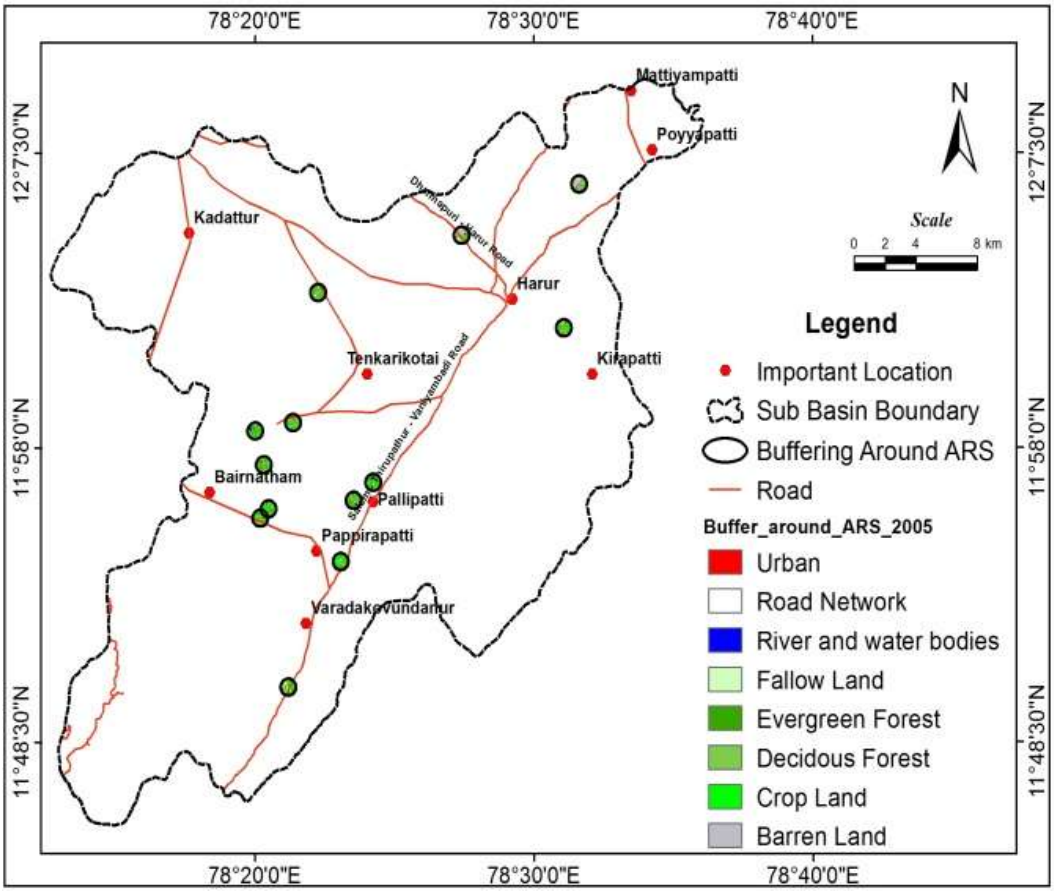

Fig.8. Buffer around ARS 2015

Table 1. Vegetation changes (NDVI) in the Vaniyar sub basin

NDVI	Value ranges	2005	2015	Changes
		Sq.km	Sq.km	Sq.km
Barren Land	<0.1	523.4	210.7	312.7
Sparse vegetation	0.2 to 0.5	467.9	700.1	232.2
Dense Vegetation	>0.5	40.2	119.4	79.2

