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Land Suitability Evaluation for High Land Agriculture in Devikulam Taluk, Idukki District, Kerala

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Abstract: ***Agriculture is now the most important use of land by man. The problem is to use land for what it is fit for according to the capabilities of soil and to raise the soil fertility and moisture and take the maximum output that it is capable of. Man still gets nearly all his food from the soil, less than one percent of what he eats being fish. Apart from the possible development of food producing resources other than land, the potential food supply depends on the amount of land suitable for food production and on the possibilities of increasing yields per unit of such land. Land suitability is the ability of a given type of land to support a defined use. The area selected for the present study is Devikulam taluk in Idukki district, Kerala. Physiographically the study area is diverse in nature. The study area is famous for tea production, Jaggery production, sandal wood and cool climate vegetables and fruits cultivation. Unscientific cultivation followed in certain part of study areas leads to fertile soil erosion, and less production. The eroded soil sometimes deposited in the low land paddy fields. Because of these, cultivation become difficult and less profitable in the study area. Monsoon failure, poor groundwater, eucalyptus cultivation near the crop land, land conversion and land fragmentation put the primary activity in a great stress. So most of the farmers change their activity and the land also converted to other than agriculture purposes. In order to conclude these problem land suitability evaluation is carried out on the basis of available groundwater potential and soil erosion vulnerability. Various terrain parameters have been taken into account and weighted overlay technique is executed in ArcGIS 9.3 platform. Through these analysis the land suitability model for the study area is arrived which shows the specific land use for a long period of time without deterioration.***

Keywords: Agriculture, land suitability, weighted overlay, GIS

1. Introduction

The Earth as a home of man because they influence on the patterns of human activity. The available land resources of any country experiences a lasting effect on the economic life of man or nation. The land area of the world is limited, and the arable land is still more limited. Because of climatic or topographic conditions, only 40 percent of the total area of the world can ever be used for crops, and most of this arable land is already so used. On the other hand, the population is inherently unlimited and is increasing in a tremendous rate. The problems of ever increasing pressure of population on limited land resources looms large. It is estimated that for every ten million increase in population, we have to provide a total of some two million tons of additional food grains, half a tons of fruits and vegetables and about a million tons of additional animal products mostly milk (B.S. Negi). In order to cater the all population the farmers need to be producing more and high quality food. So higher productivity, profitability and health of mankind as well as environment are the concerns of the present agriculture (Prakash, 2003). Therefore much attention should be given on crop selection, which suits an area the best. In these circumstance we need to evaluate land suitability for increasing crop production. Land suitability evaluation means the assessment of present land performance as influenced by physical and socio-economic aspects of the area vis-à-vis soil potential productivity or per unit area yield efficiency under optimal conditions. It serves as a manual in land development projects and deciding the use of scarce land resources. Further, it enables users to maximize use of biophysical environmental resources to new and productive uses, and gives the planners directions for land-use planning. The function of land-use planning is to guide decisions on land utilization so that the biophysical environmental resources are conserved and put to optimal use. The process of land suitability classification is the evaluation and grouping of specific areas of land in terms of their suitability for a defined use (Prakash, 2003). Land suitability assessment is defined as the measurement and rating of the impacts of a land use on the productivity and stability of an area (Rex Victor O.Cruz). The main objective of the land evaluation is the prediction of the inherent capacity of a land unit to support a specific land use for a long period of time without deterioration, in order to minimize the socio-economic and environmental costs (de la Rosa, 2000). The land use stability assessment and land capability classification based on estimated soil loss using the modified universal soil loss equation (William, 1975), with the aid of GIS could be useful in identifying the land use most suitable to a given area. It also could provide a method of examining the status of existing land uses as far as impacts on soil productivity is concerned. Tis method could be used to identify which existing land uses need to be changed or if they cannot be changed. This method would be instrumental in determining the different intensities of land uses that would best complement the capability of an area (Rex Victor O.Cruz). Therefore, it requires the evaluation of land suitability which is only a part of land-use planning.

