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Sustainable Development of Land and Water Resources - A Case Study Of Kalasapura Subwatershed in Chikmagalur Taluk and District, Karnataka State Using Remote Sensing and gis Techniques

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ABSTRACT

In the present days, globally the nations focus and approaches found mainly towards the sustainable development of land and water resources because of increase in demand for land and water all over the world. Land is comprehensive natural resource which is the core element of the biosphere and responsible to survive all living things. In recent year, the land and water resources have been subjected to a variety of pressures. The present work deals with the generation of Land & Water resources development plans for Kalasapura Sub watershed in Chikmagaluru Taluk in Karnataka based on Remote Sensing and GIS approach, in which IRS 1C LISS III 2008, SPOT - 2014 images and SOI topographic maps 48 O/15 and O/16 were used. To generation of Land & Water resources action plans, various thematic layers were prepared in conjunction with collateral data through systematic visual interpretation technique. Subsequently integration has been done in a GIS environment using ARC GIS 9.3.

KEYWORDS: Land and water resource, Action plan, Remote Sensing, GIS.

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INTRODUCTION

The land and water resources are increasingly in demand in order to help agricultural and industrial development, to create incomes and wealth in rural areas, to reduce poverty among rural people, and to contribute to the sustainability of natural resources and the environment. The integrated land and water resources management is widely accepted as an appropriate approach to strive for sustainable water resources management and to adapt to impacts resulting from changing land use and climate[3].

Watershed management approach is the best way to monitor and manage both land and water resources in sustainable manner[1,2,4]. The programmes under watershed approach broadly fall into soil and water conservation, dry land and rain fed farming and improvement in the vegetative cover. During the past two decades, the water level in several parts of the country has been falling rapidly due to an increase in extraction. The number of wells drilled for irrigation of both food and cash crops have rapidly and indiscriminately increased [7,8,13,14]. Development of the watershed needs better understanding about the various natural resources their relations with each other and their relations with livelihood of the stakeholders.

LOCATION AND EXTANT OF THE STUDY AREA

Kalasapura sub watershed lie in Chikmagalur taluk of Chikmagalur district occupies an average area of 65.47 sq. km. The sub watershed is located between latitude 13^0 13' 48" to 13^0 19' 43" N and longitude 75^0 52' 57" to 75^0 58' 2" E which is Shown in the Fig.1. In the study area from June to September constitute the south-west monsoon season, October and November may be termed the post monsoon or stretching monsoon season, July being the rainiest month. The average rainfall in the area is about 917 mm.

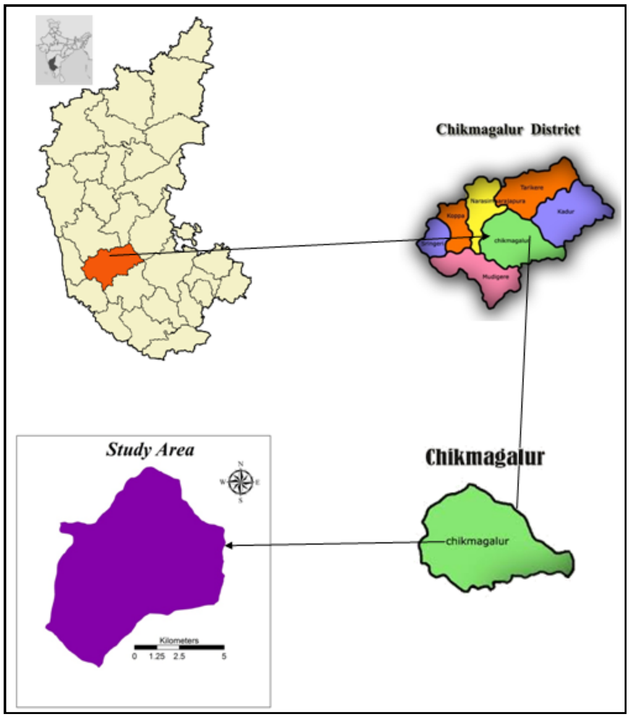

Fig. 1. Location Map of the Study Area

MATERIAL AND METHODOLOGY

The study involves generation of natural resource maps as well as optimal land and water resource development plan, basic satellite data of high resolution SPOT image 2014 downloaded from Google earth and IRS 1C LISS III 2008 are used for the preparation of various thematic layers. The base map and basic information in the form of drainage network contour and slope map are prepared using Survey of India topographical map 48 O/15 O/16 and later updated using satellite image.

The resources maps prepared through a systematic visual interpretation and subsequent integration with the ancillary data like rainfall in a GIS environment for generating for sustainable development of land and water resources. Software's like, ERDAS imagine 9.3. GIS package Arc-GIS 9.3 and GPS Garmin map 60 used to collect the co-ordinates at each place with accuracy of 3-5 meters. The thematic layers of lithology, geomorphology, soil, slope, land use, surface water bodies, drainage, isohyetal maps were used for the study area (Fig 2).

