

Preparation of Watershed Action Plans Using Geo-informatics Technology



Engineering

KEYWORDS : GIS, Watershed, Community, Integrated Watershed, Natural Resources, Soil and Ground Water, Socio-Economic.

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ABSTRACT

The community based integrated watershed approach is highly essential in order to meet the needs of ever-growing population i.e. for providing food, fodder, fiber and shelter by rejuvenating land and water resources especially in rural areas. To achieve this goal proper management of natural resources by adopting suitable scientific solutions for optimum development of land, vegetation and water resources in a sustainable manner is essential to the maximum possible extent. It is felt that in our country a majority of the areas still require great thrust and appropriate measures. Therefore the study made an attempt to assess the temporal changes in the natural resources in a watershed using IRS satellite images of 2002 and 2014, toposheet, geology, geomorphology, soil and ground water data were used. The watershed proposed structure were found and the impact of the watershed were compared using socio-economic and satellite data. The study found that there is a huge positive impact was identified due the watershed analysis in the study area.

1. INTRODUCTION

Watershed management is the most appropriate unit to protect, conserve and improve land and water resources of a particular area. A physical unit in which water from all over the area flows under gravity to a common drainage channel; Watershed is also synonymous to catchments area and drainage basin. The basic data required for Watershed management are statistics of population and livestock, pattern of land ownership, topography, land use, cropping system, data on rainfall vegetation, runoff erosion problems, groundwater and input supply, improve the socio-economic status of the concerned area.

In India more than 75% of population depends on agriculture for their livelihood. Agriculture plays a vital role in country's economy. Scientific surveys have revealed that more than 70% of the total geographical area in our country is under distress due to frequent occurrence of droughts. Agriculture is seriously affected by uncertain monsoon. In order to mitigate droughts which occur frequently in several parts of the country especially in dry land areas the Ministry of Agriculture and co-operation has launched an integrated watershed concept using easy, simple and affordable local technologies.

2. STUDY AREA

The Kuppadhithara Watershed area is located in the South - Western part of Wayanad district of Kerala state. It lies between 75° 58' 38" and 76° 1' 36.8" East longitude and 11° 38' 26.7" to 11° 43' 15.1" North latitude. The elevation varies between a minimum of 720 meter to a maximum of 840 meter. The watershed is drained by "Venniyode Puzha" which is a branch of Kabin River.

It has a total geographical area of 2181 Ha. With 8276 households and a total population of 46666. The watershed lies in the high-land region. The elevation varies from 720 meter to 840 meter.

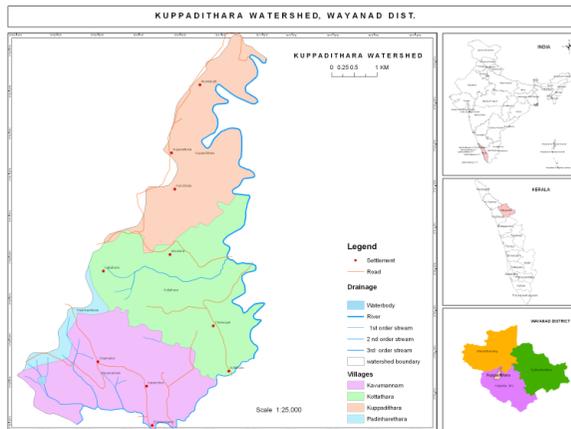


Fig.1: Study Area Map

2.1 Drainage

The watershed is drained by "Venniyode Puzha" which is a branch of Kabin River. A small lake lies south west of the area. Streams are very less in numbers. The river is flowing to east direction. Peoples are mainly depends upon the wells for drinking water.

2.2 Climate

2.2.1 Rainfall

The watershed has a humid sub tropical climate with mean annual rainfall of 1808 mm. The southwest monsoon contributes to about a 70% of total rainfall and this is received mainly during the months of June, July and August. Pre-monsoon showers which contribute nearly 5 to 10 % is experienced during April and May, and balance quantity is during North East monsoon

during September October. There is a dry spell of about five months from December to April. A steady decline in the quan-