2. Study Area

The area selected for the present study is Devikulam Taluk of Idukki district in the state of Kerala is located on the

eastern slopes of Western Ghats (Fig.1). The study area stretches between the latitudes of $9^0$56‟56„„N to $10^0$21‟29„„N and longitudes of 77^0 48‟ 31„„E to $77^0$16‟14„„E covers an area of 1140 Km^2 and is inhabited by 177621 persons with a literacy rate of 138527 (Census Report, 2011). June and September which are the months of south-west monsoon recorded at least two third amount of rainfall. Average annual rainfall in the rain fed regions ranges from 3,000 to 8890 mm and in the Marayur region it goes as low as 1270 mm (Satis Chandran Nair, 1994). Physiographically the study area is diverse in nature. The drier tracts of Anchanad valley with its river head in the KDH and the eastern facing shoals drain towards Amaravathi River through Chinnar. The rain shadow region of Marayur is situated on the back side of Anaimudi. This region is covered by riparian forest, scrub forest, paddy fields, deciduous forests. Adimali is a foot hill region of Munnar plateau situated in the south eastern direction. In Adimali before 1980, the main crops under cultivation were rice as well as pepper and cardamom. Now almost 90% of the paddy fields have been modified for other purposes such as residential land, rubber plantations and tapioca cultivation. The study area was drastically changing since 1879. Munro in partnership with two brothers named Turner acquired a concession of land for the purpose of developing Cinchona and other plantations Speer. S.G (1953). In order to cater to the aspiration of the masses, the land use pattern of the study area was totally modified. Due to food shortage and famine (1941-44), the government opened forest lands on an emergency basis for food cultivation. The narrow paddy fields in mannamkandam, Vellathuval, Marayur and other villages which lay scattered in between the hill slopes had acted as the major source of food production. Orginally paddy fields were rich in fertility and the supply of water. When people started cultivation on the steep side slopes, without proper soil conservation measures, the eroded soil got deposited in the paddy fields and cultivation become difficult and less profitable Mani. K, (2011). The annual mean temperature is also gradually increasing due to some climatic phenomena Suresh.S et.al, (2015) but it is mainly because of land cover changes. Frequent flood also occurred in this study area. Frequent removal plantations, heavy rainfall and rapid increase of land use conversion mainly for settlement etc,. provoke this area for soil erosion vulnerability and put the area under severe groundwater scarcity.

The most part of the Devikulam taluk is unsuitable for cultivation because of its undulating terrain covered by thick natural vegetation. The economy of Devikulam taluk mostly based on agriculture. Tea, coffee (Coffea), rubber (Hevea Brasiliensis), arecanut (Areca Catechu) and cardamom (Eliettaria Cardamomum) are the important plantation crops (Fig:2) cultivated here which generates income from overseas. The study area‟s cool climate make a viable condition for vegetable cultivation especially Vattavada village. Cabbage, carrot, beans, potato and Garlic are the important vegetables cultivated here. In addition, this area provides a suitable condition for cultivation of fruits, such as Orange, Apple, Plums, Gooseberry, Mango, Peach, Pear, Passion Fruit, Pomegranate, Tree Tomato, Guava, Citrus, Strawberry, Lemon, Kiwi, Custard Apple, Papaya, Jack Fruit, Litche and Sweet Lime. Moreover based on climatic condition and soil fertility, the Agricultural Department of Devikulam has introduced new high value crops in this zone. They are black berry, kiwi, durriyan, avocado, apricot, locquat, procolli, celery and pressure brinjal. Indiscriminate use of fertilizers and pesticides for crop cultivation are limited in this zone. Hence there is a high demand for fruit and vegetables of this zone in the markets of Tamil Nadu (Madurai and Ottanchathram).