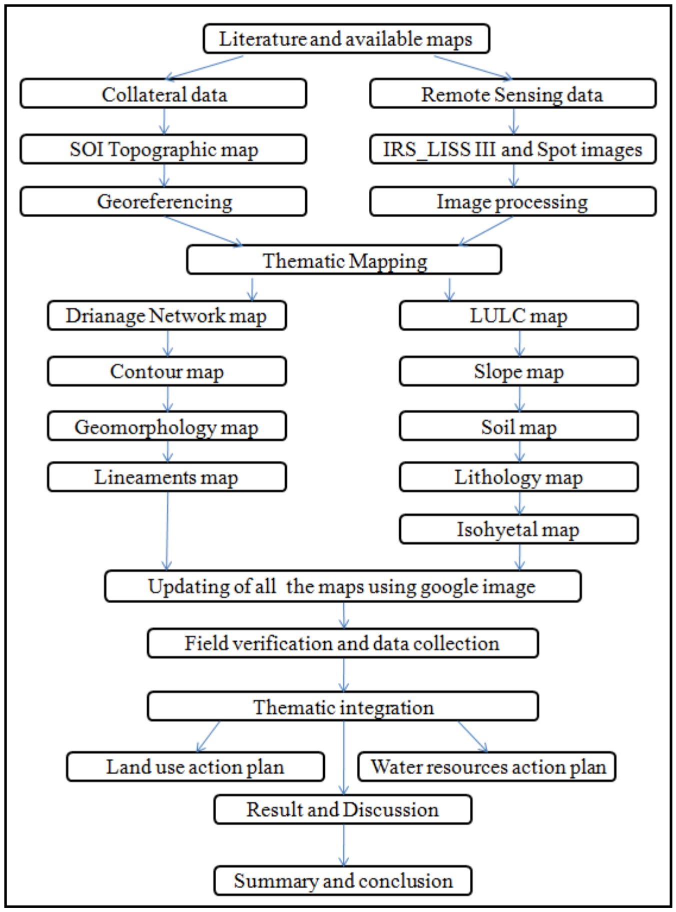

Fig.2. Flowchart adopted in the study

RESULT AND DISCUSSIONS

The Various thematic layers like drainage and surface water bodies, LU/LC, geomorphology, slope, soil map, litho logy Isohyetal maps were are integrated in GIS platform. Finally, we have given ranking for each theme to prepare land and water resource action plan and the result obtained are interpreted in fallowing headings.

Drainage and Surface Water bodies: Kalasapura Sub watershed exhibits mainly of sub parallel drainage pattern, there is a good distribution and collection and runoff during the precipitation. The study area comprises 25 tanks which are shown in the Fig.3.

Slope: A slope map prepared from the Survey of India topographic map as shown in Fig. 4. Based on the slope percent, the study area can be divided into seven slope classes namely, nearly level, very gentle slope, gentle slope, moderately steep slope, moderate, very steep slope and strong slope. The slope percentage in the area varies from 0 to 50%. The area with 0 to 5% slope falls in the 'very good' and 'good' category because of near to gentle level terrain with high infiltration rate. The area with a slope of 5–10% causes relatively high run-off and low infiltration, and hence is categorized as 'moderate'. The sixth (15–35%) and seventh (35–50%) category are considered as 'poor' and 'very poor' due to higher slope and run-off. The area statistics of slope classes is shown in table 1.

Geomorphology: The geomorphic features represents residual hill, denudation hill, moderately weathered buried pediplain, pediment inselberg complex, pediment/valley floor and shallow weathered/ buried pediplain. Denudation hill occupy nearly 28.73% of total study area. Pediment shows gently sloping erosion surface and plain of low relief, they are underlain by bedrock, this pediment are occupying nearly 26.70% of total study area (Fig. 5). The area has slightly undulating topography and the formations overlying moderately weathered and shallow weathered buried pediplains covered in almost all the parts of the study area, these have significant potential for contributing recharge to the aquifers present in this region[9,11], the area statistics of geomorphic features is shown in table 1.

Lithology: The Lithology of the study area (Fig. 6) mainly composed of four types of rocks they are migmatites and granodiorite - tonalitic gneiss, metabasalt & tuff, granite(Shimoga) and amphibolitic metapelitic schist/pelitic schist, the area statistics is shown in table 1.

Soil: Soil is an important factor for delineating the groundwater potential zones[10]. For arriving at land irrigability classes, soil characteristics namely, effective soil depth, texture of the surface soil, permeability, water holding capacity, course fragments, salinity and/alkalinity, presence of hard pan in the sub-surface, topography and surface and sub-surface drainage are considered. The soil type in the study area represents six soil categories namely Loamy, Loamy Skeletal, fine, fine loamy, clayey skeletal and habitation mask (Fig.7) the area statistics are shown in table 1.