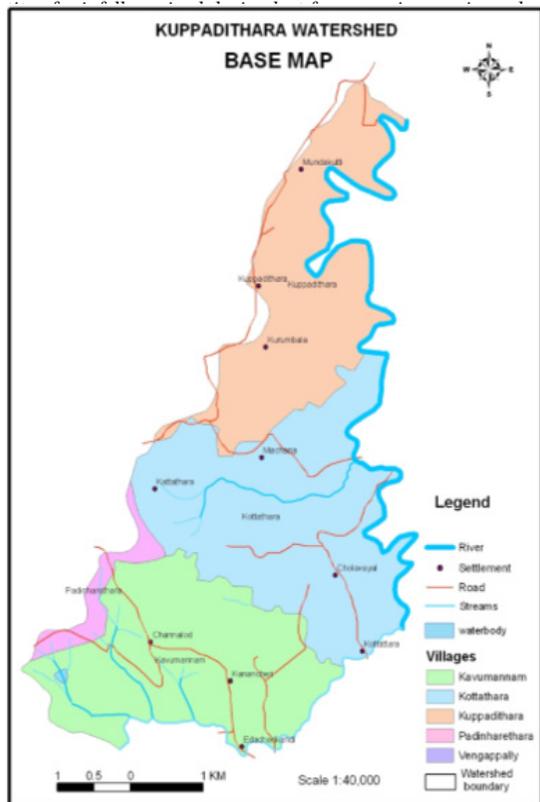


Fig.2: Base Map

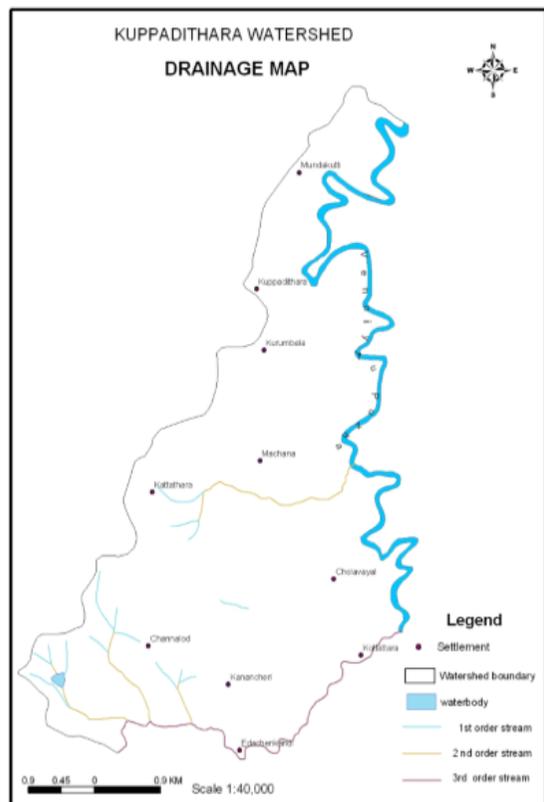


Fig.3: Drainage Map

2.2.2 Temperature

During the months of April and May, the mean daily maximum temperature is about 35° Celsius. Temperature is low in December and January- about 20° Celsius. On certain days the night temperature may go down to 16° Celsius. The following table shows the maximum and minimum temperature experiences in the area at different seasons.

Table.1
Maximum and Minimum Temperature

SL. No	Season	Maximum Temperature	Minimum Temperature
1	Summer season	43° C	24°C
2	Winter season	34° C	19°C
3	Rainy season	32° C	22°C

2.2.3 Population

Total population of the area is 46666 and the number of households is 8276.

2.2.4 Settlement

Kuppaddithara watershed comprises 5 villages via Kottathara, Vengappally, Kavumannam, Padinjarethara, and Kuppaddithara and 4 Panchayatviz Panamaram, Kottathara, Thariyodu, and Vengappally .

2.2.5 Transport

The transport network is good in this area. All the villages are connected with roads.

3. METHODOLOGY

3.1 Data and Methods

For the study, satellite data, topographical maps, and other collateral data were used. For the preparation of base map 1:25000 scale were procured from Survey of India (SOI) and used. The relief Map, drainage and watershed maps were generated by using ERDAS IMAIGINE and ArcGIS 9.2 software. Triangulated Irregular Network (TIN), Digital Elevation Model (DEM) and slope map were generated by using SOI toposheet with twenty meter contour intervals. Land Use/Land Cover Map was prepared by using satellite images. Watershed impact socio-economic data were collected from the field and watershed development plan were generated using multiple layers analysis in ArcGIS software.

3.2 Map Interpretation

3.2.1 Geology

The Wayanad district can be broadly divided into four geological domains viz., i) the peninsular Gneissic Complex in the north and central part, ii) the Migmatite Complex in the south-central part, iii) the Charnockite Group in the south and iv) the Wynad Group in the north. The watershed area consists mainly three types of geologic structures namely, Biotite-hornblende gneiss/hornblende biotite gneiss, Hornblende biotite gneiss, and Meta ultramafite (Talc-chlorite-schist, talc-pyroxene-garnet schist). Peninsular Gneissic Complex, represented by hornblende-biotite, occupies a major part of the area. All the structures are Archean formations. Migmatitic complex act as aquifuge unless fractured.

3.2.2 Geomorphology

The main Geomorphologic features of the area are flood plain, pediplain, dissected plateau, valley flat, residual hills and structural hills. Most of the area is under pediplain and dissected plateau.

Linear to actuate hills showing definite structural trends is called structural hills. Mainly act as run-off zone. Large hills contribute significant recharge to the narrow valleys and other favorable zones within the hills and to adjoining plains.