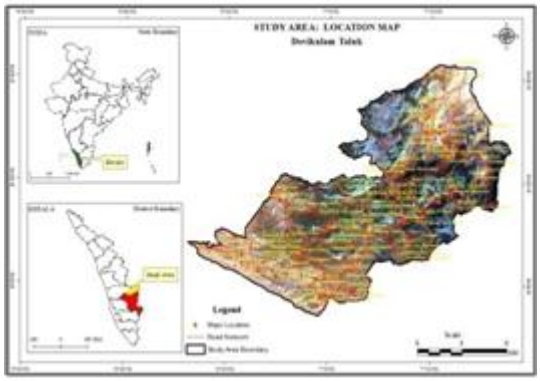

Figure 1: Study Area

Figure 2: Crop Cultivation Pattern in Devikulam Taluk

2.1 Need for Agriculture Suitability Evaluation in the Devikulam High Range

In Devikulam taluk, beginning time the area was selected for coco cultivation. Initially it was planted in Sothupara Estate but after a crop failure the British Company shifted to Tea cultivation. Except KDH village all other villages are highly engaged in food crops and cash crops cultivation. According to Giji K. Raman (2015) large scale felling of trees in the cardamom hill reserve and unscientific cultivation of „land raise‟ varieties have resulted in heavy destruction of cardamom plants in the rain and wind. In northern part of the study area such as Marayur, Keezhanthur, Kanthalloor and Vattavada villages are famous for food crop cultivation but sometimes they meet difficulties in crop cultivation due to lack of groundwater potential and absence of irrigation facilities. Rain shadow regions of Marayur always depending groundwater in crop cultivation. Unexpected droughts, leaching of fertile soil also put agriculture into grave. Likewise in Vattavada and Kanthalloor Villages most of the cultivable land is occupied by monocrop (Eucalyptus plantation) for pulp industry purposes. Because of these water demanding plantation, groundwater is severely affected. So adjacent areas also faced water deficit which resulted in crop failure, poor quality and low production. To improve crop production and maintain soil fertility farmers used red alert chemical fertilizers instead of organic

manures. This has been resulted that agriculture become unbalanced and therefore unstable. This fertilizers again contaminate into groundwater and freshwater source and affect their ecosystem. Land conversion in the slope areas from rubber plantation to other cash crop affect the soil stability and soil humus content. During monsoon season the top soil is leaching out and make this land for unsuitable for cultivation. In the same way, clearing forest for some other purposes also give much pressure on many level. Erratic rainfall, poor groundwater potential, climatic change, poor irrigation facilities, poor storage facility, low price, absence of hybrid varieties, high fluctuation in the prices, soil leaching, Eucalyptus crop deteriorate soil nutrients and affect its productivity, fertility and microbial activity, labor shortage, high labour cost, wild animals attack, pest attacks poor transport facilities, lack of market are the main problem faced by the cultivators. Therefore accounting all those problems a proper land evaluation in the high land agriculture is an urgent need in the study area. Through the conservation of natural resources such as groundwater and soil we have responsibility to enhance or improve the agricultural resources too to cater the need of the study area"s population.

To eradicate these problems we need good solutions. Spatial data based solution is an apt one when compared to other unscientific or conventional method. Crop Suitability Analysis based on spatial data give suitable solution to solve spatial related agricultural problems faced by the study area. In that view, terrain related spatial data such as slope, land use / land cover, geomorphology, geology, soil, lineament density and drainage density were involved and weighted overlay analysis has been used to generate soil erosion layer and groundwater potential layer as we do in the chapter 3. These two layers are again overlaid to generate crop suitability layer.

3. Aims and Objectives

1) To understand the general agricultural characteristics of the study area
2) To propose a suitable agricultural model for the study area

4. Methodology

The present study area boundary was extracted from taluk map of Idukki District. Geology map of the basin was prepared from GSI sheets. The map published by Soil Survey of India was used to find the existing soil units in the basin. Drainage network of the basin was prepared from SOI Toposheets 58 B/16, 58 F/3 and 58 F/4, 58 F/7, 58 F/8 and 58 G/1. SRTM DEM data with 30 m resolution was used to generate slope, relief and lineament of the study area. Geomorphology map of the study region was drawn from SOI Toposheets of 1: 50000 scale and landsat 8 OLI+ data. Land use / land cover map prepared from Google earth web application and landsat 8 OLI data.

