

Impact assessment of check dam recharge sites in the pappiredipatti Watershed (South India) by using LULC and NDVI Data

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Abstract

Abstract: Agriculture is one of the essential sector in because of the changing phenomenon of weather condition which is further complicated by the interaction of the vegetation with the environment. Scarcity of rainfall causes physiognomic changes can be identified by satellite images through the use of vegetation indices and landuse and land cover changes. The vegetation indices are sensitive to the rate of plant growth as well as to the amount of growth. They are sensitive to change in vegetation affected by moisture stress. Hence, scarcity can be monitored more systematically through remote sensing techniques than the ground based methods of collection of information. The capabilities of Geospatial techniques have been used to demarcate effective sites for monitoring functional characteristics of water conservation structures in the pappiredipatti watershed. In this study, land use/land covers have been used to delineate the existing recharge sites for water conservation measures. Increase of groundwater resource is proposed in the watershed by constructing runoff storage structures like as check dam, percolation tank and gabion structures. The site effective water conservation structures is determined by considering spatially varying parameters land use/land cover and natural difference vegetation index (NDVI) information of the watershed. Geospatial technique has been used to store, analyse, integrate spatial and attribute information pertaining to functional characteristics of land use and land cover within buffering distance in the area of interest of watershed. For detailed changes around recharge area assessment an attempt was made over the watershed. Crop growth area was assessed in and around under forest, barren land and dense vegetation area using temporal normalised difference vegetation index (NDVI) on 1985, 2005 and 2015. They have compared with vegetation area regions, and crop wise area growing were identified. Based on the result obtained from the study area on vegetation cover, buffered around recharge area impact was assessed by NDVI. Decrease in barren land on 2005 by identifying the NDVI threshold over predominantly sparse vegetation growing regions, crop wise area was identified. Further, the water body was estimated from NDVI data of 2005 and 2015 which have been validated for the vegetation assessment. The result of Landsat data use study indicated decrease in dense vegetation area that has leading to wide spread drought condition in the some part of the watershed.

Introduction

Land use and land cover changes can easily indicate growing of agriculture play a significant part in the assessment of water harvest in the watershed. Coniferous forests, for instance, ingest more water than deciduous forests, while evergreen forest land and plains area use less water than forests (Bosch and Hewlett, 1982; Brown et al., 2005). Hope et al. (2009) examined the association among yearly river harvests and remotely sensed variations of crop land cover in a great rocky fynbos catchment. Since the consequences of changes, it has chosen that the one of the spectral vegetation index of NDVI with difference a negative and positive connection with the river crop area. Dependent on environment and climatic condition, plant life is a strongly shaping influence by the surface water process. Robinson et al. (2003) suggested that no important effect of a modification in forest cover on mountains and in many

basins across N-W Europe, though deforestation directed to an surge in improper flow in more moderate environments of situation (Hornbeck et al., 1993). Land use and land cover change have a straight influence on the catchment of water process (Bhaduri et al., 2000; Tang et al., 2005; Ott and Uhlenbrook, 2004;). This impact can be dignified the change flow of water in river , or forecast by hydrological simulation model is used and combined with land use and land cover change situations of the aspect, it has allows for assessing the impression of the change on groundwater recharge and discharge of river sites. The influences of land use change in the context of recharge studies deliberated by various researcher such as Albhaisi et al.,2013,Bhaskar Narjary et al.,2014,Juan Ramón Raposo et al 2013,Tran Van.,2012, Sashikkumar et al.,2017,Kenji jinno et al.,2009,Dams et al.,2008,Hamid Hosseinimarandi et al.,2014 Bertrand Ieterme and Dirk Mallants.,2011,Stiefel et al.,2009,Vahid Amini Parsa et al.,2016,Ala-aho P et al.,2015, Rana Chatterjee et al.,2009,Marcelo Varni et al.,2013.,Ranu Rani et al.,2009 and Oke et al.,2013. An objective of this study to validate the impact of land use and land cover variation on groundwater recharge sites in area of data resulting from Landsat satellite images by using a simulated model (Molusce), for Pappiredipatti watershed, South India. The Pappiredipatti watershed was selected because it has face undergone many temporal variation of changes of land use and soil erosion in recent decades. Check dams are one of barrier on the river site that is making a new environmental cycle of system behind it and non-natural hill slope of living plant. It was imagined that the evapotranspiration would be reduced and it further recharge augmented due to this change in land use.

Study area

Pappiredipatti watershed is situated in the study area are shown in Fig 1. This study area is lies between $78^{\circ}18'0''E$ and $78^{\circ}30'0''E$ and $11^{\circ}48'30'' N$ and $11^{\circ}58'0''$ northern latitudes in Tamil Nadu, India. The total geographical area of the watershed is 184.55 sq.km of which 67343.75 acres is under cropland. Data on general crop land was collected from field investigation that may indicated that the sugarcane and coconut tree are the major crop in most of the covering part of area followed by paddy.

Materials And Methods

The main data are used for the mapping of the study area's land use/land cover and NDVI lineaments that are LANDSAT 7 enhanced thematic mapper plus (ETM+) downloaded from U.S. Geological Survey. The imagery used to comprise of subsets from the original scenes of path 143 and row 52 and path 154 and row 52 of 2005 and 2000 the respectively. Geometric rectification generated NDVI after applying corresponding sensor calibration coefficients. NDVI images over a period of month is required to get the cloud free NDVI image of the area which can represent the total scenario of vegetation condition in that particular month. The land use and land cover have predicted in the watershed using QGIS software. LU/LC has been prepared by using unsupervised classification and NDVI used in Erdas software. An important of the development on the field it have depend on the recharge sites of land use and land cover change. Modeling is one of the integration of the different components that are part of the actual modelling is supported (Kok et al, 2004), designated by the arrows in Fig.2.

LU/LC prediction is necessary for its accuracy and future development of the changes of land pattern in the recharge of groundwater. Using combined LU/LC and surface runoff which can manage the potential of vegetation through water conservation structures.

Results And Discussion

Land use and land cover changes

The barren lands are with 1.45 % in 2005 and 2 % in 2015 of the total surface area. The results show that from 2005 to 2015 there is a continuous intense trend of reducing barren land, fallow land but that this trend is because relatively less intensive in 2005. The groundwater is potential close to water conservation structure whereas natural recharge is low compared to previous because it is away from those structures. Its validity is found in the context of wells.

In this watershed, Land Use and Land Cover 2005 (45503.3 acres), are included Barren land (679.75 acres), Crop Land (12766.6 acres), Deciduous Forest (3544.92 acres), Evergreen Forest (22288.9 acres), Fallow Land (2878.79 acres), River (353.608 acres), Road network (586.233 acres), and Urban (2404.53 acres). Land Use and Land Cover 2015 (45501.661 acres), Barren land (935.171 acres), Crop Land (11431 acres), Deciduous Forest (3445 acres), Evergreen Forest (2383.9), Fallow Land (21919.1), (River 1058.49 acres), Road network (1609 acres), and Urban (2720 acres) as shown in Fig.3.

An order to assessment of real image and the simulated images that have model output to the present land use and land cover. by comparing simulated LC/LC representing the 2005 LULC with present LULC based moluse model (QGIS) have used to validate land use and land cover change to predict. Satellite Image classification between the year of 2005 and 2015 results shown eight distinct LULC class such as barren land, Crop land, Deciduous forest, Evergreen, fallow land, river and water bodies, road network and urban.

Agriculture land increased from 20 % in 2005 to 38% in 2015 due to augmentation of groundwater by in suitable construction of water conservation structures (buffered 500m). LU/LC 2015, real and simulated land use by visual inspection analysis indicates that simulated LU/LC map and actual map have moderately close resemblance. Agriculture land has the finest choice where the simulated area is 15645.4 acre. It has obviously illustrated that the simulated LULC map, barren land and agricultural land area are underestimated but the predicted amount of forestland and urban is overestimated. The accuracy of yield is in the assessment process by molusce module using the QGIS software. Resulting from the K values of all well above 0.9 is shown in a satisfactory level of accuracy. The model validation of land use and land cover indicates that 2015 optimum changes occurred in the watershed. Simulation map is a respectable promise with situation of 2015. Therefore it is concluded that molusce models is suitable for prediction of future challenges of planning of LU/LC for sustainable development of agriculture land and urban area.

Validation and Simulations of LU/LC

QGIS is a quick and convenient tool for analysis of land cover changes. Molusce is a toolbox to partially automate the process to make a model that can anticipate and utilize changes between two decades of period for predict future sustainable development. The raster configuration of land utilize classifications for the year 2005, raster of land utilize classifications for the year 2015 and its rasters of illustrative factors. Trains a model that predicts and utilizes changes from 2005 to 2015 as appeared in Fig 4. The Predicted future land utilize changes are utilizing determined model, current condition of land utilize and current elements. Display (Molusce) is a calculation that is utilized for forecast of land utilize changes. State raster is one-band raster where every pixel is allotted with land use class. Input state raster is one-band raster portraying the past. The Output state raster is one-band raster portraying present prepares the model. Change guide is a whole number one-band raster that stores data about moves. Classification estimations of progress guide are mapped coordinated to move classes.

Simulator module have been performs land use change evaluation process. Introductory state raster contains data about current land utilize classes; figure rasters contain data about illustrative factors. Model is an indicator that computes change possibilities in the state of the variables and current land utilize. The area impact is accomplished if a model uses neighborhood amid preparing, Simulator considers just broad examples. Test system takes move probabilities from the move framework and figures numbers of pixels that must be changed test system cell demonstrate, go to it starting state raster and component rasters. The model sweeps pixels of the rasters and figures move possibilities of each move class. As result the raster contains the model certainty: the greater is contrast, Simulator develops a raster of the most likely moves: the pixels of the raster are the move class with the greatest capability of move. This raster is utilized amid the following stage for each class. Simulator seeks in the raster of the most plausible moves a required check of pixels with the best certainty and changes the classification of the pixels. At least two pixels are close, and afterward arbitrary decision of the pixel is utilized to the one emphasis of reproduction. Approval module is permits to check precision of the recreation of land utilize and land cover.