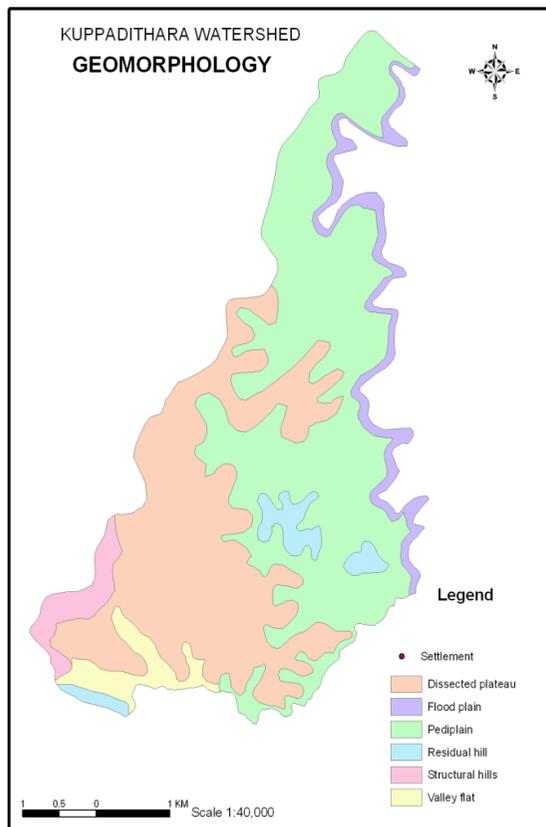


Fig.4: Geomorphology

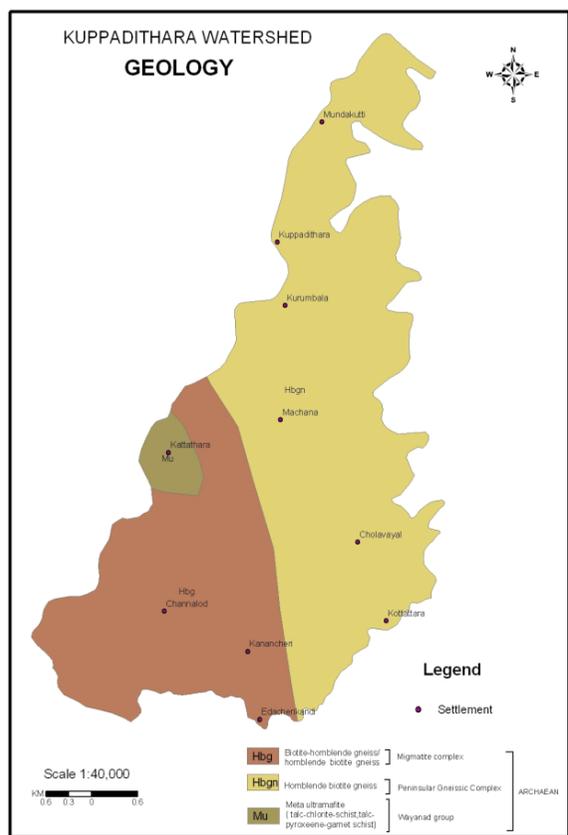


Fig.5: Geology

Residual hills are a group of hills occupying comparatively

smaller area than composite hills ranging from 2*2-10*10 system. Limited prospects along valleys and limited recharge potential to the surrounding plains. Pediplain are gently undulating plain of large areal extent often dotted with inselbergs formed by the coalescence of several pediments. Pediplain occupied by semi-consolidated sediments from food aquifers depending on their composition. In hard rocks, they form very good recharge and storage zones depending upon the thickness of weathering/accumulated material, its composition and recharge conditions. Faults/fracture zones passing through pediplain act as conduits for movement and occurrence of ground water.

Flood plain is the alluvium deposited along the minor/stream courses due to repeated flooding. Flood plains receive good recharge & form good shallow aquifers depending on the type of sediments, their thickness and recharge conditions. Moderately dissected plateau is a plateau (upper/middle/lower) which is fully preserved in its original form and has not been dissected. Shallow aquifers partially drain out into the deep valleys formed by dissection. Valley fill are the valley of different shapes & sizes occupied by valley fill material. Form moderately productive shallow aquifers, subject to thickness of valley fill water its composition and recharge conditions.

3.2.3 Relief

To generate TIN &DEM of the study area, contour with 10 m interval has been used. The relief map has been prepared by 10 meter interval contour.

3.2.4 Slope

The slope map of the study area has been generated from TIN by using 'Slope' option under Surface analysis tool.

3.2.5 Aspect

The aspect values of the study area have been measured in the compass direction. I.e. from N-NE-E-SE-S-SW-W-NW (i.e. 0°-360° in clock-wise direction). Similarly, flat surfaces which do not possess any direction have also been depicted.

3.2.6 Soil

Soils of the watershed exhibit wide variations in their physical and chemical properties. The major soil series identified in the watershed area are as follows.

These soil series are very deep, poorly drained, Loamy soils with moderately shallow water table in very gently sloping values of Wayanad plateau, with slight erosion; associated with very deep, imperfectly drained, clayey soils with moderately shallow water table on nearly level lands

These soil series are very deep, well drained, clayey soils on gently sloping lands of Wayanad plateau, with moderate erosion; associated with very deep, well drained, clayey soils

These are deep, somewhat excessively drained, gravelly clay soil with moderate surface gravelliest on steeply sloping high hills with thick vegetation, with moderate erosion; associated with very deep, well drained, clayey soils on gentle slopes

These are very deep, well drained, loamy soils on gently sloping uplands with valley, with moderate erosion; associated with very deep, well drained, loamy soil on gentle slopes.