To prepare groundwater potential map of the study area multi-influencing techniques were applied (Suresh. S et.al, 2014). Parameters like geology, geomorphology, land use / land cover, soil, drainage and lineament thematic layers were involved. Based on the state of deciding groundwater potential strength weights were assigned to individual theme and for each features within the theme. Overlay technique using Geographic Information System (GIS) have been used to delineate the groundwater potential zones. A factor with a higher weight value indicates a larger impact whereas lesser weight value shows a smaller impact on groundwater. The soil erosion vulnerability map of the study area was prepared by incorporating parameters which are used in groundwater potential zone delineation like slope, geology, geomorphology, lineament, land use land cover, soil and drainage. Based on the state of deciding soil erosion weights were assigned to individual theme and for each features within the theme. In soil erosion vulnerability assessment "rank sum method" techniques adopted by (Surjit Singh Saini et. al, 2013) are followed. Overlay technique using Geographic Information System (GIS) have been used to delineate the Soil erosion vulnerability. The groundwater potential zone map, soil erosion vulnerability map and existing land use model were overlaid to generate a proposed suitable agricultural model for the Devikulam Taluk. The methodology diagram (Fig:3) illustrate the clear outline of agricultural land suitability modeling.

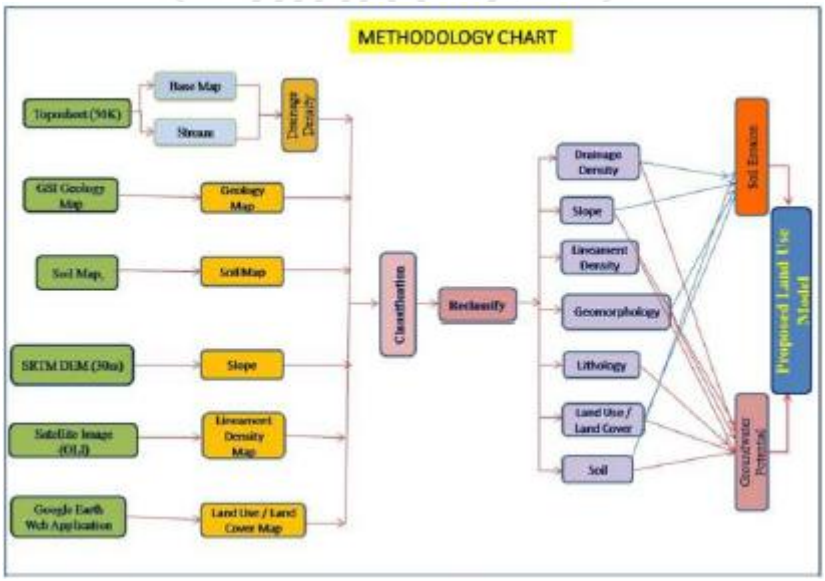

Figure 3: Methodology Chart

5. Results and Discussions

5.1 Tea Cultivation

As mentioned earlier, tea is the major plantation crop which vastly covered in the study area. Kannan Devan Hills Plantation, Mankulam and Pllivasal villages are extensively cultivated Tea. Two varieties of tea plants are found in the study are, China tea and Assam tea. The estates under the study are not found to have been introducing new high yielding varieties and this tendency has adversely affected the productivity. Productivity level is also affected owing to the over aged plants. On an average, the plants in estates under study are more than 80 years of age. It may be noted that the productivity of tea begins to decline after 30 years of age. Replanting is required for rejuvenation productivity, but none of the estates are found to have been properly engaged in replanting. Thus, the estates are operating at sub-optimal level of productivity. Tea plantation industry is labour intensive. Plucking or harvesting tea leaves is the most important work. In majority of the companies hand plucking is the normal method of harvesting. Quality of raw leaves is high when hand plucked, however during harvest season, due to paucity of labour, most of the companies adopt mechanical harvesting. Hand held manual shears and hand held motorized shears are used for plucking of the tea leaves. Normally, the plucking interval for hand plucking is 7 to 10 days and for shearing, 12 to 16 days. Plucking interval varies due to climatic conditions. All the factories are producing mainly Black tea. Other types are Black tea – Orthodox, CTC (crush, tear and curl) tea, Nallatanni tea, Green tea and Top Station special produced by factories (Table:1) .