Effect of land use change

In the watershed, it has been increased irrigation due to check dam construction that strongly indicates the crop yield has impacted positively on socioeconomic. 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 benefit perceived from the construction of check dams at 500 meter depend upon recharge structures.

The contributions of the different LU/LC classes are for effects on groundwater storing. The consequences of groundwater revive assurance for unmistakably appears from the impact of land utilize change on groundwater stockpiling (Fig.5). The observational model aims of the yearly groundwater revive of the watershed. For the land use maps of the years 2005 and 2015, individually. The commitment of the woodland arrive in groundwater revive locales diminished from 2005 to 2015, subsequently of deforestation. Barren land contribution increases due to proper selection of suitable sites from 4th order

stream. By comparative, contribution of fallow land are in major changes with values of 6.4% in 2005 and 48.17 % in 2005 and cropland 28% in 2005 and 25.12 % are small rate of changes, respectively.

The monthly rainfall data were collected from the Public Work Department (PWD) converted into average seasonal rainfall. The data has interpreted for 2000-2015. Taking data, two periods of time has helped to assess the real impact of artificial recharge structure by comparing low and high rainfall years (Fig 6). The groundwater level has been due to the recharge from annual rainfall of 971.24 mm and recharge from check dam for growth vegetation. The average rainfall from year 2000 was 990.62 mm higher than the rainfall from year 2015 was 971.24. For comparison reasons in Fig.7 presents the average monthly values of temperature and potential evapotranspiration observed from climatological data. From this comparison, it occurred that the winter temperature was slightly high whereas potential evapotranspiration also increased. Therefore, it was decided reasons due to catchment scale, the mean historical data useful instead of the baseline climatic since the observed differences in and around artificial recharge structures for further recharge calculation.

In addition, the areal scope and sort of land use classes in the catchment, the appropriation and area of these classes can influence the groundwater recharge amount use to delineate the year 2005-2015. Notwithstanding the expansion in fruitless land zone and reduction in woodland zone, the estimations of groundwater energize have contrasted on 2015. Decrease in groundwater revive could be an after effect of the circulation of the bush terrains in the ranges of high energize values; these regions near the seepage arrange in the catchment of the Vaniyar Dam. As the precipitation in the period on 2015 is high whereas changed land use has a significant contribution to expand revive. In this way, vegetation contributes to the anticipated increment in groundwater energize. Henceforth, which reproduced the time arrangement from 2005–2015 with the land utilize outline that there is a deliberate extreme of revive increment of 18 % in late year due to the in land utilize little transform from the 2015, which confirms that the significant land utilize change unmistakably adds to energize exceptionally.

Proximity of WCS Function by NDVI

NDVI data have generated using the yearly (10 years interval) time composited over the watershed in 1985, 2005 and 2015 by Landsat image. This is presented in Area of interest buffered in the context of Water Conservation Structures (Fig 8) using ArcGIS Software. Buffer techniques can create polygons around input (Vegetation indices) features to a specified (500m) distance. Normalized Difference Vegetation Index (NDVI 1985) is in the study area as shown in Figs 9 and 10. With verifying, the temporal variation of NDVI are through years 1985 NDVI over the region that indicates low crop condition whereas 2015 indicates high crop condition. Based on the prepared GIS layers of different land use, the total crop area has been extracted from the satellite. The major crops were classified by temporal variation. From the data, reduction in crop area is observed in 1985 when compared with 2015 because of the prolonged dry spell that occurred in the month of July-August 2015 which is critical for crop sowings. Barren land (0.33-0.10 in whole area, around check dam -0.07 to 0.10 and percolation pond -0.03 to 0.10), Sparse vegetation 0.10-0.50 compared to recharge sites is 0.10 to 0.43. Area of interest buffered (NDVI 1985) in

the context of water conservation structures is dominant of sparse vegetation than dense vegetation. Normalized Difference Vegetation Index (NDVI 2005) in the watershed of area of interest buffered in the context of water conservation structures as shown in Figs 11 and 12. Crop condition in the 1985 is assessed the comparison of temporal NDVI data of 2015 and 2005 kharif seasons. The mondal wise crop condition image for the watershed indicates that most of the mandals are facing the deficiency situation with the indication of lower NDVI 1985 when compared to the NDVI 2015. Normalized Difference Vegetation Index (NDVI 2015) and area of interest buffered (NDVI 2015) in the study area (Fig 13) as shown in Figs 13 and 14.

Changes in the vegetation condition are weighted for average with NDVI and water deficit values obtained from water planning procedure for crops comparison. The results indicated that the paddy dominated mandals deficit water in July the NDVI value has fallen 0.37 to 0.17 and due to continuous deficit values the NDVI continuous to fall down till September. It is observed that due to constant water deficit over kharif the NDVI has fallen in August and September even though NDVI is good July. In mandal due to high deficit in the month July the NDVI is fallen down in August and September. Scatter plot (Fig 15) showing 70 to 100 % of NDVI in context of water conservation structures indicates rainfall influence occurred and 30 to 70 % indicates natural store of water in the watershed.

Land Use and Land cover Change Analysis

LULC changes from 2005–2015 periods the area in acres of two satellite images was projected by different land use categories to observe the effects of changes around check dam. Classification results were concise, using ERDAS Imagine creating tables of conversion matrix among land use classes for the two periods. Then, LULC-classified images were added to the change analysis the pre and post construction of check dam that provided the functional characteristic of the area changes as Shown in Fig.16. Shannon's and Simpson's diversity index (H) are used for changes of each category by comparing pixel values of the pre and post in the classified using image for changes analysis. The cross classification image provides a map of locations of categories in the prior image that are the same as categories in the post image.

Shannon's Diversity Index (H)

Shannon's diversity index (H) quantifies the diversity is based on two components such as richness and abundance of species. In the present research species are represented by LU/LC categories. Richness indicates the number of LC/LC categories and abundance represents the relative proportion of the different LU/LC categories. The index is computed using the following equation:

$$H = -\sum (P_i * \log P_i)$$

Where

H Shannon index of diversity,

i LU/LC category,

Pi probability of i = f_i/n

Where,

f_i frequency of species i.e. patch frequency of different LU/LC categories (i) and n = number of species (LU/LS categories) (equals 4 in the present study) Log p log of Pi.

In the present study, the relative abundance of the individual Land use/land cover categories to represent their respective patch frequency while the richness represents the number of LU/LC categories considered in the present study which is equal to eight. The Shannon's index of diversity would be primarily determined by the relative abundance of the eight LU/LC categories such as in 2005(H) are ranges 1.45 to 1.29 and after images 2015(H) are ranges 1.68 to 1.5, evenness in prior images ranges between 0.75 to 0.62 after ranges 0.80 to 0.55 in the study area. The highest abundance of the individual is indicating their functional perform in the table 1

Table 1 Showing relative abundance of the LU/LC

Check dam ID	2005		2015	
	H	Evenness	H	Evenness
Manjavadi (2-MCD)	1.454	0.734	1.175	0.565
Aalapuram (MCD)	1.399	0.721	1.465	0.704
Nadur (MCD)	1.455	0.735	1.152	0.554
Erumiyampatti(MCD)	1.291	0.620	1.680	0.807

Simpson's Diversity Index (D)

The Simpson's diversity index (D) measures the diversity among the species (LU/LC) of their accountability of distribution within a landscape (Offwell Woodland and Wildlife Trust, 1998, <http://www.go.to/offwel>) are expressed by equation:

$$D = \sum N(n-1)/N(N-1)$$

Where,

n = the total number of land of a particular Land use and land cover

N = the total number of land of all Land use and land cover

Since it is neither intuitive nor logical so D is often subtracted from 1 i.e. 1-D (Simpson's index of diversity) or its reciprocal, i.e. 1/D (Simpson's reciprocal index) is computed for studying the diversity of landscape 2005 and 2015 in the present study (Pammi Nitin Sinha et al 2011).

Table 2 Showing the Simpson's Diversity Index around check dam

Land Use/Land Cover categories 2005			
Si.No	Simpson's Index (D)	Simpson's Index of Diversity (1-D)	Simpson's Reciprocal Index (1/D)
1	1	0	1
2	1	0	1
3	1	0	1
4	1	0	1
Land Use/Land Cover categories 2015			
1	0.35	0.64	2.78
2	0.31	0.68	3.19
3	0.46	0.53	2.14
4	0.22	0.77	4.43

Simpson's Index of Diversity are ranging between 0 and 1, but now, the greater the value, the greater the sample diversity. In this case, the index represents that randomly selected from a two different land use and land cover. Simpson's Reciprocal Index starts with 1 as the lowest possible. This table 2 would represent one individual dominant land use and land cover. The higher the values indicates the greater the diversity.

Field photographs of inspected area

Siltation in this area is characterized by dry and heavy monsoon rainfall and high erosion because the high sediment load to occur at the check dam site originates from the hillside of flows near check dam carrying high fine-sediment load as shown in Fig.17. However, the sediments carriers of sediment which carried are coarse and fine accumulated at the check dam site. Though the upstream gradient is low to moderate, the velocity of water during the monsoon is high and this is evident by the large amounts of sediments and boulders in the behind of check dam.

Conclusion

This study clearly indicates to be useful for planning and management for sustainable watershed development through natural and artificial conservation structures by response of land use (LU) and land cover (LC) to increase vegetation. It is necessary for the land use planner retrieval data about past, present and future to make appropriate decision regarding land use for future challenges. Landscape alternation in the urban area is more significant as compared to past in this watershed. Deforestation and human impedance are more essential dangers to the exceedingly rate biodiversity asset around there. The simulated land use map is beneficial for water conservation where exact site selection for well

development. The above showing the NDVI for the year 1985, 2015 and 2015 over pappiredipatti region clearly indicates that the vegetal cover in the year 2005 is much less compared to 2015. Crop land analysis indicates the drought condition during 2005. Generally, it is observed that almost 60% of total area is affected by decrease in crop area. Regression equation concerning the yield to maximum NDVI for 2005 has been developed for the year 1985 based on maximum NDVI values of 2015. In the watershed has been carried out to estimate water deficit and found good relation with reduction in NDVI. It is also observed that there is reduction in total crop area as well as in the dynamism in the vegetation in 2005 when compared with 2015 and it indicates deficiency of rainfall in watershed. The detailed analyses of NDVI clearly are indicated drought condition assessment in the watershed for development of agriculture pattern and predict future vegetal cover.