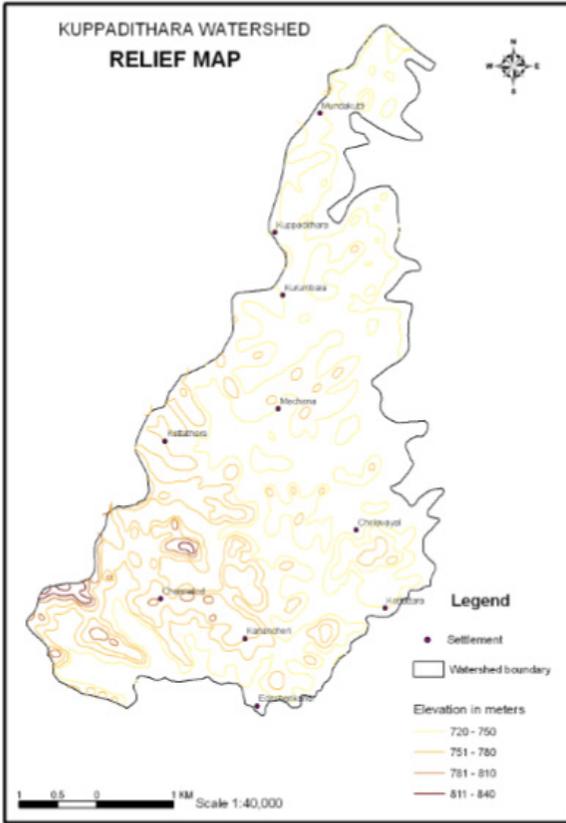


Fig.6: Relief Map

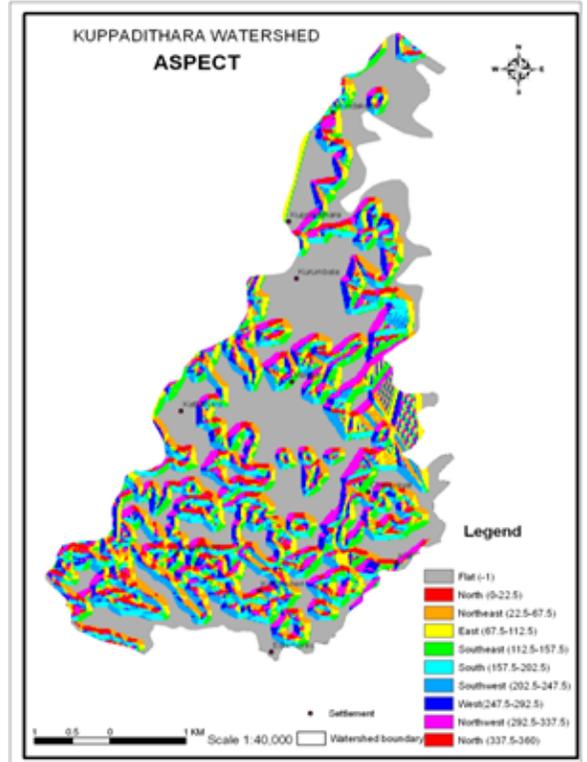


Fig.8: Aspect Map

3.2.7 Land use /Land cover

The Land use /Land cover of the area is mainly five types, crop land, plantation, fallow land, water body and land with or without scrub. Paddy is dominant crop in the wetland. Coffee and Pepper is predominant plantation in the dry land.

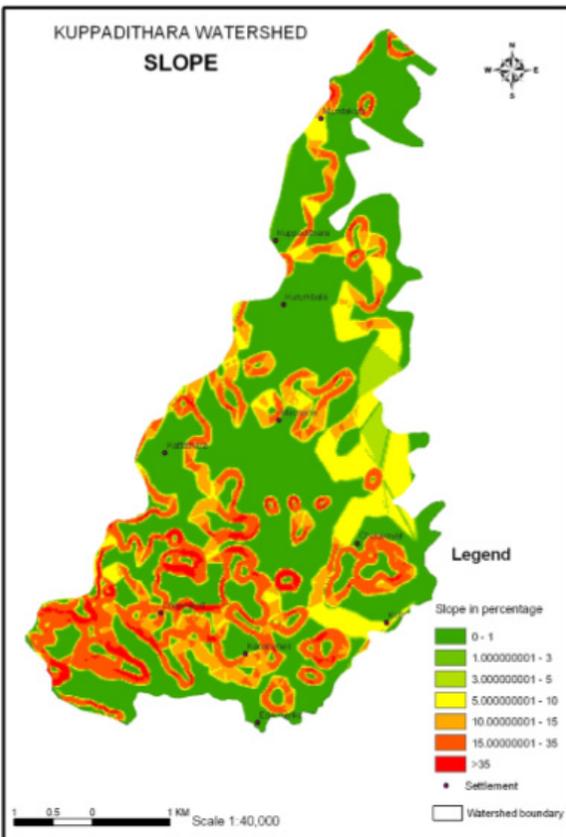


Fig.7: Slope Map

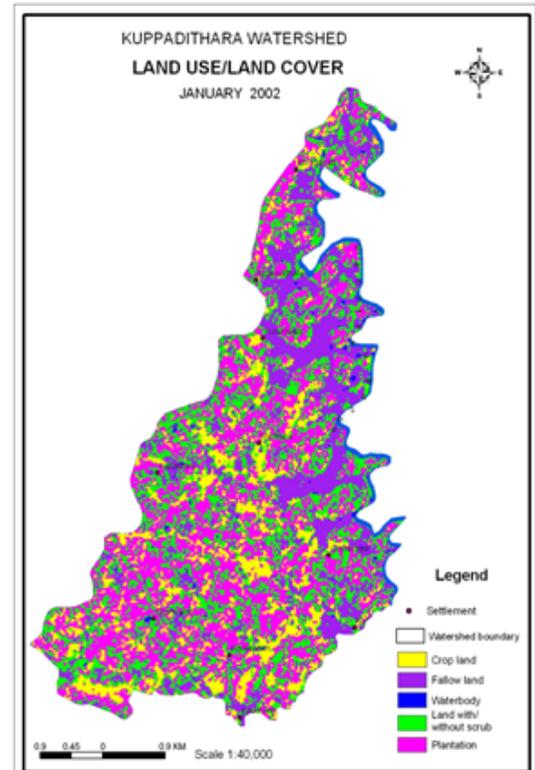


Fig.9: LU/LC - 2002

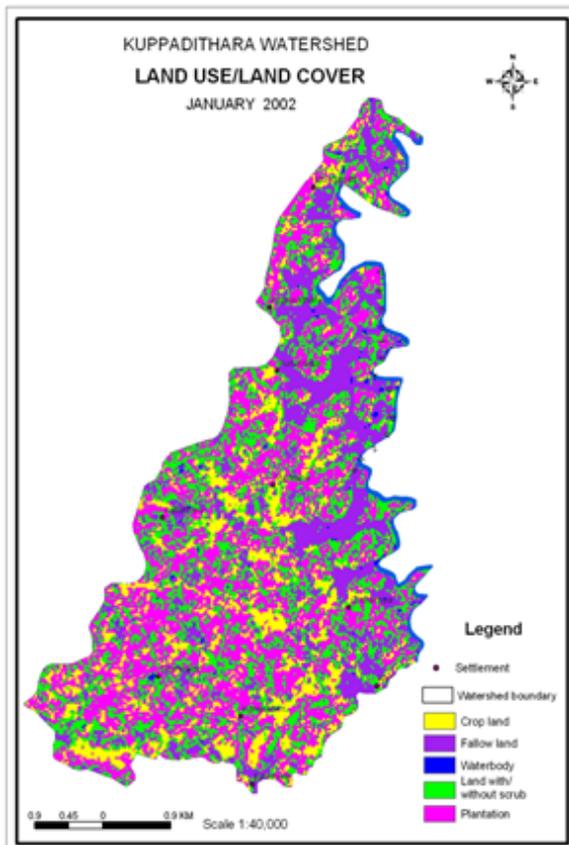


Fig.10: LU/LC - 2014

Tapioca, Banana, Vegetables and Areca nut are also cultivated in this low lying valley fills. The temporal data were analyzed to identify the changes of Land use /Land cover.