Table 1: Tea Types in KDH Village

Tea Types	Factories
Orthodox	Devikulam, Chundavurrai, Kadalar, Thenmalay
CTC	Chokkanadu, Guderale, Gundumallay, Kallar, Kanniamallay, Letchmi, vaguvarrai, Madupatty, Periyavurrai,
Organic	Chittavurrai
Green Tea	Yellapatty
Top Station Special	Aruvikad

Source: KDHP Office (2016), Munnar

The factories are established years ago and technological upgradation seldom happened. Due to lack of professional management and failed to introduce product diversification tea industry is faced many problem. Primary marketing of tea is mainly done by auction. Seventy seven percent of the total tea produced in Kerala is coming for auction. Most of the companies are marketing their product through auction. Other marketing methods are direct export or forward contract and Ex-garden sale. Besides this companies are also producing and marketing packet teas.

5.2 Cardamom Cultivation

Cardamom is the second dominant crop covered nearly 23% mainly in Mankulam, Mannamkandam, Pallivasal and Vellathuval villages. This has to be bearing on the district economy too. The prime season for cardamom cultivation is June to December. Because it needs a humid climate and low temperature to thrive. At that time thousands of workers including from Tamil Nadu are engaged in the cardamom production. Sometime severe drought largely affects the newly planted areas where the possibility of irrigation is low. When the trees in the cardamom areas were pruned, the green cover lost resulted in change in atmospheric temperature, which impact negatively the sustainability of cardamom cultivation as the land raise varieties were highly sensitive to atmospheric conditions and pest attack. When the trees were cut, direct sunlight started to fall on the soil, resulting in the growth of pests. To control them, the farmers need to apply large quantities of pesticide affecting the soil condition and the atmospheric temperature.

As per the survey by the Botanical Survey of India, there are 13 species of cardamom in the Western Ghats of which a large number is now confined to the forest areas, as farmers prefer highly productive varieties, through they are highly sensitive to changes in climatic and soil conditions. The highly productive cardamom species need extra care and farmers spray red labeled pesticides and apply chemical fertilizers for high production. This has badly affected natural elements in the soil and the atmospheric temperature in the cardamom cultivation areas, in addition to the high level of pollution to water sources and living organisms over 80 percent of cardamom cultivation in the cardamom cultivation areas has turned to one or two varieties that require less shade and frequent application of pesticides and fertilizers (The Hindu, Oct 18, 2016). For sustainability in cardamom cultivation and protection of the Western Ghats‟ biodiversity, better farming practices required in the cardamom cultivated areas.

5.3 Sugarcane Cultivation

Marayur and Kanthallor villages are famous for sugarcane cultivation and its high quality Jaggery and make good demand in market. The price also little high when compared to normal Jaggery which is imported from Tamil Nadu. Sugarcane here is a 12 month crop and the harvesting is almost throughout the year. The location of Marayur (rain shadow region) and its climate is highly feasible to sugarcane cultivation. A number of small scale industries are engaged in Jaggery preparation mainly along the Marayur and Kanthalloor main road. According to the sugarcane cultivators society, the area under sugarcane cultivation has fallen from 2,500 acres in 2008-2002 to 1,200 acres in 2008. The production of Marayur Jaggery has fallen from 10000 tonne to 3,600 tonnes in the same period (Giji. K. Raman, 2008).

