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Research/Technical Note

Assessment of Tree Planting Trend in Karemo Division in Siaya County: Kenya

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Abstract: Tree planting-trend has been taking in Karemo Division for the last 28 years (1985-2014). This is an average rotation of exotic trees species in the study area like Eucalyptus, cypress, casuarinas and pine that are present in the study area. Survived trees sequester carbon, but the amount of carbon that can be sequestered by these trees is not known. An important question is to what extent of carbon that trees sequesters, can be significantly contributed due to tree planting-trend. An important question is to what extent of carbon that trees sequesters, can be significantly contributed due to tree planting-trend, the type of on-farm management practices applied by farmers and the role of forest of rural forest development institutions on farm forestry in the study area? That's why the study attempted to answer this vital question applied by farmers and the role of forest of rural forest development institutions on farm forestry in the study area? That's why the study attempted to answer this vital question. This study sought to find out if tree planting trend. An objective was: assessing tree planting trend from 1985-2014 in relation to tree cover. Survey research design was employed and sample size of 234 farmers was selected from a target population of 600 farmers from register in county forest office. Tree resource inventory was carried out on sampled farms in Karemo Division to determine the number and status of trees in the farms. Modeling with differential equations, Euler's method shows that 3.7% trees has increased in the last 28 year and Study recommends Participatory Planning for Eco-Commercial Tree Farming (PPECTP) as a concept for afforestation strategies by all stakeholders.

Keywords: Tree Planting, Farm Forestry, Trend, Tree Resource Inventory, Tree Cover and Eco-Commercial Tree Farming

1. Introduction

1.1. Background Information

The most appropriate strategy of increasing tree cover globally is the application of farm forestry intervention. Farm forestry have played vital role in the development of many countries and continue to be a major part of their economy, for example in Central India, studies of tribal communities in a number of provinces have shown that forests may contribute up to 30% of the diet for millions of family farmers (FAO, 2012). Farm forestry also serves as critical reservoirs of food during droughts and floods, often making the difference in poor peoples' ability to withstand significant climate fluctuations and maintain resilience in times of poor harvests provinces have shown that farm forests may contribute up to 30% of the diet for millions of farmers. Farm forests also serve as critical reservoirs of food during droughts and floods, often making the difference in poor peoples' ability to withstand significant climate fluctuations and maintain resilience in times of poor harvests (FAO; 2012).

There are more trees on the farms than in state forests worldwide and the distribution of trees differs significantly between continent to continent and country to country (FAO; 2013). In Western Europe, tree planted on farms hold up to 54% of the total forestlands and 49% in North America. The distribution by size of individual owners in North America skewed towards large commercial forest owners and corporation while in Western Europe, the majority of the tree owners are smallholders. (Cheboiwa, Langat & Siko; 2006) stated that 42% of the private forests in Germany are owned by farmers who hold less than 5 hectares of land while in Japan, smaller individuals and communities own 64% of forestland. Scandinavian countries are reputed to have one of the most developed private forests in the world for example, in Finland 60% of the forestland, are trees planted and owned by small holders under the umbrella of forest owners' association.

In Africa region, forest and wood lands occupy an estimate of 650 hectares of 21.8% of the total land and 78.2% are trees on individual farms (UNEP, 2011) in South Africa. According to UN FAO (2011), Uganda has 15.2% or about 2,988,000 hectares of forest and1.72% or 51,000 hectares are planted forest, FAO (2011) State that Rwanda has 17.6% or about 435,000 hectares of rested land. Primary forest is 1.6% or 700 hectares of the most biodiversity and carbon dense form of forest 85.7% or 373,000 hectares.

The Kenya concept of trees outside forests exists within a broad context of land tenure system comprising all tree resources and land lying outside gazette or protected forests. These include woodlands, pastoral systems, agroforestry, scattered trees, and hedges among others. Kiyapi (2002) state that trees may occur naturally or they may have been planted, and there are no conceptual limits on density or area.

According to UN FAO, Kenya has 6.1% or about 3,467,000 hectares of forested land, of this 18.9% or 654,000 is classified as primary forest the most biodiversity and carbon dense. Planted forest consists of 18.6% or 645,000 hectares. Kenya's forest contains 476 million metric tons of carbon in living biomass.

The Forest Act No 7 of 2005 of the Republic of Kenya provides three types of forests namely: state forests, local authority forests and private forests. State forests are public forests which are protected by the state and they are designated in specific areas such as hilly terrains, catchment areas and other suitable sites. Local authority forests are trust lands vested under County government to manage for the public, whereas farm private forests are those that are owned by individuals, but most of them have limited information on tree resource survey.