Isohyets (Rain fall): Rainfall distribution along with the slope gradient directly affects the infiltration rate of runoff water hence increases the possibility of groundwater potential zones. The study area depends mainly on south-west monsoon rains. The ten years rain fall data are taken as average per year and then it made average for ten years for each station and plotted in GIS mode for both pre and post monsoon seasons using ARC-GIS 9.3. Isohyetal map of study area is prepared using the rainfall data which are collected from rain gauge stations in the study area from 2004 to 2013 which indicates the variation in rainfall represented by very low rainfall zone, low rainfall zone, medium rainfall zone and high rainfall zone as shown in Fig.8.

Land Use Land cover: The land use/land cover (LULC) plays important role in the development of land and water resources. The LULC of the area provides important indications of the extent of groundwater requirements and utilization. From the point of view of land use, dense vegetation is an excellent site for groundwater exploration[15]. The current LULC patterns of the study area consists of tanks, kharif crop, agriculture plantations (coconut and eucalyptus), land with and without scrub, settlements, scrub forest, forest blank, mining/ quarry industries and barren rocky/stony waste. Nearly around 50% of the total study area is covered with cultivated lands which are shown in Fig.9 and its area statistics in table 1.

Lineaments: Lineaments are natural, linear fractures like faults, joints and fractures which can be interpreted directly from satellite imagery. By visually interpreting the satellite imagery, the lineaments of the study area are picked up and traced on the basis of tonal, textural, soil tonal, vegetation, topographic and drainage linearity, curvilinear ties and rectilinear ties. Lineaments represent the zones of faulting and fracturing in the bed rocks resulting in increased secondary porosity and permeability. These factors are hydro-geologically very important as they provide the path ways for ground water movement and enhanced well yields can be expected[10]. A number of mega- and micro-lineaments are identified from the satellite imagery and further checked by field studies, and demarcated for the study area. The drainage pattern in general and tributaries in particular, are controlled by the geological structures in the area, as revealed by the perfect linearity of the second- and third-order streams. Total 186 lineaments were extracted for the study area which is shown in the Fig.10.