3.4. Impact of Artificial Recharge Structures

Functional characteristic of managed aquifer recharge is based on the potential of agriculture and response of groundwater table around the artificial recharge structures in the sub basin. The literature review helps to identify LU/LC around ARS and is useful to contribute the research effectively. Impact of artificial structures in the agriculture has significantly increased (Table.4). The number of ARS could be increased in the sub basin in yield of agriculture and groundwater levels also have improved. Significant impacts of ARS are the saving of crops during crucial times like that of low rainfall and improper investigation of ARS in the sub basin. Before the construction of check dams farmers could give slightly support irrigations, while after construction could give enormous irrigations in the sub basin. The groundwater was available through natural rainfall that gives more support for water table increase around ARS. The availability of water from the presence of ARS, water was available in the wells for the winter crop and farmers could be increased cropland for cultivation. This indicates that the rain water was conserved through the check dams, which helped recharge wells. Response of groundwater table in and around selected artificial recharge structures increased 2 to 3 meter in the Vaniyar sub basin (Venkateswaran et al 2015)[1] based on PWD monitoring well and the Present field investigation continues monitoring well observed in some places such as at Menasi, Adikarapattiy, Alamelupuram, Ellapud, Erulapatty, Gudalamadu, kathripuram, Kurubarahalli, Manjavadi, Melanur, Menasi and Molaiyanu and Gurubarahalli have shown partly no impact, it may be due to over exploitation of groundwater and insufficient rainfall. The example of manjavadi check dam shown in Fig.9

Table 2. Impact of Land use and land cover changes around ARS 2015

ARS locations	Ever green forest	Deciduous forest	Crop land	Fallow land	Road network	built up	water bodies	Barren land
Adikarapattiy	12.62	14.23	110.7	22.96	13.40	7.01	10.12	2.78
Alamelupuram	17.85	26.08	98.85	3.45	19.57	25.63	0.33	2.45
Ellapud	0.44	2.17	78.23	84.45	3.78	13.73	6.78	4.50
Erulapatty	0.72	7.78	80.05	36.08	18.96	31.09	12.62	6.89
Gudalamadu	6.78	7.12	55.53	86.8	4.78	30.25	1.67	1.17
kathripuram	1.28	8.90	64.33	68.61	10.45	37.42	2.45	0.83
Kurubarahalli	0.28	1.33	62.60	111.3	2.78	12.01	2.78	1.00
Manjavadi	24.02	23.91	127.6	2.72	5.73	4.45	3.56	1.83
Melanur	5.00	2.11	41.14	37.36	5.06	11.51	13.73	78.45
Menasi_putha	0.00	0.72	49.13	105.3	7.90	23.31	1.56	6.34
Molaiyanur_ga	25.35	32.36	91.79	15.85	10.56	16.12	2.11	0.00
Molayanur_CD	11.29	11.95	94.52	19.52	26.58	25.30	4.73	0.44

Table.3. Impact of Land use and land cover changes around ARS 2005

ARS locations	Ever green forest	Deciduous forest	Crop land	Fallow land	Road network	Built up	Water bodies	Barren land
Adikarapattiy	26.47	19.18	97.8	15.46	7.84	26.85	0.02	0.22
Alamelupuram	45.48	22.41	97.13	8.56	12.45	8.17	0.01	0
Ellapud	1.46	7.34	66.79	43.52	3.28	30.63	0.00	41.07
Erulapatty	9.08	22.41	94.2	32.40	5.17	10.12	0.33	20.7
Gudalamadu	8.16	44.03	57.71	54.67	7.95	10.17	9.56	1.89
kathripuram	4.64	22.52	36.57	43.73	5.17	29.58	0.05	52.06
Kurubarahalli	9.68	15.29	77.8	42.14	3.56	19.96	0.90	25.72
Manjavadi	35.36	15.29	87.29	39.75	1.89	12.23	0.00	2.06
Melanur	8.12	5.23	39.64	39.97	5.95	20.85	4.11	70.5

Menasi_putha	43.42	24.35	62.17	17.12	6.23	15.51	0.00	25.45
Molaiyanur_ga	31.97	32.08	73.02	11.40	9.28	15.01	0.30	21.39
Molayanur_CD	15.80	17.68	89.13	29.12	7.06	23.02	0.80	12.5

Table.4.Functional characteristic of artificial recharge structures

Si.No	ARS Locations	ARS Name	Construction Year	Land use maximum(acres) around ARS
1	Adikarapattiy	Check Dam	2014-15	Crop land
2	Alamelupuram	Check Dam	2014	Crop land
3	Ellapud	Check Dam	2013	Crop land
4	Erulapatty	Check Dam	2014-15	Crop land
5	Gudalamadu	Percolation Pond	2007	Crop land
6	kathripuram	Check Dam	2008	Crop land
7	Kurubarahalli	Check Dam	2008	Fallow Land
8	Manjavadi	Check Dam	2013-14	Crop land
9	Melanur	Check Dam	2007	Crop land
10	Menasi_putha	Check Dam	2012	Crop land
11	Molaiyanur_ga	Gabion Structure	2007	Crop land
12	Molayanur_check	Check Dam	2011	Crop land