They are several issues which have led to low tree cover in Kenya, among them are the ban on Shamba system in 1988, the Structural Adjustment Programmes in late 1980s and early 1990s resulted in many forest employees getting retrenched. This reduced labour force in the forest sector, thus increasing planting backlogs.

Excisions by government on state forests, land grabbing in local authorities' lands and 1999 Government Moratorium on harvesting in public forests, also played significant role in the reduction of forest cover (Kiyapi, 2002). This made the then Forest department to put more effort on forest extension service and trees have increased on the farms, thus carbon capacity sequestration has increased.

Farm forestry Started in Karemo division in 1971, since then, several afforestation programmes under the context of social forestry have been taking place in the County since the creation of rural afforestation and extension service division in the then Forest Department. Similarly, there are several non-community organizations and community based organizations that have funded afforestation programmes in Kenya.

Some of the forest agencies are Danish international agencies, Care-Kenya, World Vision, Japanese international cooperation agencies and Finish international development agencies. Despite all the above mention agencies playing roles in tree planting, state forest is consisting of 0.01% and of over 99% are trees on both individual and community farms. The amount of carbon sequester that can be significantly contributed by these is not known.

Mygatt (2006) reported that nearly 4 billion hectares of forest cover the earth's surface and roughly 30 percent of its total land area, extensively the world's forests have shrunk by some 40 percent since agriculture began 11,000 years ago. Three quarters of this loss occurred in the last two centuries as land was cleared to make way for farms and to meet demand for wood. The shrunk of forest due to agriculture activities is wanting, therefore strategies to increase tree cover such as farm forestry intervention and agroforestry necessary to be incorporated in the agricultural farms.

To some extent tree cover has increased in some countries due to planting of trees outside gazette forests as per the findings of (FAO, 2008). Kenya is a good example where tree cover has increased from less than 2% to 6.1%, because farmers have been engaging in tree planting in their farms, more so in Arid and Semi-Arid Lands (ASAL) areas (FAO, 2012), so determined the tree-trend planting in relation to tree cover.

There is growing recognition by both international and local communities that forests play a significant role in mitigating climate change (FAO, 2008), but forest in developing countries are experiencing severe threats from deforestation and forest degradation, 13 million hectares are reportedly being lost every year contributing about 20% of the global warming. Global warming is caused by high concentration of Greenhouse Gases (carbon, carbon dioxide, Sulphur nitrite, methane) in the atmosphere (FAO, 2000). There is deforestation and forest degradation in Karemo Division which has reduces tree cover, and so there is need to sensitize farmers and other stake holders on tree planting interventions and technologies.

1.2. Statement of the Problem

Tree planting-trend has been taking in Karemo Division for the last 28 years (1985- 2014). This is an average rotation of exotic trees species in the study area like Eucalyptus, cypress, casuarinas and pine that are present in the study area. Survived trees sequester carbon, but the amount of carbon that can be sequestered by these trees is not known.

An important question is to what extent of carbon that trees sequesters, can be significantly contributed due to tree planting-trend, the type of on-farm management practices applied by farmers and the role of forest of rural forest development institutions on farm forestry in the study area? That's why the study attempted to answer this vital question.

1.3. Objective

The objective of study intended to assess tree planting trend in the division from 1985 – 2014 in relation to tree cove.