Table.2
Distribution of Land use /Land cover

Sl. No	LU/LC	2002 (Area in Ha.)	2014 (Area in Ha.)
1	Crop land	295.95	362.3
2	Fallow land	450.32	316.89
3	Plantation	25.12	27.07
4	Water body	605.54	310.96
5	Land with/without scrub	804.07	1163.78
Total		2181	2181

The images of IRS 1D-L3 of 12th January 2002 and IRS P6 /LISS IV of 06th February 2014 were used for the Land use /Land cover classification. The following table shows the area under different classes.

3.2.8 Ground water potential

Ground water potential maps are prepared by integrating information on geomorphology, slope, Lithology, structural features and the precipitation. Ground water recharge depends on favorable slope, permeability and degree of compactness of the rocks.

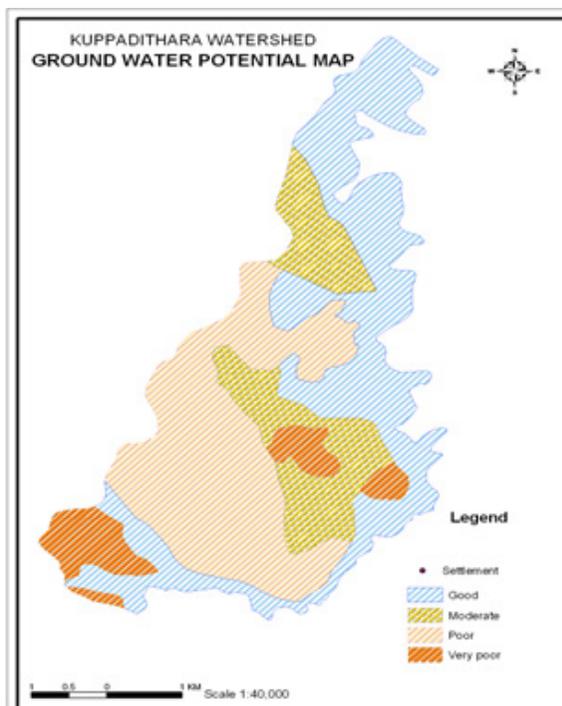


Fig.11:Ground Water Potential Map

Ground water potential is mainly grouped into three categories, very poor, poor, moderate and good to moderate. Ground water potential is high in the eastern part of the area, along the river side and pediplain land.

Table.3
Ground water potential

Sl.No	Ground water potential	Area in ha	Area in%
1	Good	814	37.3
2	Moderate	404	18.52
3	Poor	775	35.54
4	Very poor	188	8.62
Total		2181	100

Nearly 780 ha.of the area falls in this category.All other areas are very poor in Ground water. The people are mainly depends upon the dug wells for drinking and irrigation purposes.

3.2.9 Land Capability

Land capability classification is a systematic classification of different kinds of land according to those properties which determine the ability of the land to produce common cultivated crops & pasture plants virtually on permanent basis (Tejwani, 1976).

The watershed is divided into four capability classes, which are numbered in Roman numerals from II to IV and two subclasses E and S.

Class II -land has moderate limitations that reduce the choice of crops.

It needs simple soil and water conservation practices and requires some attention to soils management.

Class III -land has severe limitations for use, hence it needs intense soil and water conservation treatment and requires careful soil management. Graded terraces are made on moderate slopes.

Class IV -land has very severe limitations. The soil and water

conservation practices are more

difficult to apply and maintain.

Subclass e is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass.

Subclass s is made up of soils that have soil limitations within the rooting zone, such as shallowness of the rooting zone, stones, low moisture-holding capacity, low fertility that is difficult to correct, and salinity or sodium content.

3.2.10 Land Irrigability

The interpretation of soil and land conditions for irrigation is concerned primarily with predicting the behavior of soils under the greatly altered water regime brought about by irrigation. To carry out land irrigability classification of command areas, special interpretation and classification of soils for sustained use under irrigation are often required. The classification is based on effective soil depth, soil texture, soil permeability, coarse fragments etc. The soils are grouped into soil irrigability classes according to their limitations for sustained use under irrigation, regardless of their location or the size of the individual mapping unit.

The suitability of land for irrigation depends on physical factors like quality and quantity of irrigation water and socio-economic factors like land development costs provision of drainage facilities production costs of individual crops.

The Kuppadithara watershed has three irrigability classes.

Class II Lands That Have Moderate Limitations Of Soil, Topography Or Drainage For Sustained Use Under Irrigation.

Class III Lands That Have Severe Limitations Of Soil, Topography Or Drainage For Sustained Use Under Irrigation.

Class IV Lands That Are Marginal For Sustained Use Under Irrigation Because Of Very Severe Limitations Of Either Soil Topography Or Drainage. E Not suited for irrigation.