Declarations

Competing Interests

The authors declare no competing interests

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Figures

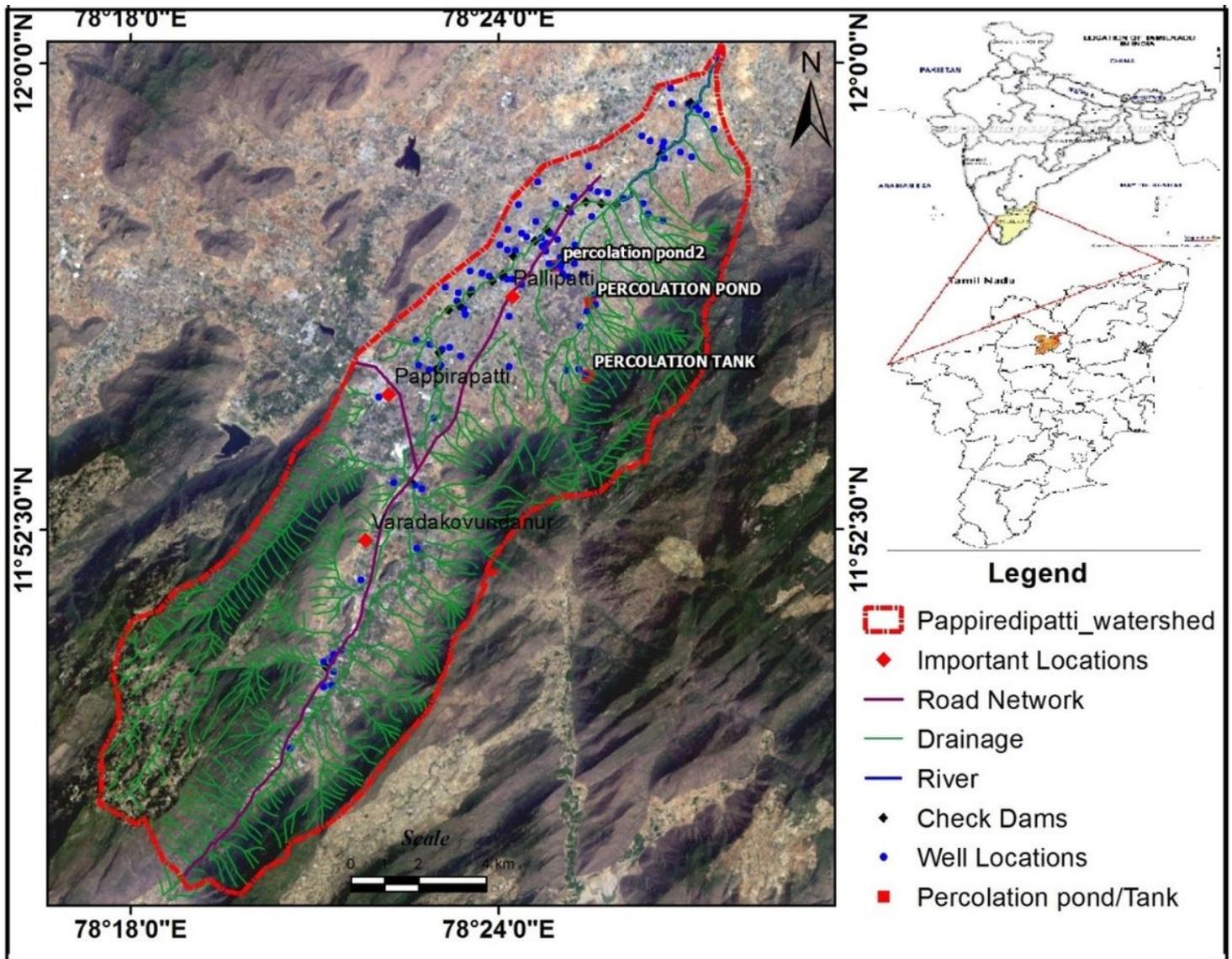


Figure 1

Location of the pappiredipatti watershed

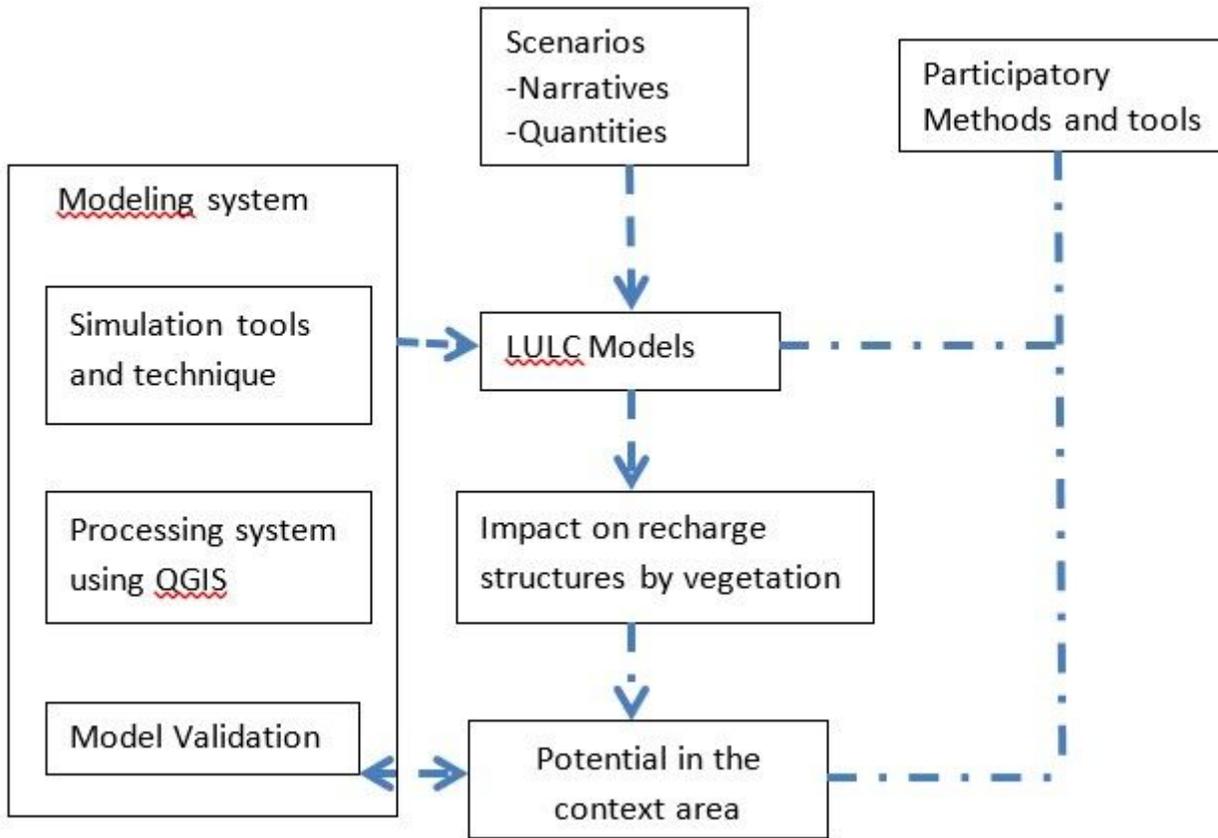


Figure 2