In the present day, sugarcane cultivation has dwindled and sugarcane field now slowly made away for arecanut, coconut and other cultivations. As per data available in Krishibhavan, there was about 60% drop in area under sugarcane cultivation at Marayur and Kanthalloor in the past one decade. From the recent survey it states that at present only 1000 acres of land is under sugarcane. But a decade ago 2500 acres were under sugarcane cultivation (Giji. K. Raman, 2015).

High labour cost, attacks of pests, Jaggery imported from Tamil Nadu and labeled as Marayur Jaggery, low price rate, 4% tax for sugarcane cultivation, wild animals attacks, massive flowering in sugarcane, low groundwater level and climatic change are the big challenges faced in sugarcane cultivation in both villages.

5.4 Vegetable Cultivation

Kottakambur, Kanthalloor, Keezhanthur, Vattavada and some parts of KDH villages are known as the "Vegetable bowl of Kerala". Carrot, potato, cabage and various beans varieties are harvested in these villages. They followed step cultivation method . Very limited fertilizers are applied in vegetable cultivation here. The small sized garlic and traditionally tubers are the famous crops cultivated in Vattavada.

In 2015, vegetable cultivation in Kanthallor and Vattavada had been affected by lack of rainfall. Low groundwater level in the upland areas that had led to vegetable loss in this region. Nearly 1414 farmers engaged in vegetable cultivation and 711 ha was vegetable cultivation in Kanthallor and in Vattavada it is 2927 ha. (Giji. K. Raman, 2015). In season time (June to September) nearly 100 tonnes of vegetables were sent to various markets daily from Vattavada and Kanthallor. Koviloor town in Vattavada act as a main vegetable market.

In the present time considerable changes in the areas cultivated by vegetables in Vattavada. The cultivable area dropped from 3,800 acres to 1,700 acres now. In addition to that as many as 350 farmer families migrated to Tamil Nadu in the recent times (Giji K. Raman, 2013).

In Kanthallor village, most of the area is covered by Eucalyptus plantation which is grown within 5-6 years. It is maily used for firewood and paper industry. But in the same time, Eucalyptus crop deteriorate soil nutrients and affect its productivity, fertility and microbial activity. It also causes for reducing groundwater level significantly. The government department is now proposed a plan that is zonal productivity enhancement by uprooting Eucalyptus plantation in Kanthalloor panchayaths. Rupees 20 lakhs is sanctioned for this plan. Increased the area of cool vegetables and fruits, improved the economic status of the poor farmers, develop a land for temperate fruit belt, produce pesticide free fruits and vegetables and conserve the soil moisture and nutrient content of the soil (Directorate of Agricultural, 2015).

5.5 Fruits Cultivation

Munnar, Vattavada and Kanthalloor villages are considered as fruit belt in the Devikulam Taluk. Strawberry, Mango, peach, plum, Apple, Orange, Passion Fruit, Tree tomato are the notable fruits cultivated here. Munnar climate is conducive environment to the strawberry crop cultivation. Strawberry processing unit is set by Rashtriya Krishi Vikas Yojana (RKVY) scheme and horticorp. The state Horticultural Mission Kerala has started on a project to provide critical support facilities for procurement, marketing and value addition of the high value crop. Since strawberry is a perishable fruit, processing is to be execute within a few hours after harvest. The verdant high range of Munnar are soon be sporting a new colour as about 3,500 farmers train to takeup commercial cultivation of strawberry as high value crop.

5.6 Irrigation

In Devikulam taluk, due to terrain condition the irrigation facility is almost insignificant in crop cultivation. Rainfall and tail of hydro electric project are the main source of water for irrigation. Canal system is the notable irrigation source which supplied water in Marayur village. The innumerable non perennial streams, rivulets and small check dams provided irrigation facility especially in KDH village.