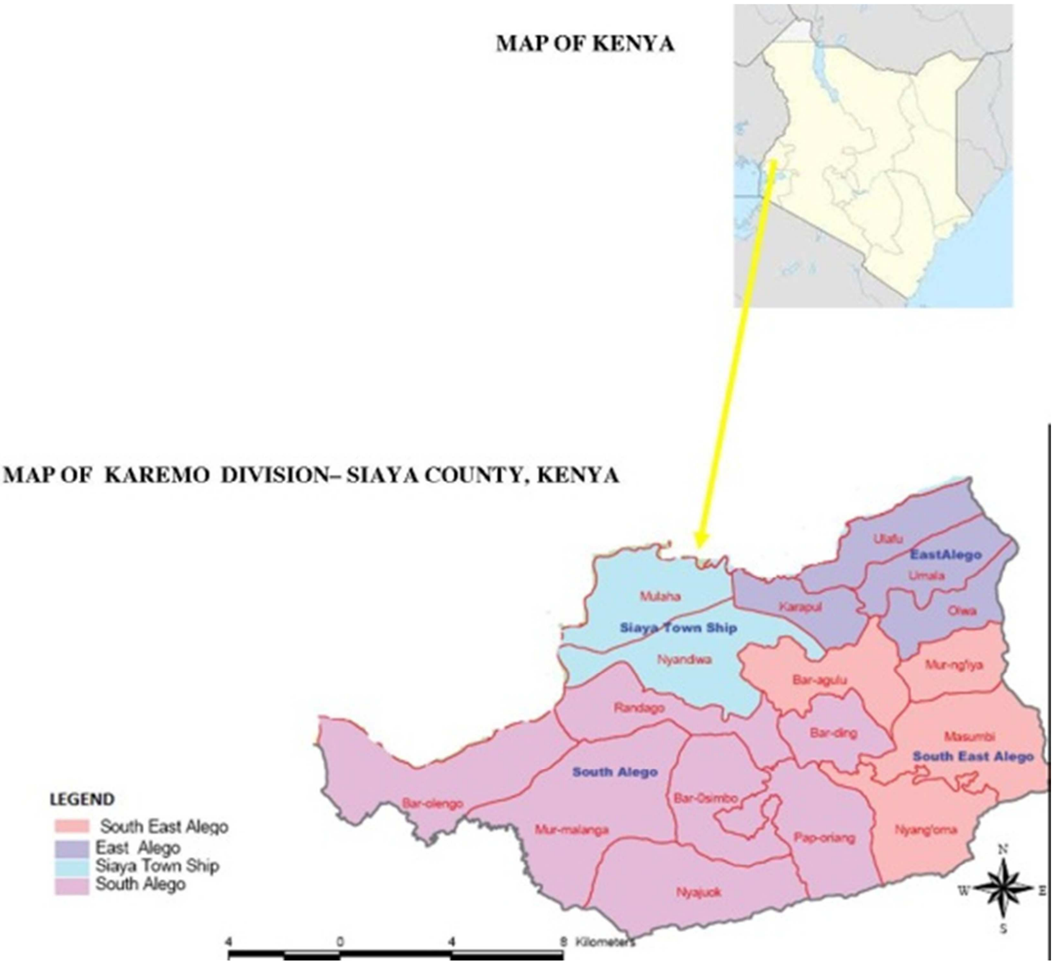

Figure 1. *Map of Karemo Division: the study area.*

2. Methodology

2.1. Study Area

The study was undertaken in Karemo Division of Siaya County in Kenya, it is one of the three Divisions forming Siaya Sub-county; others being Boro and Uranga Divisions. The Division has four locations with a total area of 293.8 km^2 and lies within latitude 0°13North to 0°18 North and longitude 33°58 East to 33° East. It neighbours Gem District to the North East, Uranga division to the North West, Bondo district to the South and Boro to the North. The research area is about 70 km North- West of Kisumu. The area is characterized by undulating land Features include hills, flat lands holding pastures and agricultural fields and valleys having pastures**.** The altitudinal variation ranges from1140 to 1420 meters above the sea level. There are few streams traversing the division and there are isolated hills which most of community use for grazing lands (GOK; 2005)

The geology of the area is composed of the old Nyanza system forming exposed rocks in the Division. These rocks include basalts, *desites* and *rylites*, they are the bearers of course and fine aggregates used in construction industry and important for soil formation minerals which support plant growth. The main soil type is classified as UV2 which is chromic and orthi *cacrisols*. It has the following characteristics: The drainage id well, soil depth ranges from deep to very deep in some areas, soil texture is fine and the fertility is low (Sombroek, Braun and Van derpouw 1982) These type of soils well drained, deep and low fertility, thus influence the tree growth in that they require pioneer and intimidate tree species that can survive in bare and unfertile soil like *Cassuarina species*, *Eucalyptus species*, *Leucaena leucocephala*, *Jacaranda mimosifolia*, *Markhamia lutea*

It has a bimodal pattern of rainfall with long rain falling between March and June and short rain between September and December. While the temperature ranges between 15°C and 21°C and the evaporation rate is 1800-2000 mm per year

Maingi, (2008) refers an Agro-Ecological Zoning as the division of an area of land into smaller unit which have similar characteristics related to land suitability, potential production and environmental impact. The essential elements in defining an agro-ecological zone are the growing period, temperature regime and soil mapping unit. Ecologically the Division spreads over three agroecozones as:

UM_1: Upper midland annual maximum mean temperature 18-21°and minimum mean temperature 11-14°, coffee zone

LM_1: Lower Midland annual mean temperature 21-24° and minimum temperature mean >14° a sugarcane zone. Agro-ecological zones have maximum and minimum temperatures which determine the tree growth and survival of certain tree species, thus influence the tree cover. For instance, UM_1 is an Upper midland coffee zone prefers climax trees like Eucalyptus (Kalandari) species (Grandis and Saligina), *Cupressus lusitanica* (Cypress/ Obudo), *and Grevillea robusta*, *Pinus patula* (pine), *Podocarpus gricilia*. Tree cover is zone is relative high compared to other zones. LM_1 is a Midland sugarcane zone tree such Melicia excels (Olwa), Markhamia lutea (Siala), *Cassuarina equesitifolia* and *Eucalyptus camadulensis*. Tree cover in this zone is moderate. LM_2: is Lower Midland tree are scattered in this zone leading to lower tree cover as compare with the other zones. Preferred trees are Eucalyptus camadulensis, *Calidris robusta*, *Ficus sycomora* (Ngo'owo), *Albizia corarria* (Ober), *Vanguaria rudata*, *Cassuarina equestifolia* and *Teclae simplifolia.*

2.2. Research Design

Exploratory survey research design was used because; The method seeks to generate hypothesis by examining data set and looking potential relationship between variables, it is use to conduct a problem which has not been clearly defined, it allows the use of questionnaires, focused group discussion and carry out field activities such as tree resource inventory and uses secondary data (Kothari, 2004).

2.3. Sample Design

2.3.1. Target Population

Target population was 600 farms obtained list of 600 registered farmers from register in Ecosystem conservator's office at Siaya County

2.3.2. Sample Size

It was determined using a tabulated figure given by (Krejcie & Morgan; 1970) where Population of 600 corresponds to 234 sample size. Appendix (iv) PP 102

2.3.3. Locations and Sub-Locations Sample Size Determination

It was determined using proportional allocation formula given by Kothari (2004) as:

$$i = n.\ pi$$

$$P_i = N_1/N$$

Where: Pi represents the proportion of population included in stratum i, and n represents the total sample size, i = location/sub-location, N1 = sample size, N = population.

2.3.4. Selection of Farms

Simple random was used to select the farm from list of registered farmers and numbers are generated from the calculator.

2.3.5. Selection First Farm

Simple random sampling procedures where farms obtained farmers register, assigned numbers and balloting process was employed.

2.4. Data Collection Method

Before leaving for field and the following apparatus were assembled: GPS, Suunto Clinometers, linear tape measures, Diameter tape, Panga, Maps, booking sheet, Check list, and Surveyor's pens. Maps of each sub-location were plotted in the ecosystem conservator's office in Siaya town thereafter; reconnaissance survey was conducted before carrying out the actual tree resource survey with the aim of taking the general view of the study area, noting where sampled plots would be, tree species and topography of the area.

In the actual field, plot samplings were determined using simple random sampling methods. First sampling point was chosen randomly first, then systematic sampling followed at an interval distant of 50 meters. Circular plot of radius 28 m was established, where the diameters of all the trees within circle and those which were on the border were measured and the dominant heights of 4 trees were measured too. The Diameter at Breast Height (DBH) and height measurements were grouped in classes of an interval of 5 cm diameter and 5 meters' height, and booked on the sheet. Four plots were established in each farm. Questionnaires were filled by the researcher in the same farm.

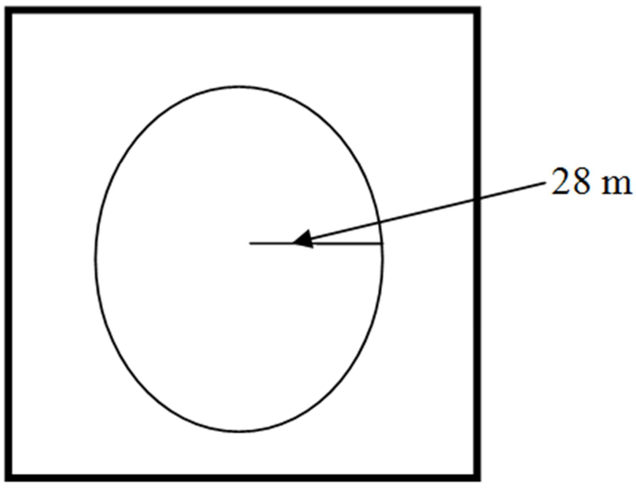

Figure 2. *Circular sample plot.*

The area sampled in each farm was determined as follows: Area of a plot = $(3.14 \times 28^2)\ m^2 = 2500m^2$.