(Note: ARS-Artificial Recharge Structures

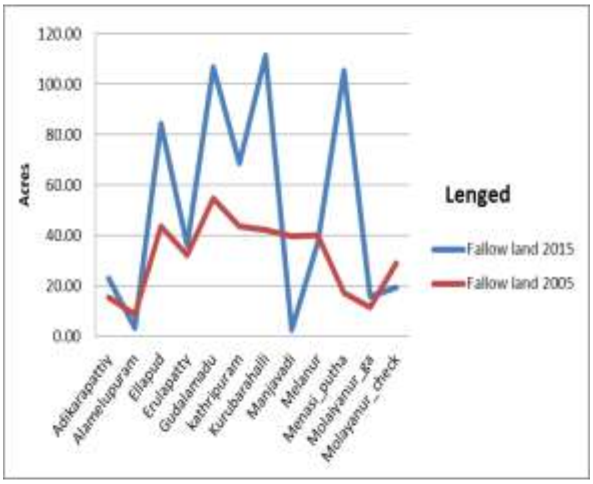

Fig .7 Impact Variation of Fallow Land

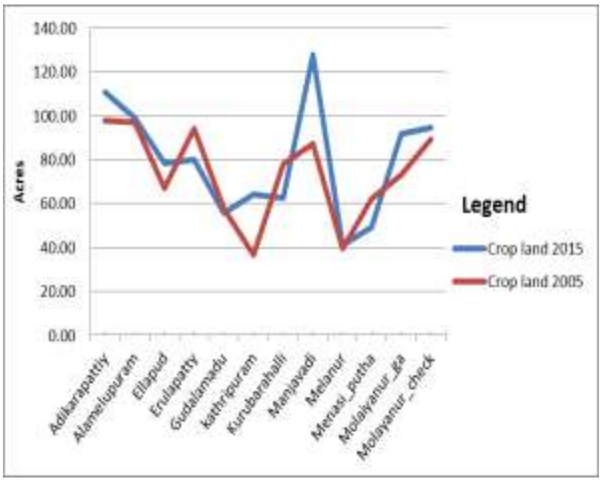

Fig .8 Impact Variation of Crop Land

The existing of check dam farmers was more confident about water availability, and therefore they increased their input spending and harvest. The Agriculture lands are showing (Fig.9, 8,11). The impact variation of Kurubarahalli check dam may considered as a partly functional recharge structures based on low range of agriculture land, groundwater levels, Rainfall, barren land and improper investigation of ARS in the sub basin.

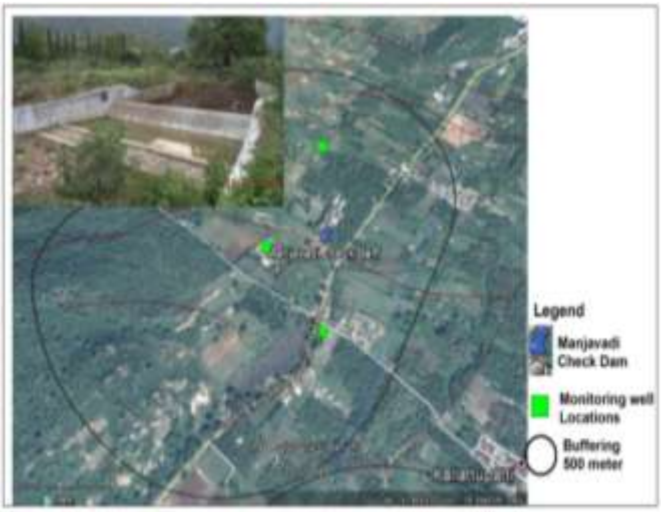

Fig.9. Field Photograph and Google earth image showing 500 meter buffered around Manjavadi check dam