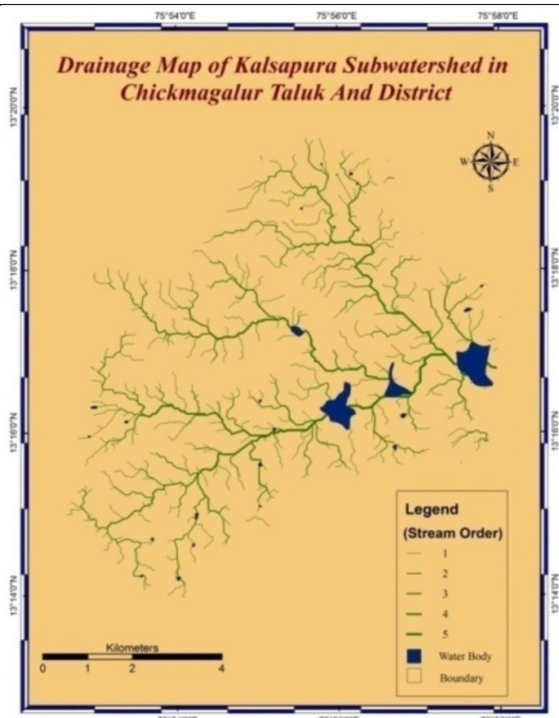

Fig. 3. Drainage and Surface Water body map

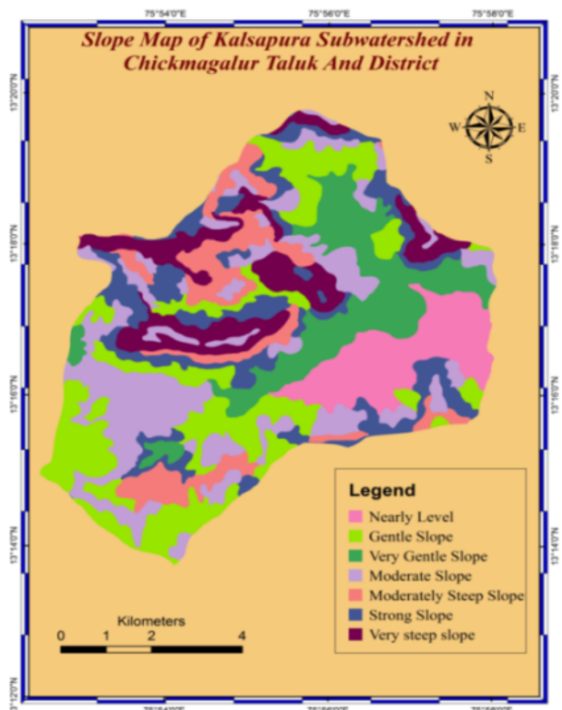

Fig. 4. Slope map

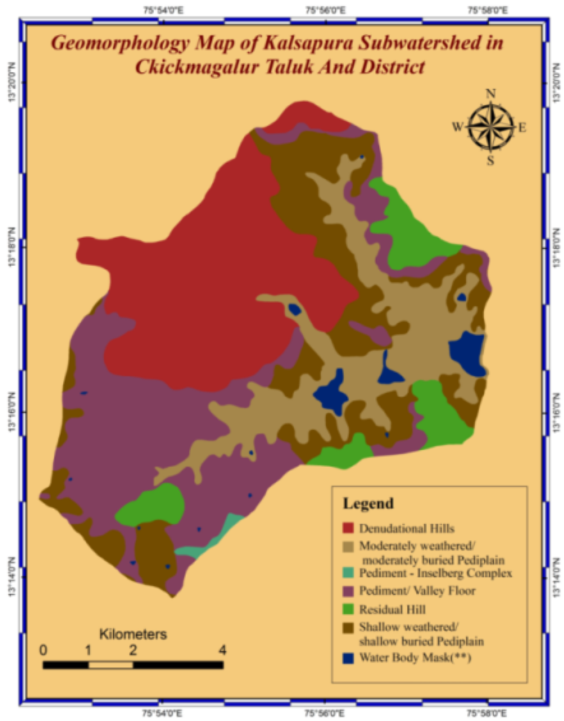

Fig. 5. Geomorphology map

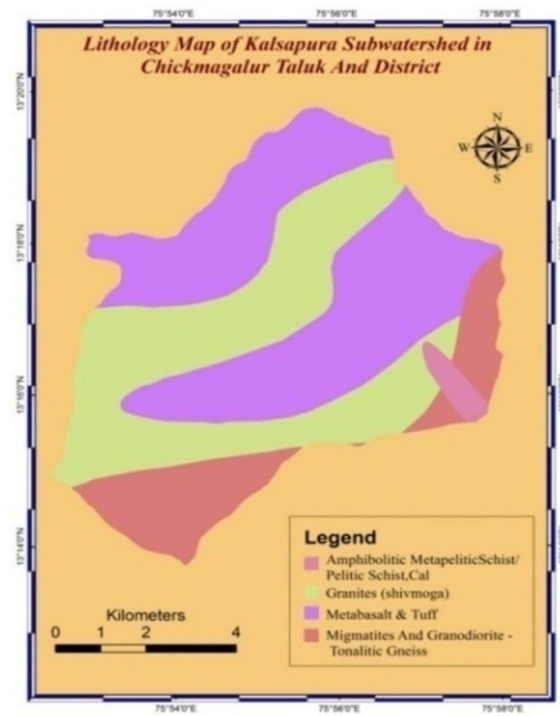

Fig. 6. Lithology map

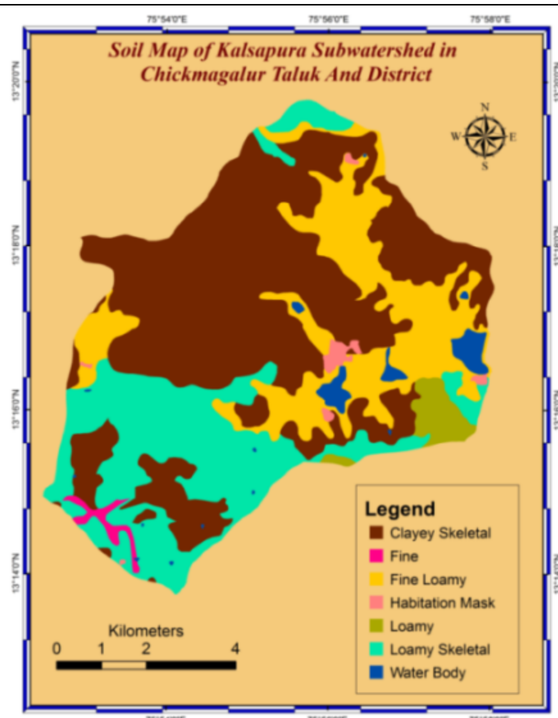

Fig. 7. Soil map

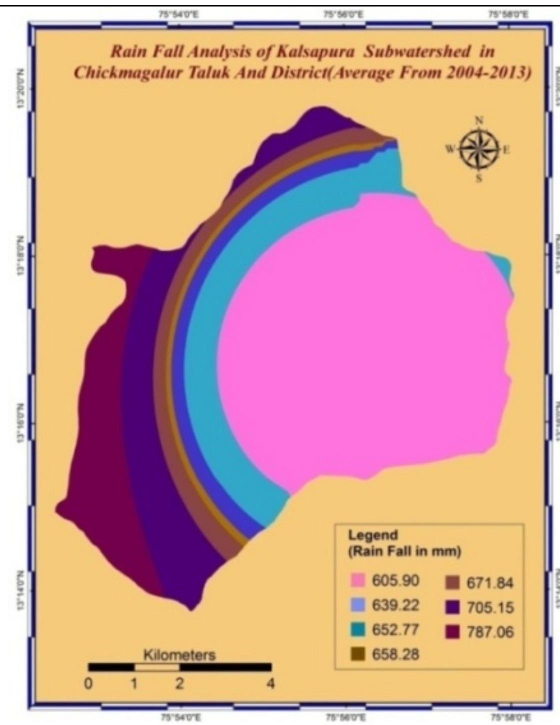

Fig. 8. Average Rainfall map.

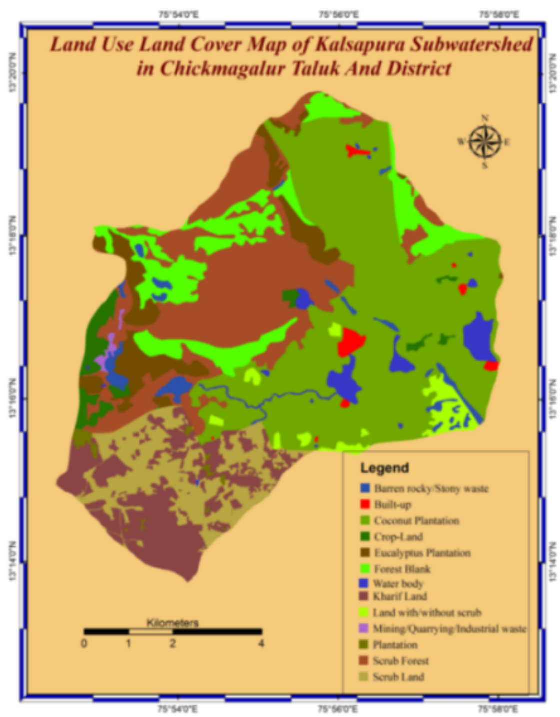

Fig. 9. Land Use Land Cover map

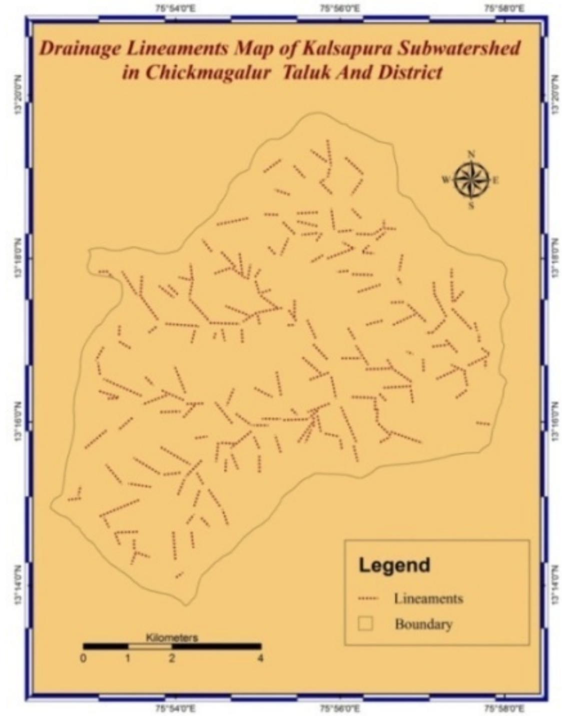

Fig. 10. Lineaments map

Table 1: The thematic layers and their area statistics

LU/LC	Area in sq. Kms	Slope	Area in sq. Kms	Geomorphology	Area in sq.kms	Soil	Area in sq.kms	Lithology	Area in sq.kms
Barren rocky/Stony waste	1.26	Clayey Skeletal	32.57	Denudational Hills	18.81	Clayey Skeletal	32.57	Amphibolitic Metapelitic Schist/Pelitic Schist, Cal	1.2 0
Built-up	0.49	Fine	0.55	Moderately weathered/ moderately buried Pediplain	10.85	Fine	0.55	Granites (Shimoga)	25.81
Coconut Plantation	23.84	Fine Loamy	12.73	Pediment - Inselberg Complex	0.30	Fine Loamy	12.73	Metabasalt & Tuff	28.58
Crop-Land	1.45	Habitatio n	0.56	Pediment/ Valley Floor	17.48	Habitation	0.56	Migmatites andGranodiorit e -Tonalitic Gneiss	9.89
Eucalyptus Plantation	3.61	Loamy	1.53	Residual Hill	4.51	Loamy	1.53		
Forest Blank	6.28	Loamy Skeletal	15.74	Shallow weathered/ shallow buried Pediplain	12.25	Loamy Skeletal	15.74		
Kharif Land	6.82	Rocky outcrops	0.53						
Land with/without scrub	1.32								
Mining/Quarrying/In dustrial waste	0.17								
Plantation	0.32								
Scrub Forest	13.32								
Scrub Land	5.52								