Indication of the potential vegetation in the context area of LU/LC

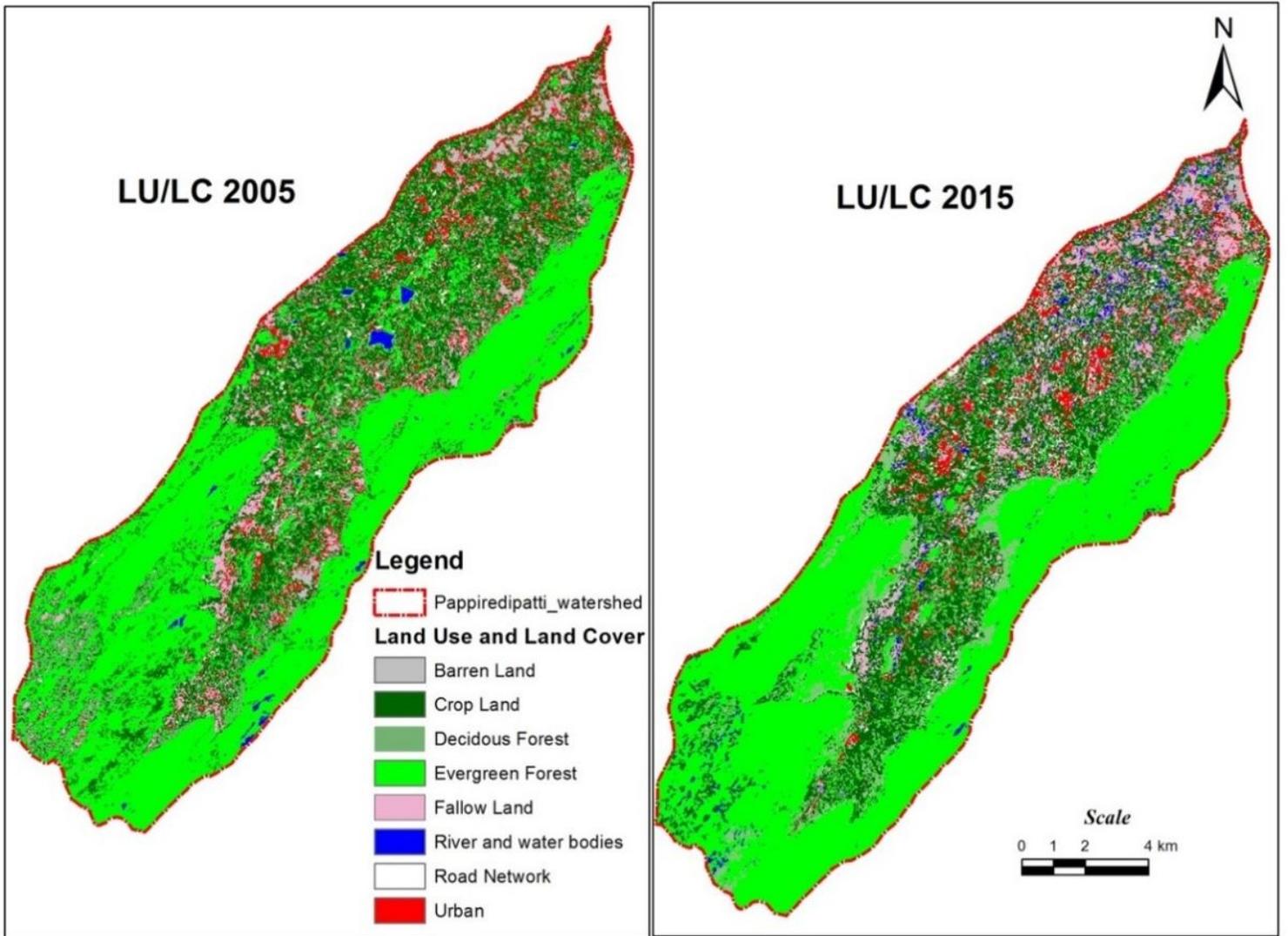


Figure 3

Land use and land cover in the area of interest

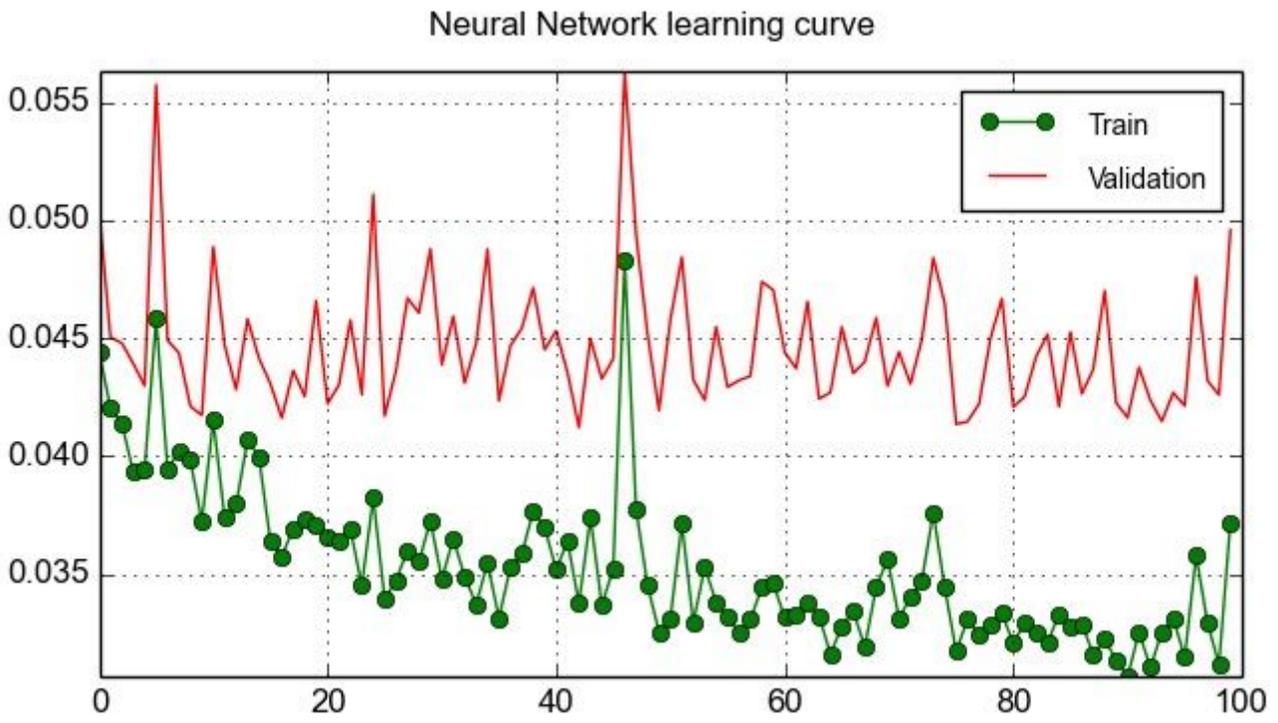


Figure 4

Validation of land use and land cover

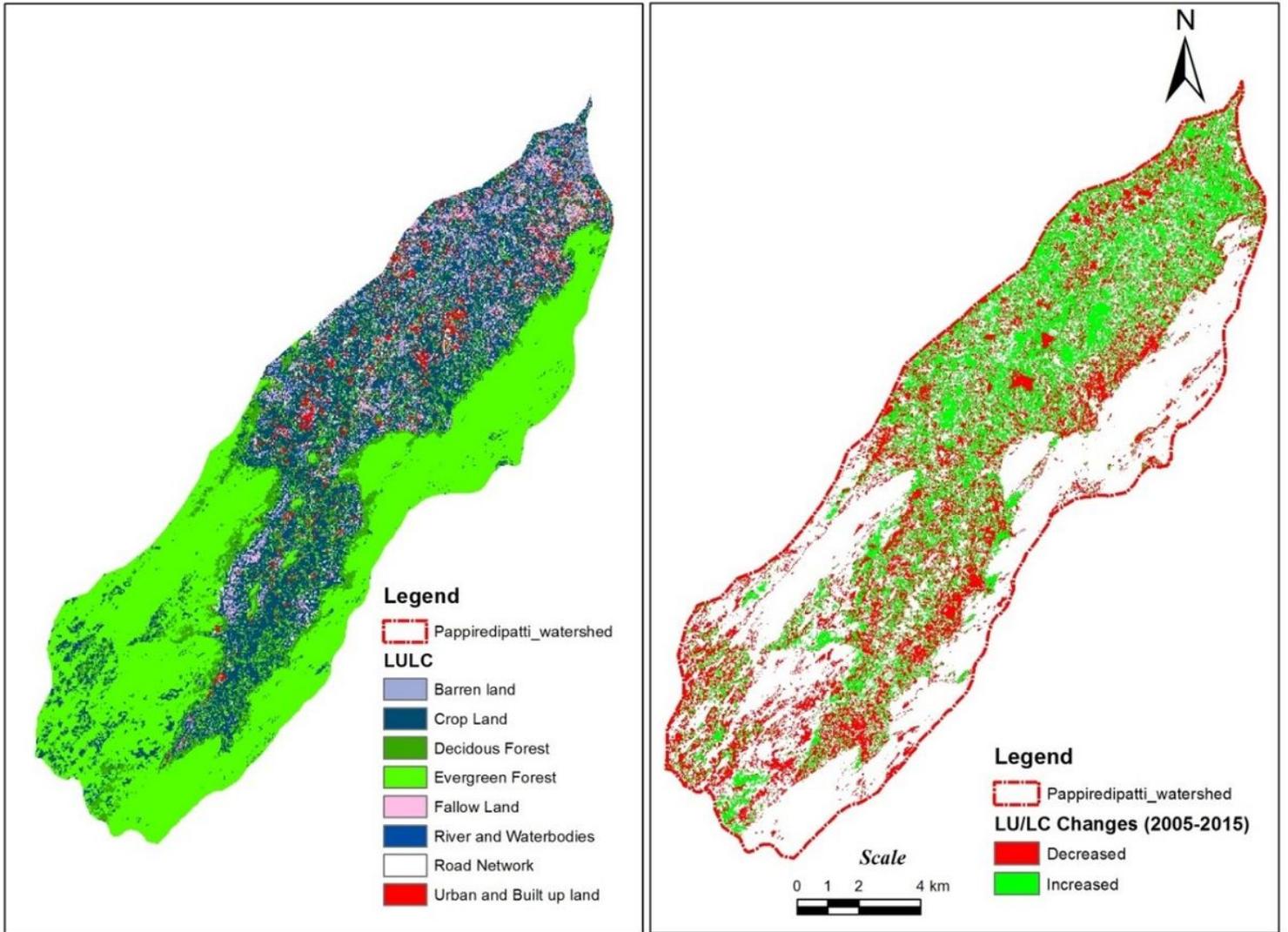


Figure 5