4. CONCLUSION

The impact of land use/land cover patterns have been identified by the multi-temporal satellite images of 2005-2015 using ERDAS and ArcGIS platforms for spatial assessment around artificial recharge structures. The quantitative impact assessments of LU/LC were revealed by artificial recharge structures. Fallow lands have been increased at 20.28 % around ARS in the sub basin. The rate of change was as high as for built up surface. The agricultural lands were converted at 6.9 % from barren land in the sub basin. The trend and extent of agriculture land toward potential of after ARS construction for agriculture development. The existing check dam the majority of changes in agriculture land in the sub basin was higher in the south-west in Pappiredipatti watershed area due to increased agriculture development. The adverse environmental impacts of the current growth pattern needs to be managed through effective land use planning and management in the sub basin. Functional characteristic of artificial recharge structures are to be prove the improvement of groundwater potential.

ACKNOWLEDGMENT

The authors wish to express their sincere thanks to the Department of Science and Technology (DST) and Natural Resources Data Management System (NRDMS) for providing financial support and also thanks to National Remote Sensing Centre (NRSC), Public Works Department (PWD), Tamil Nadu Forest Department, Agriculture department and Non-Governmental organization (NGO) for providing the necessary data during the period of study.

REFERENCES

[1] Ardavan Ghorbani, Amir Mirzaei Mossivand and Abazar Esmali Ouri (2012)Utility of the Normalised Difference Vegetation Index (NDVI) for land/canopy cover mapping in Khalkhal County (Iran) Annals of Biological Research, 2012, 3 (12):5494-5503 (http://scholarsresearchlibrary.com/archive.html)

[2] Bruce D.R. Misstear (2000) Groundwater Recharge Assessment: A Key Component Of River Basin Management, National Hydrology Seminar 2000.

[3] Ehsan Sahebjalal and Kazem Dashtekian (2013) Analysis of land use-land covers changes using normalized difference vegetation index (NDVI) differencing and classification methods, African Journal of Agricultural Research, Vol. 8(37), pp. 4614-4622, 26 September, 2013, http://www.academicjournals.org/AJAR

[4] Gunasekaran S et al.,(2014) geo-system based aquifer development through artificial recharge in pudukkottai district, tamil nadu, india. International journal of water research, available online at http://www.urpjournals.com

[5] Ganasria B P, Dwarakish G S (2015) Study of land use/land cover dynamics through classification algorithms for Harangi catchment area, Karnataka State, INDIA, Aquatic Procedia 4 (2015) 1413 – 1420, Available online at www.sciencedirect.com

[6] Gao, Jay., 2009. Digital Analysis of Remotely Sensed Imagery. McGraw-Hill Companies, Inc

[7] Jayakumar S., Arockiasamy, D I., 2003. Land Use/Land Cover Mapping and Change Detection in part of Eastern Ghats of Tamil Nadu using Remote Sensing and GIS. Journal of the Indian Society of Remote Sensing 31, 70-78.

[8] Sundarakumar K et al (2012)land use and land cover change Detection and urban sprawl Analysis of vijayawada city Using multitemporal landsat Data, international journal of engineering science and technology (ijest), vol. 4 no.01 january 2012, ISSN : 0975-5462

[9] Tamilenthi S and Baskaran R (2011) Geomatic based urban sprawl detection Of salem city, india, recent research in science and technology 2011, 3(2): 70-76 Issn: 2076-5061 Www.recent-science.com

[10] Vanum, G., Hadgu, M K., 2012. Land use/ Land cover changes through the applications of GIS and Remote Sensing and the implications on Sustainable land management. International Journal of Geology, Earth and Environmental Sciences 2, 136-147.

[11] Venkateswaran S, Satheeshkumar S and Kannan R (2015), Impact Assessment of Water table Fluctuations in and around Artificial Recharge Structures in Vaniyar sub basin of the Ponnaiyar River, South India. International Journal of Current Research. Vol. 6, Issue, 7, pp.5480-5486, July, 2015

[12] Lu D, Mausel P, Brondizio E, Moran E (2004). Change detection techniques. Int. J. Rem. Sens. 25:2365–2407