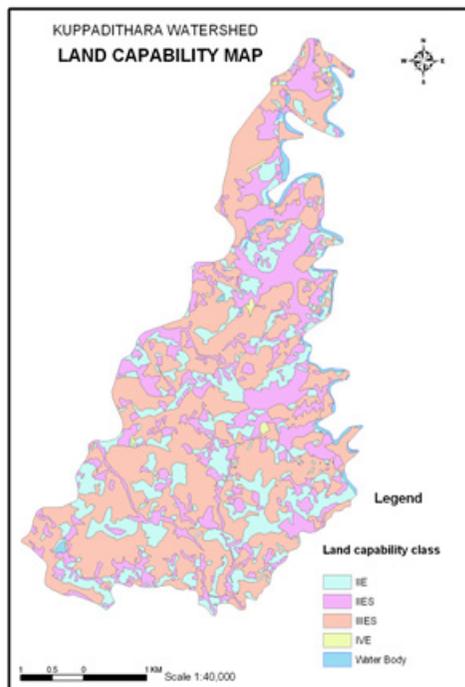


Fig.12: Land Capability Map

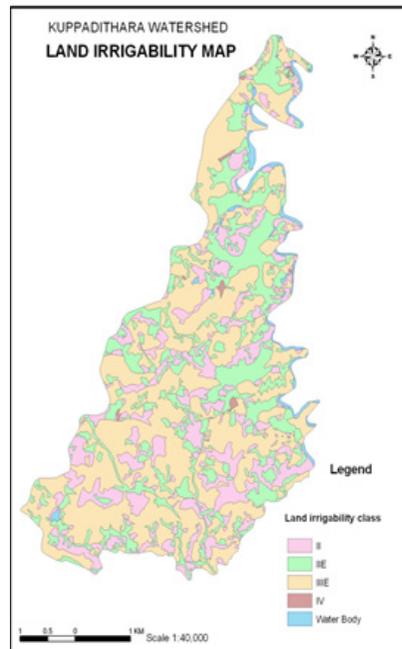


Fig.13: Land Irrigability Map

Existing Water harvesting structures

During the period of Kabini River Valley Project, different water harvesting structures were constructed to develop the Kuppadithara watershed. The important structures constructed in the Kuppadithara area is check dam (Loose boulders), contour vegetative hedge, contour staggered trenches, and farm ponds.

Table. 4

Existing structures

Sl. No	Structures	Numbers/area covered
1	Earthen loose boulders	475
2	Loose boulder with vegetative support	58
3	Contour vegetative hedge	388 Ha land with 0.12 m ³ section
4	Farm ponds	210
5	Contour/Graded Bunds	68

Proposed Water harvesting structures

After the detailed study about the Kuppadithara watershed, using GIS and remote sensing analysis suitable location for constructing Water harvesting structures has been proposed.

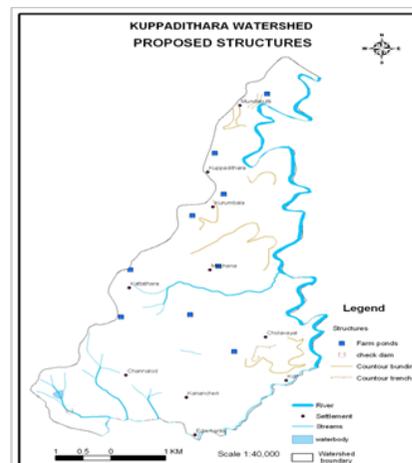


Fig.14: Watershed Proposed Structures

4. RESULT AND DISCUSSION

4.1 Spatial distribution of Land use /Land covers

The land use/land cover categories of the watershed have been grouped into four classes, crop land, Fallow land, water body, plantation and land with/without scrub.

4.1.1 Crop land

These lands are primarily used for production of food. The main crop in this area is paddy. The crop land covers an area of 295.95ha. in 2002 and 362.3ha. in2014.

4.1.2 Fallow Land

These are the agricultural lands temporarily kept as vacant land during the agricultural year. It covers an area of 450.32ha.in 2002 and 316.89ha. in2014.

4.1.3 Water body

The streams and rivers are included in this category. The major river flowing in the study area is theVenniyatturiver and its tributaries. The total area under water body is 25.12ha. in 2002 and 27.07ha. in2014.

4.1.4 Plantation

These lands are primarily used for production of commercial crops. Coffee is ubiquitous in Wayanad. It is cultivated in every Panchayat, both in the form of large plantations and small holdings. The economy of Wayanad depends mainly on coffee. This land use class is extensively distributed throughout the watershed. The major plantation crops in the study area are rubber, coffee, tea and pepper. Pepper is grown as an additional crop on trees that are groomed to give shade to the coffee shrubs. The total area under plantation is804.07 ha. in 2002 and 1163.78ha. in2014.

4.1.5 Land with/without scrub

The land with scrub are the lands with soils that are too shallow, skeletal or chemically degraded lands with moderate to steep slope and are mostly covered with scrubs of different densities and varying height. Land without scrub is the counter part of the previous category, but without any vegetation cover on the land. The total area under this category is 605.54 ha. in 2002 and 310.96 ha. in2014.

Table: 5 Land use/Land cover - 2002

Sl. No.	LU/LC	Area in 2002
1	Crop land	295.95
2	Fallow land	450.32
3	Water body	25.12
4	Land with /without scrub	605.54
5	Plantation	804.07
Total		2181

Table: 6 Land use/Land cover - 2014

Sl. No.	LU/LC	Area in 2014
1	Crop land	362.3
2	Fallow land	316.89
3	Water body	27.07
4	Land with /without scrub	310.96
5	Plantation	1163.78
Total		2181

4.2 Land Cover and Land Use Changes

Land use and land cover are dynamic. Changes may involve the nature (for instance, from a dense forest to a natural savannah, or to cropland) or intensity of change (for instance from a dense forest to either a temporary smallholder’s field under slash-and-burn exploitation, or a permanent plantation), but may also include spatial (forest abatement at village level, or for a large-

scale agro-industrial plant), and time aspects.