Simulated Land use/land cover and changes from 2005 to 2015

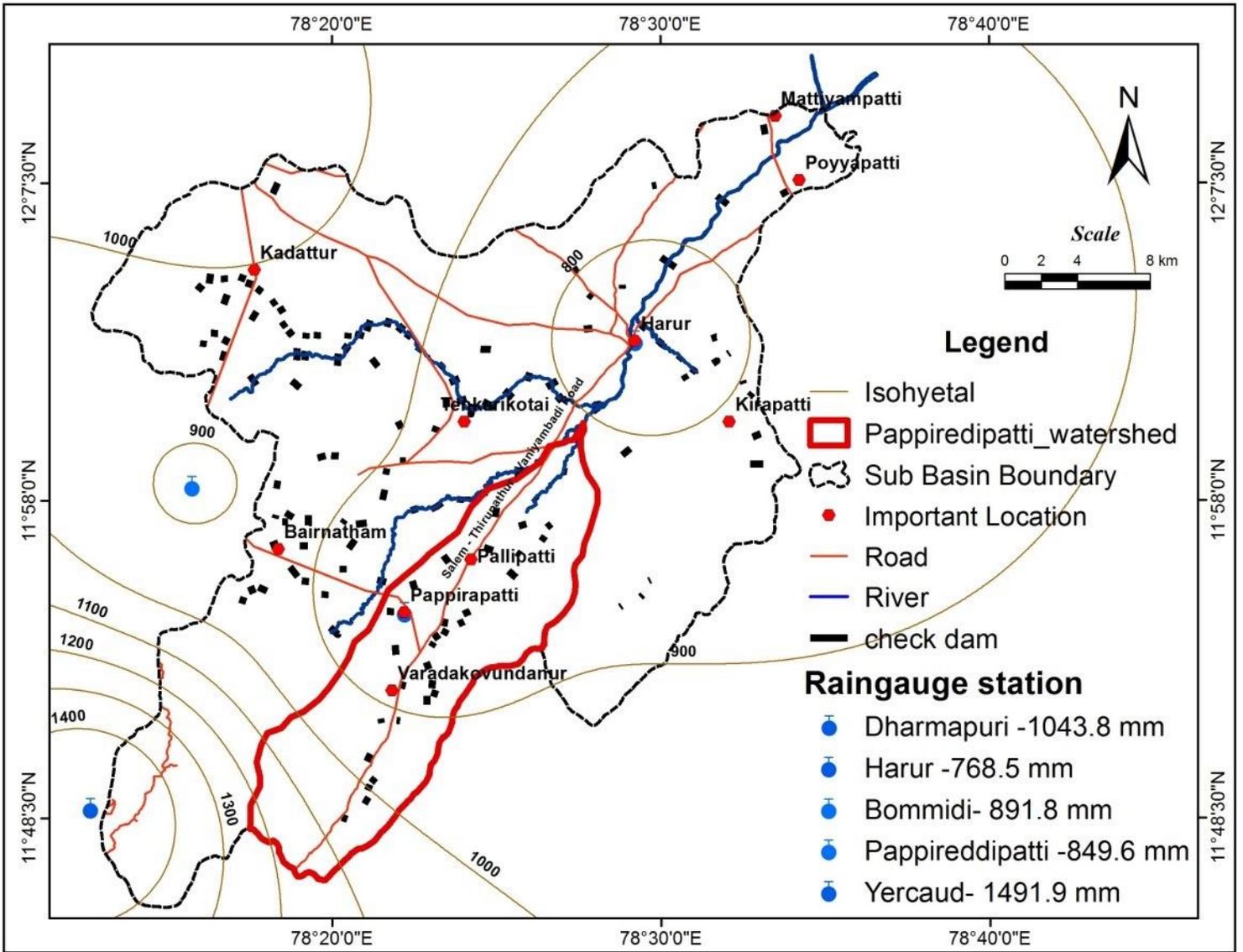


Figure 6

Isohyetal map of the study area

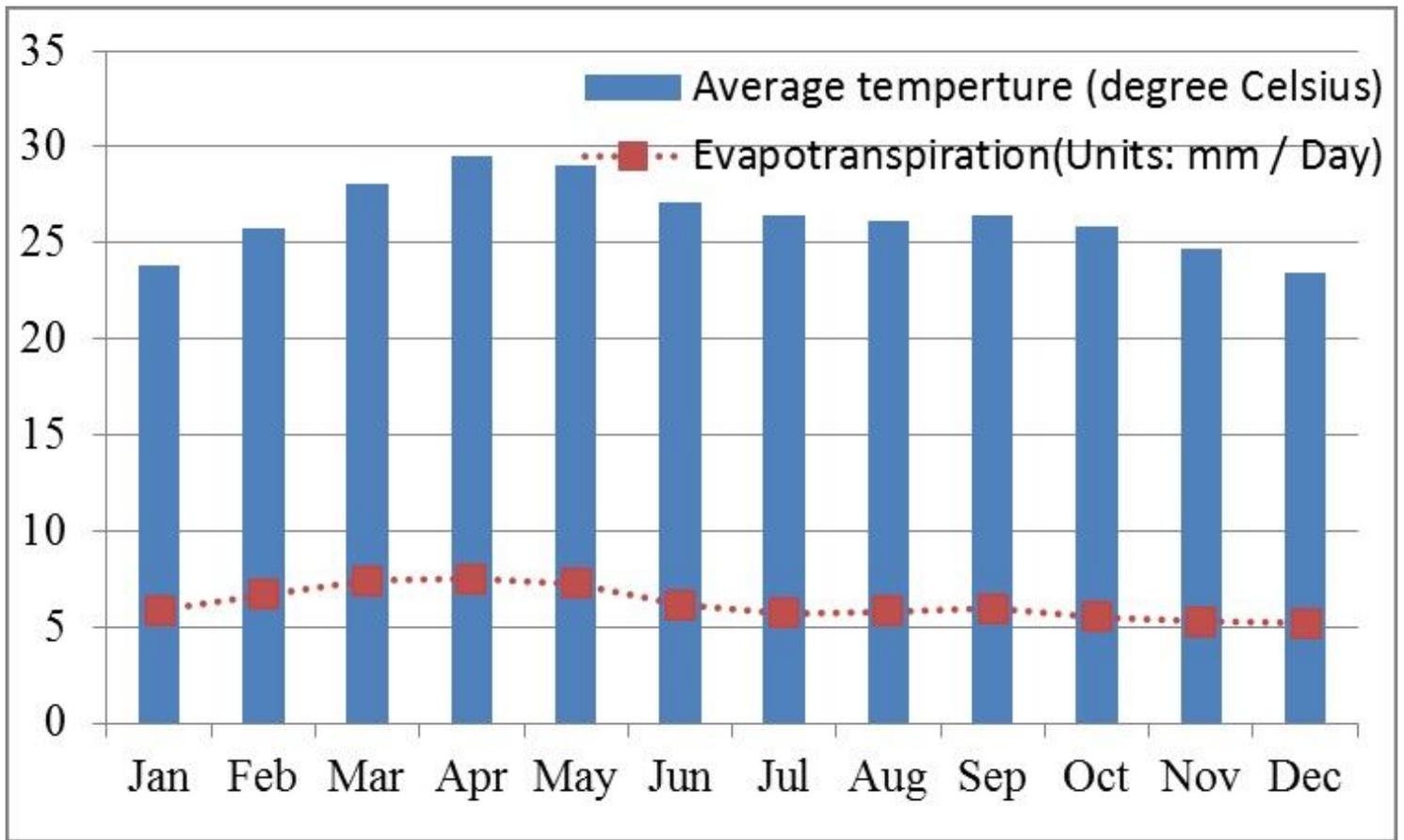


Figure 7

Potential evapotranspiration with average temperature

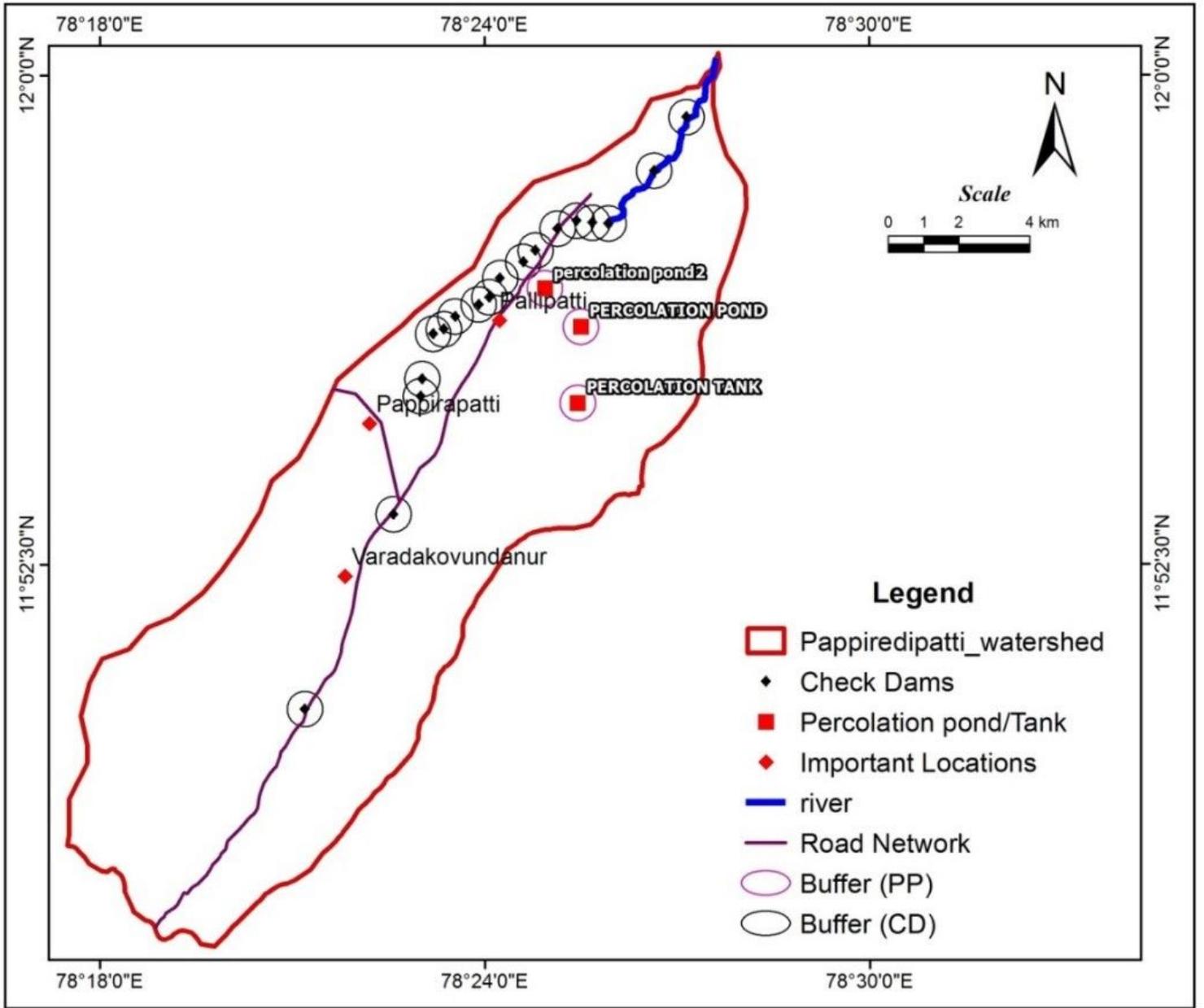


Figure 8