GROUND WATER POTENTIALITY

The thematic layers of lithology, geomorphology, soil, slope, land use, surface water bodies and drainage were used for the delineation of groundwater potential zones for the study area. To demarcate potential zones, all these thematic layers were integrated using Arc GIS 9.3 software. Different features of each theme were assigned weights according to their relative influence on ground water potential shown in the table 5 Based on this evaluation of different features of a given theme were preformed, with very poor, poor, moderate, good, and very good. To demarcate ground water potential zones, all the thematic layers after assigning weights were integrated and generated the ground water potential map from the study area (Fig.11) and its area statistics is shown in table 2.

Fig.11. Ground Water Potential map

Table.2. Area Statistics of Ground Water Potential Zones

Weights	Area in Sq km	Area in %
Good	7.27	11.1
Moderate	30.03	45.86
Poor	18.39	28.08
Very Good	6.8	10.38
Very Poor	2.98	4.55
Total	**65.47**	**100**

LAND RESOURCE DEVELOPMENT PLAN

The weights of the different themes were assigned based on their influence on the land and water resources potentiality, different features of each theme were assigned weights according to their relative influence on potential. Based on these evolution of different features of a given theme were preformed and suggested alternative land utilization plan for sustainable development for both land and water resources. The criteria used for integration to generate action plans are given below.

Sustainable land management technologies require reliable and repetitive information on the current status and utilization potential of natural resources. Satellite remote sensing data in conjunction with collateral data proved to be very effective in meeting these requirements. Geographic Information system (GIS) served as a very effective tool in the storage, manipulation, analysis, integration and retrieval of information[6]. The synergistic use of these front line technologies helped to evolve an ‘action plan’ which was quite useful in planning for sustainable management of land resources.

The Development Plan for shown derived from integration of various thematic maps and suggested alteration action plan namely Intensive Agriculture, Agro-horticulture, Fodder and Fuelwood Plantation, No action, Afforestation. The distributions of different agro-based alteration land use suggestion are given in Fig.12, its area statistics and the criteria used for integration to generate action plans are given in table 3 and table 6 respectively.

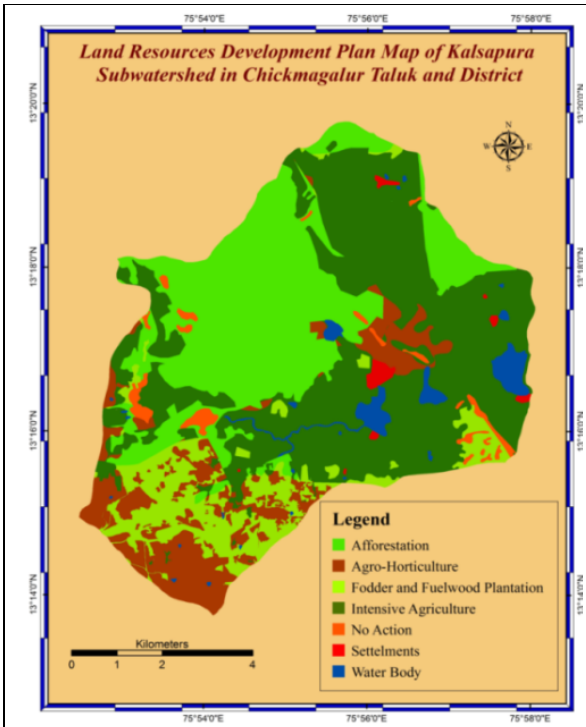

Fig. 12. Land Resources Development plan

Table. 3. Area Statistics of Land Resources Development Plan

Recommendations	Area in Sq km	Area in %
Afforestation	19.77	29.47
Agro-Horticulture	9.54	14.23
Fodder and Fuel wood Plantation	7.01	10.45
Intensive Agriculture	27.19	40.54
No Action	1.26	1.87
Settlements	0.47	0.71
Water Body	1.83	2.73
Total	65.47	100.00

WATER RESOURCE DEVELOPMENT PLAN

For generation of integrated water resource development plan, thematic layers such as hydro-geomorphology, land use /land cover and lineament features were generated from the remote sensing data and integrated with drainage, soil and slope maps under GIS environment. The interpretation of remote sensing data in conjunction with ancillary data and sufficient ground truth information makes it possible to identify and outline various ground features such as geological structures and geomorphic features that serve as direct or indirect indications of groundwater occurrence. Thus, integrated remote sensing and GIS can provide the appropriate platform for convergent analysis of large volume of multi disciplinary data and decision making for development of integrated water resource development plan. Remote sensing data can especially play significant role in generation of parameters from remote areas of watershed and enable us to arrive at natural resource management solutions by adopting a holistic approach. The methodology developed may be applied to similar terrain conditions, with some local considerations and modifications.