Land use changes can move in two directions: either, in the negative sense, leading to land degradation and loss of (production) potential, or, in the positive sense, resulting in a higher value or potential.

Table 7 Land Cover and Land Use Changes

Sl. No.	LU/LC	Area in 2002 (ha.)	Area in 2014 (ha.)	Changes
1	Crop land	295.95	362.3	66.35
2	Fallow land	450.32	316.89	-133.43
3	Water body	25.12	27.07	1.95
4	Land with / without scrub	605.54	310.96	-294.58
5	Plantation	804.07	1163.78	359.71
Total		2181	2181	

There is a positive change in crop land, water body, and plantation. 66.35 ha.ofareashave brought under crop land in 2014. In 2002, 25.12ha .of land was under water body. Now it is 27.07 ha. There is an increase of 1.95 hectares. Land with /without scrub has decreased to 310.96ha. It was 605.ha. on 2002. Fallow land has also decreased.

4.2.1 Change detection

The sensing of environmental changes that uses two or more scenes covering the same geographic area acquired over a period of time.Change detection is useful for monitoring: urbanization, agricultural development, forest land management, ice forecasting, etc. The most widely used methods are: Difference Image, Ratio Image, Classification Comparison, and Change Vector Analysis.

Image differencing is probably the most widely applied change detection algorithm (Singh, 1989). It involves subtracting one date of imagery from a second date that has been precisely registered to the first. According to recent research, image differencing appears to perform generally better than other methods of change detection (Coppin & Bauer, 1996).

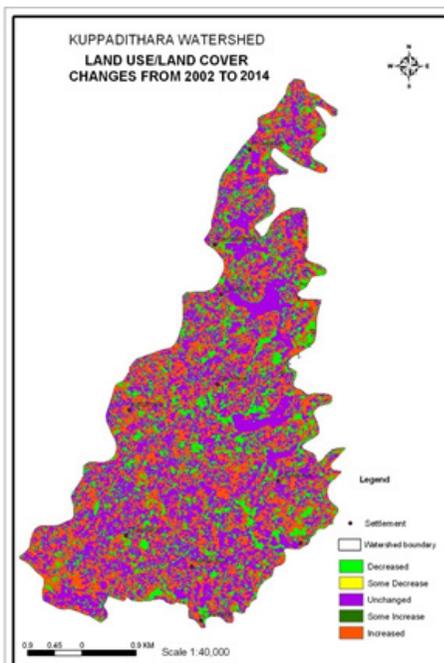


Fig.15: LU/LC Changes 2002 to 2014

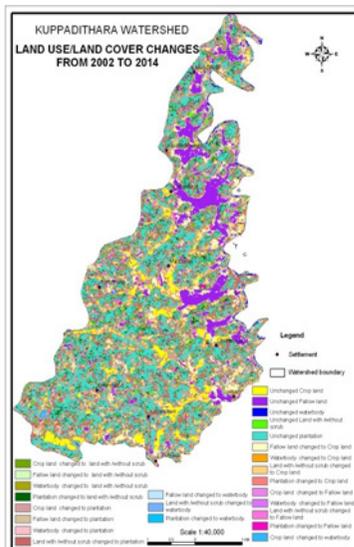


Fig.16: Details in LU/LC Changes from 2002 - 2014

4.2.2 Change matrix

Using this technique the unchanged land and the land converted to other types of lands etc. were identified. The following table shows detailed information on the converted land.

Table.8

Change Matrix

Sl. No.	LU/LC classes	Crop Land	Fallow land	Plantation	Land With/without Scrub	Water body
1	Crop Land	116.15	16	141.1	21.6	1.1
	Fallow land	83.2	201.42	94.9	64.7	6.1
2	Plantation	69	33.6	592.77	105.2	3.5
3	Land With/without Scrub	93.2	67.8	345	91.27	8.27
4	Water body	2.1	4.4	5.6	4	9.02

4.2.3 Vegetation density

The Vegetation density in the study area has been divided in to four classes, low density, moderate density, high density and very high density vegetation.