Area of interest buffered in the context of water conservation structures

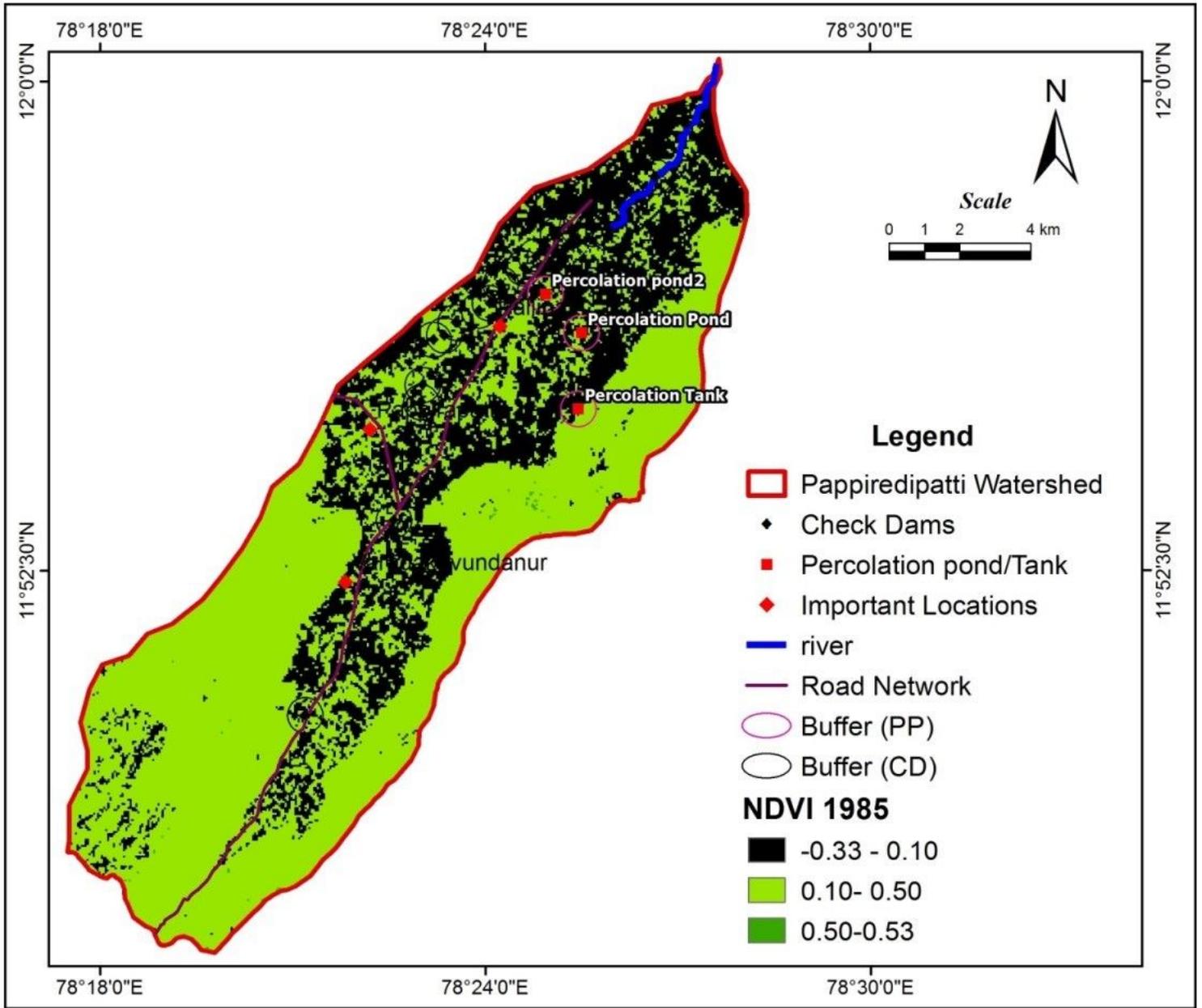


Figure 9

Normalized Difference Vegetation Index (NDVI 1985) in the study area

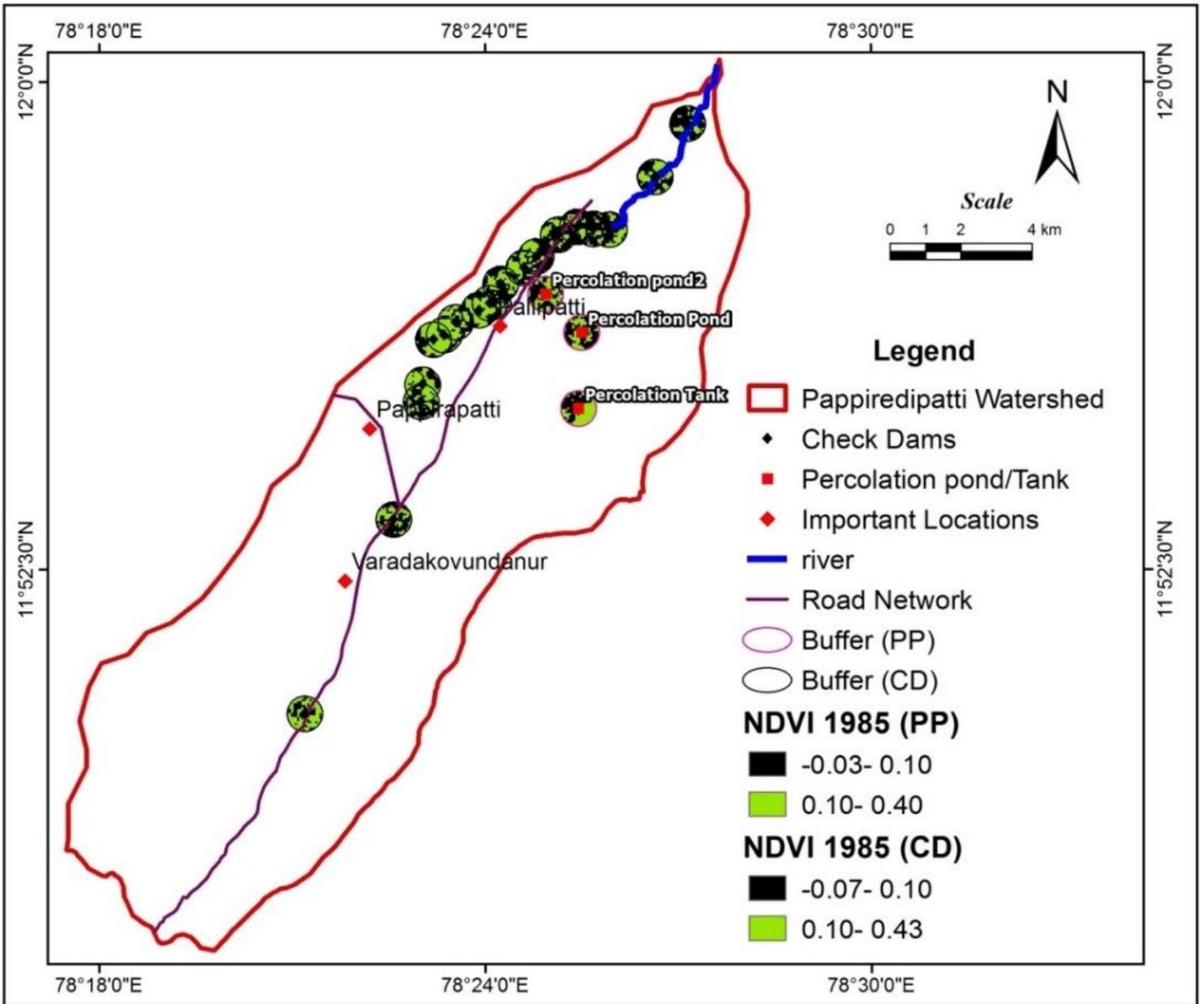


Figure 10

Area of interest buffered (NDVI 1985) in the context of water conservation structures