Table 2: Existing Village wise crops and its cultivated area

Village	Crop	Cultivated Area (in Sq.Km)	% of Cultivated Area	% of Cultivated Area to the Total Area of the study region
Anaiviratty	Cardamom	18.47	89.78	1.68
	Mixed Crops	0.51		
Kannan Devan Hills (KDH)	Mixed Crops	29.43	35.07	14.80
	Cardamom	01.07		
	Coffee	0.18		
	Rubber	0.69		
	Tea	148		
Kanthalloor	Mixed Crops	13.50	28.99	1.19
Keezhanthoor	Mixed Crops	2.54	3.75	0.22
Kottakamboor	Mixed Crops	3.06	8.57	0.27
Kunjithanny	Mixed Crops	1.12	7.13	0.12
	Cardamom	0.23		
Mankulam	Mixed Crops	15.14	34.52	2.30
	Cardamom	10.65		
	Rubber	0.16		
Mannamkandam	Rubber	2.11	13.42	2.15
	Cardamom	13.99		
	Mixed Crops	8.15		
Marayoor	Mixed Crops	13.68	12.91	1.21
Pallivasal	Mixed Crops	0.17	36.59	1.30
	Cardamom	9.37		
	Rubber	0.04		
	Tea	5.06		
Vattavada	Mixed Crops	4.41	14.50	0.39
Vellathuval	Cardamom	0.002	4.31	0.12
	Rubber	0.61		
	Mixed Crops	0.74		

Source: Google Earth and SOI Toposheet (1:25,000)

From the table 7.2, almost 25.75% of area in Devikulam taluk is occupied by agricultural activities. Anaiviratty village holds higher percentage of cultivated area (89.8%) followed by Pallivasal (36.59%), KDH (35.07%) and Mankulam (34.52%). In area wise cultivable land, KDH village secure first position (14.80%). The tea cultivation occupies a major area of about 148 sq.km of the total area, and the tea cultivation in KDH, Mankulam and pallivasal region are undertaken by corporate such as TATA tea limited company, Kannan Devan Hills Plantation Limited, Malayalam Plantation Company and Talayar Tea Plantation Company. Rubber plantation was done mostly in Mannamkandam, Anaiviratty and Vellathuval villages. It has covered an area of about 4 sq.km (1.29% of the total

area). The other plantation crops cultivated in this study area is Coffee 0.18 sq.km (0.06%). Food crops are represented in the name of mixed crops such as paddy, sugarcane, tapioca, banana, coco and vegetables are mostly cultivated in Marayur, Kanthalloor, Vattavada, Keezhandur, Kottakambur and some parts of KDH village. Almost 56 sq.km area is used to food crop cultivation in the entire study area. Marayur, Vellathuval, Mannamkandam, Mankulam and Kunjithanni villages highly engaged in paddy cultivation. Nearly 450 hectare in Mannamkandam, 900 hectare in Vellathuval and Kunjithanni villages practiced pepper.

5.7 Proposed Land Use Model

According to the result only 6.22% area is suitable for paddy and sugarcane cultivation which are confined in Marayur, part of Kanthalloor and Mannamkandam village. Almost 18.72 % area is suited for cold climate vegetable and fruit cultivation. The main areas which are identified for vegetable and fruit cultivation is KDH village, Kottakambur, Vattavada and Keezhanthur village. More than 66% area is identified as suitable for plantation and Forest resource. Nearly 8% area in the mountain top and gentle to steep slope region is fitted for grass and scrub land. The existing condition also support to this model (Table: 3). To an extent the proposed model would help the cultivators to take the wise decision in farming and have optimum utilization of the available resources that are present in the study area.