The development of water resources in Kalsapura sub watershed derived from integration of various thematic maps and suggested alternate action plans namely vegetative check, rubble check, boulder check and check dam are proposed. The proposed different water harvesting structures are given in Fig.13, the area statistics is given in table 4 and the criteria used for integration to generate action plans are given in table 7.

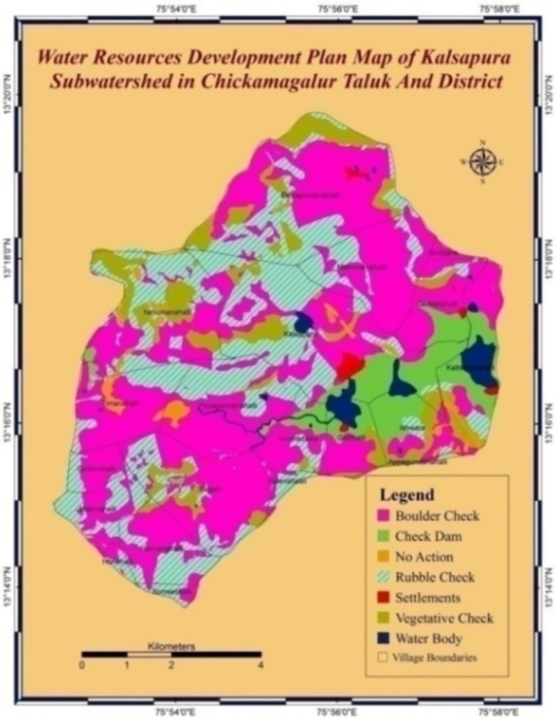

Fig.13.Water Resources Development Plan

Table. 4. Area Statistics of Water Resources Development Plan

Recommendations	**Area in Sq km**	**Area in %**
Boulder Check	31.84	47.46
Check Dam	5.37	8.01
No Action	1.20	1.79
Rubble Check	19.62	29.25
Settlements	0.47	0.70
Vegetative Check	6.83	10.18
Water Body	1.75	2.61
Total	65.47	100.00

Table 5. Criteria adapted for the preparation of ground water prospect map

Geomorphology	LU/LC	Slope	Soil	Recommendations
Moderately Weathered/ Moderately Buried Pediplain/Shallow Weathered/Pediment/ Valley Floor/Water Body Mask.	Kharif Land, Forest Plantation, Plantation, Water body	Very gentle Slope/Gentle Slope/Moderate Slope	Clayey Skeletal, Loamy Skeletal, fine loamy, Water body mask, Habitation mask.	Very good
Moderately Weathered/ Moderately Buried Pediplain/Shallow Weathered/Pediment/ Valley Floor/ Residual Hill	Agriculture Plantation, Scrub Forest/ Coconut Plantation/Scrub land/ Kharif Land	Gentle Slope/ Moderately Slope/ Very gentle Slope/ Nearly Level,	Clayey Skeletal/ Fine Loamy / Loamy Skeletal	Good
Shallow Weathered/ Pediment/ Valley Floor/ Pediment Inselberg Complex/ Moderately Weathered/ Moderately Buried Pediplain/ Denudational Hill/ Residual Hill	Land With/Without Scrub/ Barren Rocky/ Stony Waste/ Agriculture Plantation/ Mining/Quarrying/ Scrub Forest/ Forest Blank/ Kharif Land/ Coconut Plantation	Gentle Slope/ Moderately Slope/ Very gentle Slope	Fine Loamy	Moderate
Shallow Weathered/ Denudational Hill/ Residual Hill	Agriculture Plantation/ Barren Rocky/ Stony Waste/ Scrub Forest/ Forest Blank	Strong Slope/ Moderately Steep Slope	Loamy Skeletal / Clayey Skeletal/Fine Loamy	Poor
Denudational Hill	Scrub Forest/ Forest Blank/Stony waste	Strong Slope/ Moderately Steep Slope/Very Steep Slope	Clayey Skeletal	Very Poor