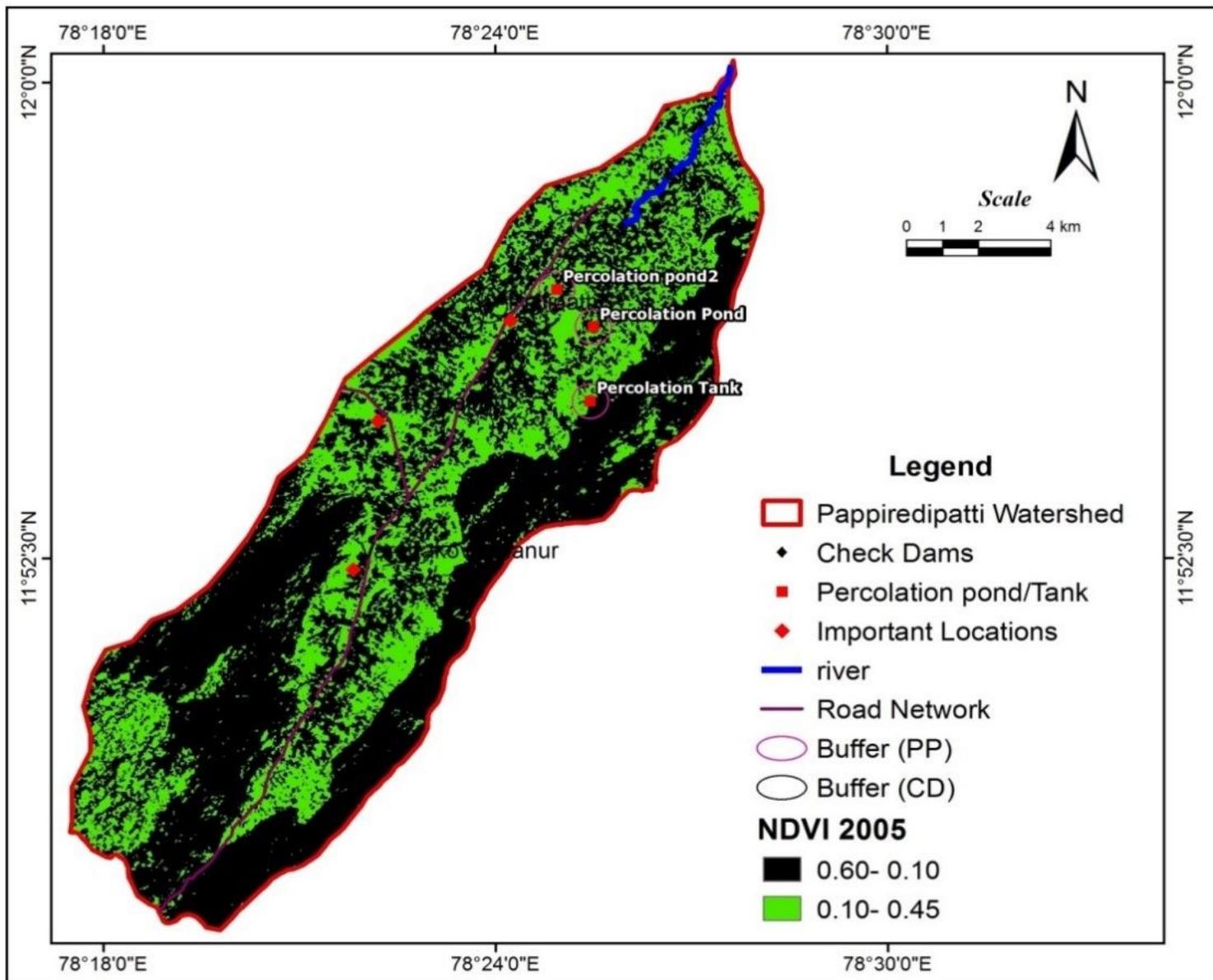


Figure 11

Normalized Difference Vegetation Index (NDVI 2005) in the study area

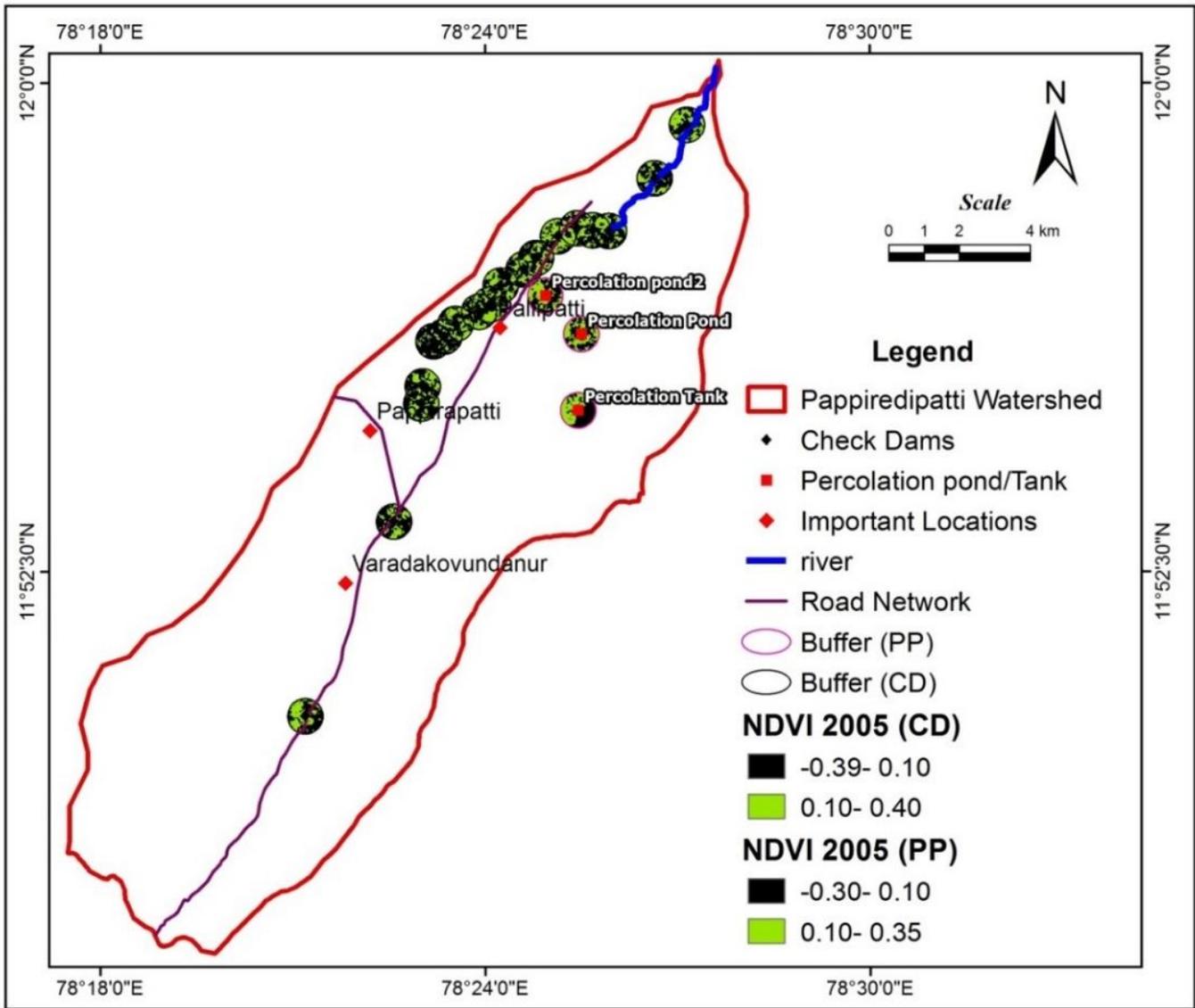


Figure 12

Area of interest buffered (NDVI 2005) in the context of water conservation structures