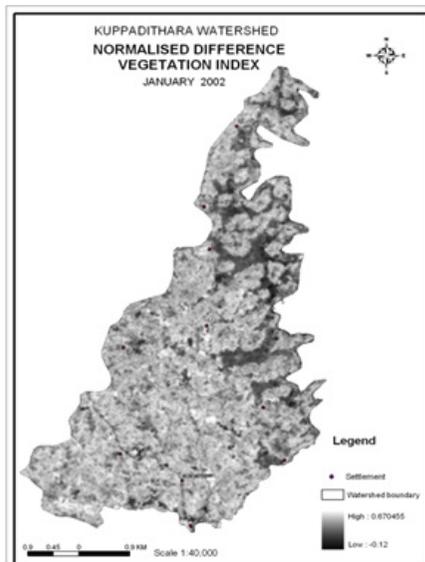


Fig.17: NDVI - 2002

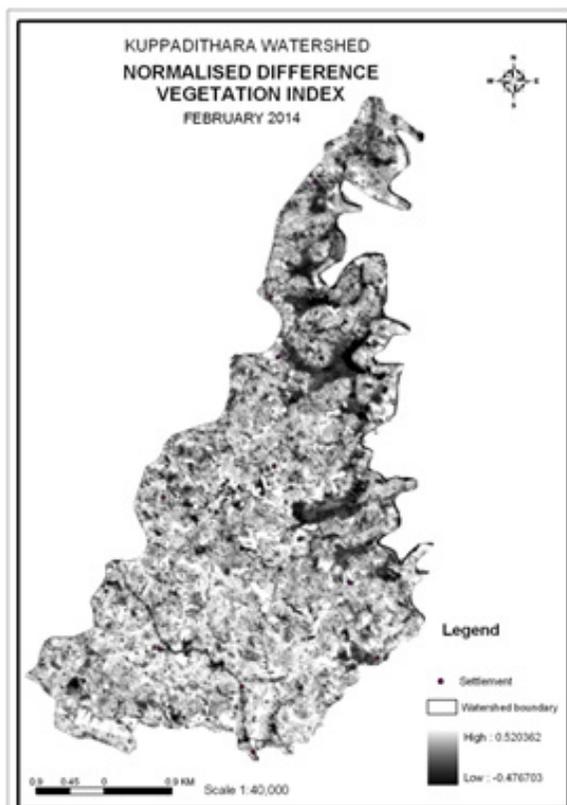


Fig.18: NDVI - 2014

5. CONCLUSION

5.1 Water harvesting structures and its impact

Contour vegetative hedge were taken in 388 Ha land with 0.12 m³ section and planting fodder grass (mostly Congo signal slips) for strengthening the buds. These vegetative hedges control erosion and conserve moisture in the agricultural land. The fodder grass which was grown on bunds is a very good feed for cattle.

Construction of contour bunds at required vertical and horizontal intervals were taken up on 630 Ha for conserving moisture, reducing run off and consequent increase in crop yield. Bunding works increased time of concentration and thereby allowing more opportunity for rainwater to get absorbed in the soil profile and to convert long slope to short one so as minimize the velocity.

Progressive farmers like GovindaMararKuppadithara, Rossaand GrazyAttumalil, Devayani W/o Damodaran Nair, Meppalli-Chempakachalil, Thressyamma Sebastian, MundakuttyKuppadithara were impressed with these low cost bunds as those conserved moisture and improved the level of ground water.

Contour Staggered Trenches were taken up in 834 hectare in the watershed on ridge portion of steep sloppy lands and barren hillocks. Staggered contour trenching across the slope was done to control erosion, to arrest water velocity and to store runoff water. The water stored in the trenches was percolated in the soil making good development of pasture in addition to recharge of water in to the dugout ponds constructed at lower reaches of the project area. The fodder species planted on the ridges of trenches is growing well and is useful feed to livestock.

All the Arable land conservation measures were executed with the active participation of "Kuppadithara Watershed Farmers

Association” and the Farmers of the project area. A series of training programme were conducted from time to time to importing training to the project staff and farmers, about the approaches, strategies, guideline technical contents as well as various measures taken up in the project area.

Construction of 475 No’s earthen loose boulders and 58 No’s loose boulder with vegetative support in series across small gullies were taken up with the objectives of preventing erosion and deepening of the gully beds, reducing runoff, improving soil moisture regime for establishing plant cover.

Construction of 210 No’s farm ponds were taken up under the project for collecting runoff water which can be recycled especially during drought period either for giving life saving irrigation or for establishing a new crop.

Construction of 18 No’s water harvesting structures were taken up under the project area for collecting and impounding runoff water during monsoon season and to facilitate infiltration to raise ground water level. It also facilitates infiltration in the fields closer to the water harvesting structures. Before taking up this structures, the runoff lose of water was a common feature under high intensity rains causing a considerable damage to the top soil.19 No’s water harvesting structures constructed in the project area can store 6840 cubic meters of water during one year.

Under entry point activity, drinking water supply scheme through the construction of water tank with well, pump set and distribution system has been commissioned at Kurinjimal.S.T.Colony, Cholappuram, and Pinangode benefiting the inhabitants of the area.

A corpus fund has been established for the maintenance of community assets, created under the project. An amount of Rupees 3, 26,000/- has been set apart for the corpus fund. This corpus fund will be utilized by the Watershed Farmers Association for the purpose of maintaining structures in the community land and other structures in the watershed.

As a result of watershed activities, crop production has increased by 10-15 %, increase in water level in wells by 3 to 5 feet, increase of employment generation by around 70,000 man days and reduction of runoff losses up to 80 % has been observed.

The increase in production of various crops is given below

Table.9
Production of crops

Sl. No	Crop	Production		Increase in %
		Pre project	Post project	
1	Rice	275 Kg/Ha	330 Kg/Ha	12
2	Coconut	200 Nos	225 Nos	12.5
3	Pepper	250 Kg/Ha	275 Kg/Ha	10
4	Coffee	600 Kg/Ha	680 Kg/Ha	13

5.2 Benefits Accrued By Implementation of Programmes

The execution of contour vegetative hedges in the watershed has control erosion and conserves moisture in the agriculture land. Planting fodder grass which was grown on bund is a very good feed for cattle.

Construction of contour graded bund at required vertical and horizontal intervals helps for conserve moisture reducing runoff. As result of this crop yield has increased.

Contour staggered trench taken up across the slope controls erosion, arrest water velocity and store runoff water.The water store in trench has been percolated in the soil and making good development in the pasture in addition to recharge into the dug-out ponds constructed at lower reach of the project area.

Construction of check dams (ELB & LBV) has prevent erosion and deepening of the gully beds, besides these help reducing run off.

Construction of water harvesting structure provided assured irrigation to grow more crops and thereby there is an increased yield by 5 o 10%.

5.3 Socio economic status

A total number of 1750 farmers were benefited by the scheme and out of which 100 number beneficiaries belongs to S C/S T Category. The project created 70000 man days of employment in the scheme area.

Progressive farmers like Joseph, KoovakkalVeedu, Kottathara Village, Ibrahim Kaniyamkandi, VarkeyVellaram Kala Veedu, Chennelode.P.O, Bobby Njarakulam, Chennelode etc. have opinion that lifesaving irrigation through construction 210 farm ponds and water harvesting structures have provided assured irrigation to grow more crops and thereby there is an increase in yield by 5 to 10 %.

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