Table 6. Criteria adapted for the preparation of land resource development plan

Geomorphology	LU/LC	Slope	Soil	Ground Water Potential	Recommendations
Denudational Hill /Moderately Weathered/ Moderately Buried Pediplain/Residual Hill/ Shallow Weathered/Shallow Buried Pediplain/ Pediment Valley Floor	Scrub Forest , Forest Blank	Very Steep Slope/ Moderately Steep Slope/ Strong Slope /Gentle Slope/ Very Gentle Slope	Clayey Skeletal/ Loamy Skeletal/ Fine Loamy	Moderate/Poor	Afforestation
Denudational Hill/ Residual Hill/ Shallow Weathered/Shallow Buried Pediplain/ Pediment Valley Floor	Forest Blank, Kharif Land/ Coconut Plantation	Gentle Slope/ Very Gentle Slope/ Strong Slope /Nearly Level	Clayey Skeletal/ Loamy Skeletal/ Fine/ Fine Loamy	Poor/ Moderate/ Good	Agro-Horticulture
Denudational Hill /Residual Hill/ Moderately Weathered/ Moderately Buried Pediplain/ Pediplain Inselberg Complex	Eucalyptus Plantation /Coconut Plantation/Barren Rocky/Stony Waste/ Scrub Land/ Kharif Land	Strong Slope/ Moderately Steep Slope/ Gentle Slope/ Nearly Level	Clayey Skeletal/ Fine Loamy/ Loamy Skeletal/	Moderate /Poor	Intensive Agriculture
Denudational Hill/ Moderately Weathered/ Moderately Buried Pediplain /Pediment Valley Floor	Barren Rocky/Stony Waste	Strong Slope/ Very Strong Slope/ Moderate Slope/ Gentle Slope	Clayey Skeletal/ Fine Loamy	Poor /Moderate	No Action
Moderately Weathered/ Moderately Buried Pediplain/ Pediplain Inselberg Complex/ Pediment Valley Floor /Residual Hill	Scrub Land /Scrub Forest/ Kharif Land /Mining/Quarrying	Moderate Slope/ Gentle Slope /Very Gentle Slope	Clayey Skeletal/ Fine Loamy/ Loamy Skeletal	Moderate	Fodder And Fuelwood Plantation

Table 7. Criteria adapted for the preparation of water resource development plan

Geomorphology	Lu/Lc	Slope	Soil	Ground Water Potential	Recommendations
Shallow Weathered, Pediment/ Valley Floor/ Denudational Hill/ Moderately Weathered/ Moderately Buried Pediplain/ Residual Hill	Kharif Land/Agriculture Plantation/Land With/Without Scrub/Mining/Quarrying/Scrub Land/ Scrub Forest/ Forest Blank/ Coconut Plantation/	Very gentle slope/ Strong Slope/ Moderately Slope/ Gentle Slope/ Moderately gentle Slope	Clayey Skeletal/Fine Loamy/ Loamy Skeletal /	Moderate	Boulder Check
Shallow Weathered/ Pediment/ Valley Floor/ Moderately Weathered/ Moderately Buried Pediplain/ Residual Hill	Coconut Plantation/ Kharif Land/ Scrub Forest	Very Gentle Slope/ Nearly Level/ Moderately Slope	Clayey Skeletal/ Fine Loamy/ Clayey Skeletal	Good	Check Dam
Shallow Weathered/Pediment/ Valley Floor/ Denudational Hill/ Residual Hill/ Pediment Inselberg Complex	Agriculture Plantation/Scrub Forest/ Scrub Land/ Mining/ Quarrying/ Coconut Plantation/ Kharif Land	Strong Slope/ Moderately Slope/Gentle Slope/	Clayey Skeletal/ Fine/ Loamy Skeletal	Moderate	Rubble Check
Shallow Weathered/ Pediment/ Valley Floor/ Denudational Hill/ Residual Hill	Agriculture Plantation/ Forest Blank/ Scrub Forest/	Strong Slope/ Moderate Slope	Loamy Skeletal / Clayey Skeletal/Fine Loamy	Poor/Moderate	Vegetative Check
Shallow Weathered/Pediment/ Valley Floor/ Denudational Hill/ Residual Hill	Barren Rocky/ Stony Waste	Strong Slope/ Very Steep Slope/Moderately Steep Slope	Clayey Skeletal/Fine Loamy	Moderate/Poor	No Action

CONCLUSIONS

Remote Sensing and GIS tools are less time consuming and cost effective, which provide sufficient support in land and water resource development studies. The overall results demonstrate that remote sensing and GIS provide potentially powerful tools for studying land and water resources.

The land resource development Plan suggested for the study area derived from integration of various thematic maps and suggested alternate action plans are Intensive where the water resource is good, Agro-horticulture where the single cropped area, Fodder and Fuel wood Plantation where the water resource is poor, No action where the existed plantations are there and afforestation where the density of the vegetation is less in forest area. Similarly the water resource development plan for the study area derived from integration of various thematic maps and suggested alternate action plans are vegetative check, rubble check, boulder check and check dam are proposed.

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