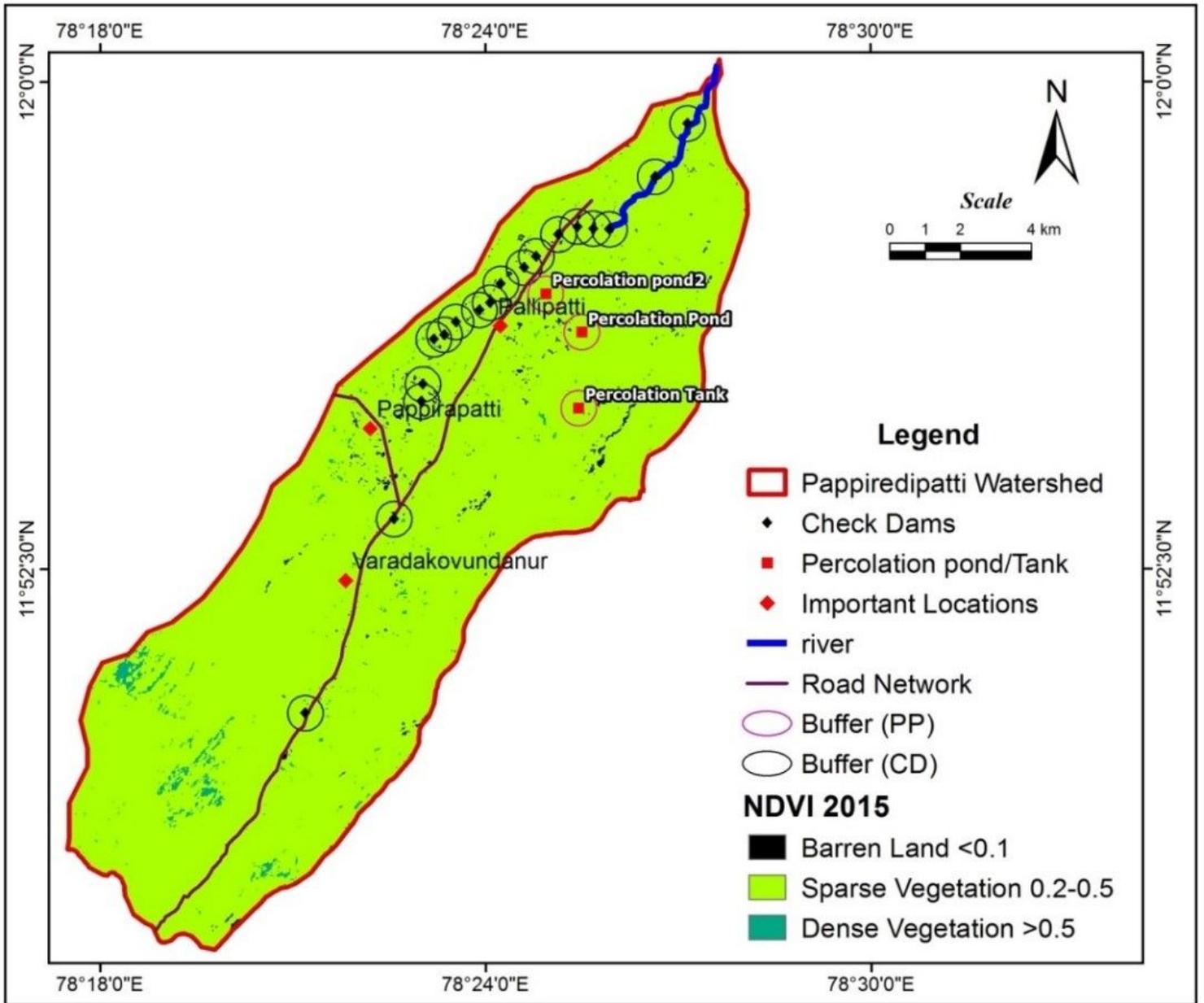


Figure 13

Normalized Difference Vegetation Index (NDVI 2015) in the study area

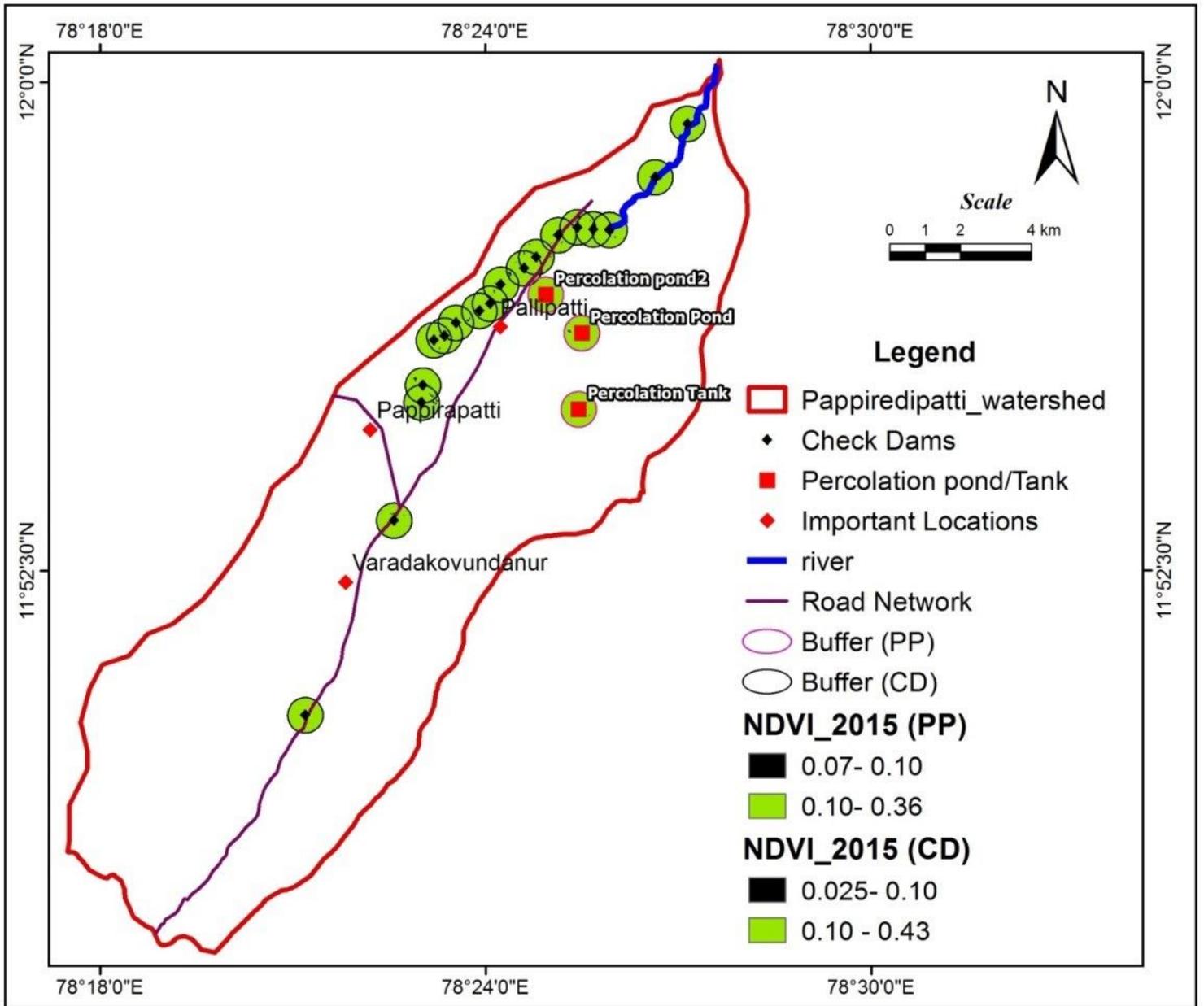


Figure 14

Area of interest buffered (NDVI 2015) in the context of water conservation structures

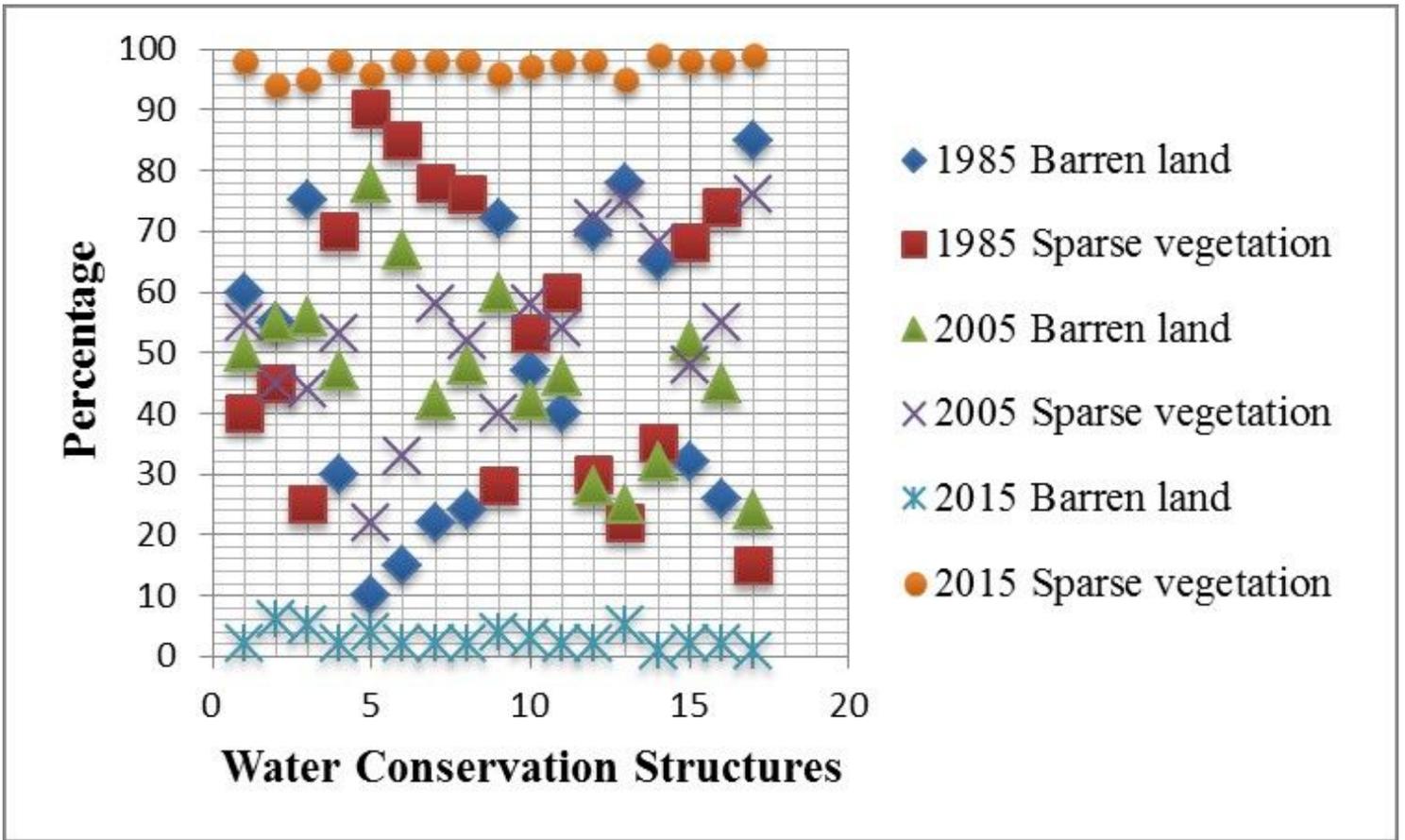


Figure 15

Percentage of NDVI in context of water conservation structures

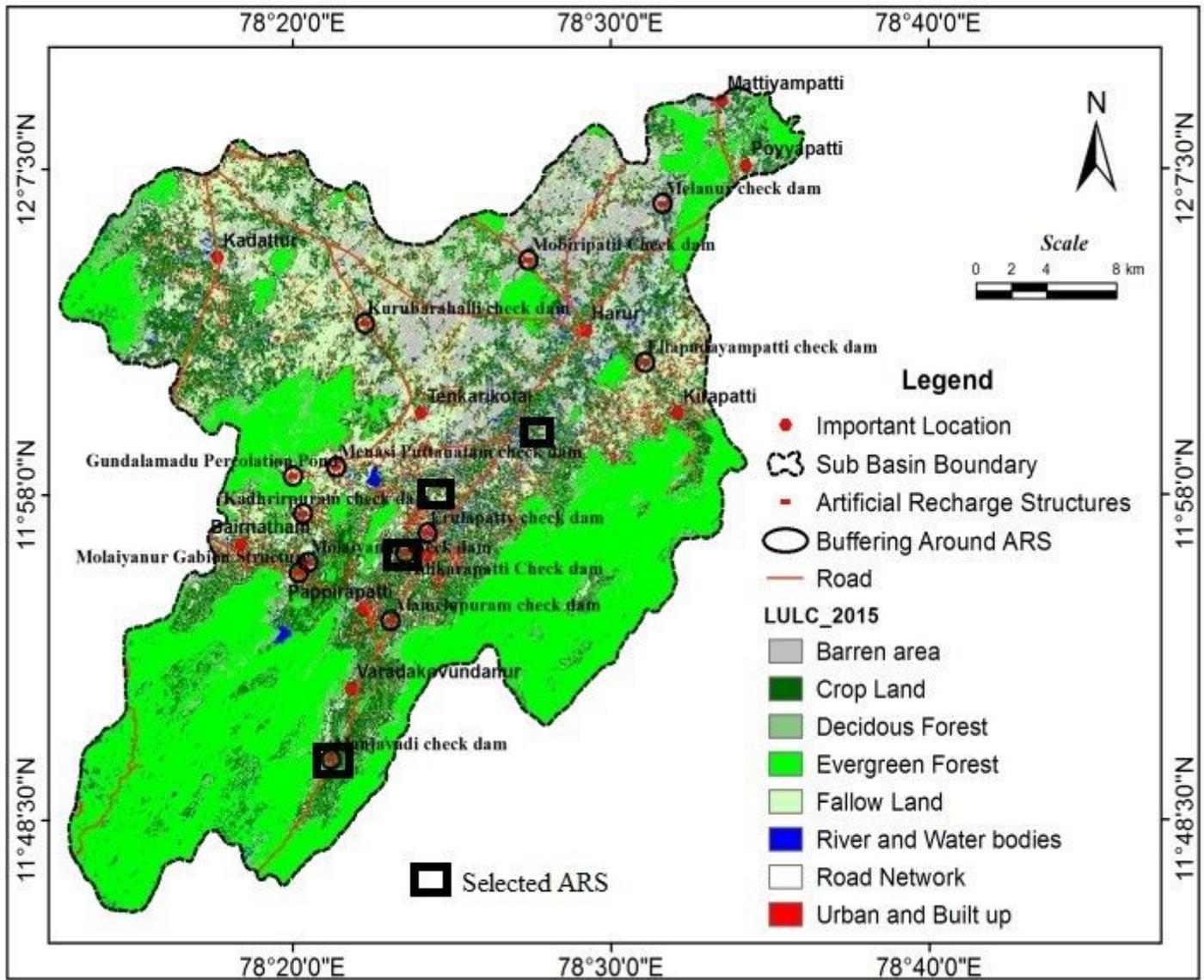


Figure 16

Shown Land use and Land cover Pattern 2015



Figure 17

(a) Showing a well 4 at Manjavadi Open well cutting for the geological formations of conglomerate and silt deposits, (b) Showing well location 3 at Manjavadi Measuring water level and Open well cutting for the silt deposits with crop land (bottom left) (C) Erosion control of the small check dam at kombur (bottom right)(D) Major check dam at manjavadi when heavy rain season