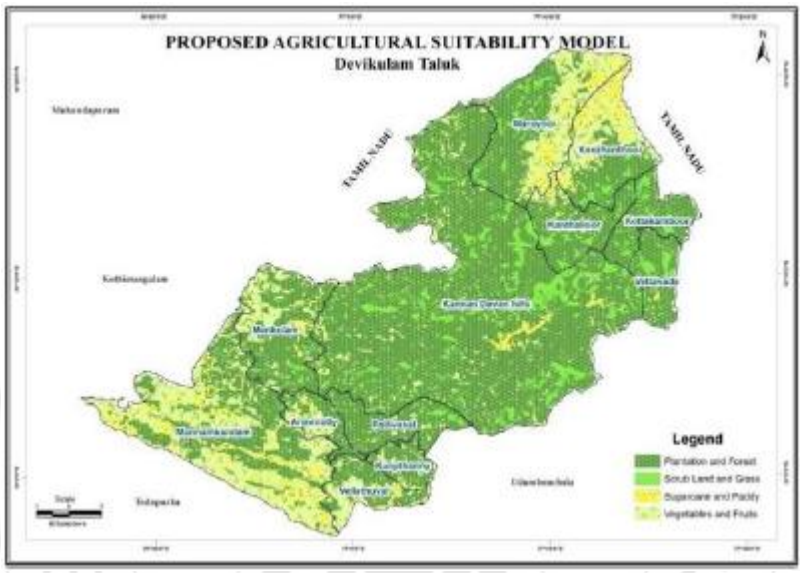

Figure 4: Proposed Land Use Model

Table 3: Proposed Land Use Plan

SI.No	Proposed Land Use	Area in Sq.Km	Area in %
1	Scrub Land And Grass	96.89	8.50
2	Plantation and Forest	758.79	66.56
3	Vegetables and Fruits	213.42	18.72
4	Sugarcane and Paddy	70.90	6.22
Total		1140	100

The present existing land use pattern shows forest and plantation is covered nearly 614 sq.km. The proposed land suitability model illustrate that it is 758.79 sq.km which is exceed 144 sq.km from the present pattern. In fact almost 144 sq.km forest land is already converted to some other land use. In addition to that the model shows 284 sq.km (25%) area is suitable for food crop cultivation. But the existing land use pattern shows it is 56 sq.km (4.7%). So this model will support to identify the food crop suitable locations beyond the present conditions. More over this model is derived from groundwater suitable model and soil erosion vulnerability model. Accounting this credit, we can cultivate groundwater based crops for instance paddy in the respected areas. The areas which are not suitable for agricultural cultivation can be proposed to construction and other tourism development purposes.

5.8 Suggestion

Kerala government (forest department and Horticorp) can be procure Marayur Jaggery for Horticorp, Milma and Sabarimala. The financial assistance also made available to farmers for sugarcane cultivation through the scheme of "Rashtriya Krishi Vikas Yojana". Vegetable and Government can improved the Fruit Promotion Council Keralam (VFPCK) programs, extend the cool vegetable producers society not only in Vattavada and Kanthalloor but the entire study area and installed Horticorp (Kerala State Horticultural Products Development Corporation) in Munnar, Marayur, Kanthalloor, Mankulam, Vattavada, Vellathuval and Adimali. Government can be directly procured vegetables from farmers not only in Vattavada and Kanthalloor but from the entire study area. Govt also give high priority to VFPCK and Kudumbashree units for increasing cultivation and allow them to convert fallow land under cultivation. Govt. should take necessary steps to get fair price for rubber production. Other suggestions are

- As the current landuse practice does not coincide with the inherent capacity of the land, a serious initiative should be taken by the administrators and planners to regain the resilience of the land.

- Eco-friendly methods should be adopted in the vulnerable zones.
- A serious attempt should be taken to diminish land conversion.
- Existing laws concerning wetlands and paddy fields should be implemented strictly.

6. Conclusion

Land is the most fundamental element that determines the agricultural development of a region. Land suitability analysis is a prerequisite for the sustainable agricultural practices. Preparation of land suitability map is highly useful to tackle diminishing agricultural potentiality. The evaluation of physical land qualities of the study area indicates that the area has a rich potential for agricultural production. It can be concluded that overlay method in GIS with appropriate weights to the thematic layers such as groundwater potential, soil erosion vulnerability and existing landuse can bring out agricultural suitability map which shows the most appropriate agricultural potential zones. The accuracy of results obtained from the method described in this paper also is largely a function of the accuracy of the different input or source maps.

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