Therefore 4 plots sampled in each were = 4 x 2500 = $10{,}000m^2$ = 1 hectare.

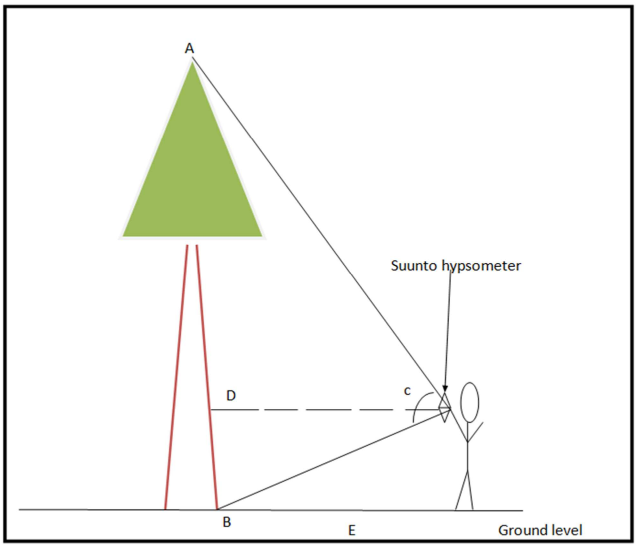

Figure 3. *Illustration of height measurement techniques using Suunto hypsometer.*

A = Top Reading (TR), B = Bottom Reading (BR), C = angle between TR and BR, D = Diameter at Breast Height (DBH), E = distance between the tree and the person taking measurement.

Determination

Tree height = (A +B) +1.3 * the ratio scale * the ground distance, where TRs were positives and BRs were negatives. Tree height = (A – B) + 1.3 x the ratio scale x the ground distance where both TRs and BRs were positives, trees were measured using suunto clinometers with ratio of 1/20 at a distant of 20 meters. Tree height = (A + B) +1.3 * the ratio scale * the ground distance where both TRs and BRs, were negatives.

Table 1. *Data booking sheet.*

Name of farmer/farm:------						
Plot No	Sub-location	DBH class (cm)	Height class (m)	Altitude (m)	Latitude (°)	Longitude (°)

2.5. Data Analysis

The Model was used to explore the objective of the tree planting trend, it is described as a set of variables prescribed for finding future values of those variables and its identify the rates of change that appear within them as derivatives of functions. Differential equations are essential tools in many areas of mathematics and the sciences, it has two ideas and the first was to write down equations for the rates of change that reflected important features.

In mathematical terms, the assumption takes the form of the differential equations.

dTr/dt = kTr (number of trees present/ years present)

Where, Tr = trees planted, t = time, dTr = change in trees, dt = change in time, k = per capita growth rate and its unit is number of trees per year. The reciprocals of the coefficients in the differential equations had natural interpretations (tree increase rate). Specifically, 1/k is the number increased of trees. In general, modeling with Differential equations was used to model the relationship between tree planting trend and average farm size cover trees in 324 sampled farms. The second was that the equations determined the variables as functions of time, so that could make predictions about the real process that was being modeling (Callaha, 2008).

The total number of trees (Tr) at any time t, were assigned Tr (t) and the rate at which the Constant per capita (k) growth population changes is simply proportional to the number of trees present at that time. For instance, if annual tree survival rate is known, which is equivalent to annual increment which proportion to the constant annual increment multiple and finally Euler's method was used to illustrate graphical tree planting trend in the last 28 years.

Differential equations

(Total number of planted trees planted after 28 years – Original planted/ original number of trees at 0 year) x 100

The actual value of planted trees in the last 28 years was determined, where the logged and death were taken care by the natural log in the initial number of trees in the last 28 years as: present ($^{e\ 2.48}$) was calculated as:

Annual survival rate in the study area (k) = 9.24% (KFS annual reports 2012), reciprocals of 1/ k is given as 1/ 9.24 = 0.1082 then multiply by 100 because survival rate is express in percentage equals to 10.82 step. This is equivalent to number of increased trees per year.

Average age of trees TR (t) = 28 years and Time step = 10.82.

Tree increased in the last 28 years is equivalents to 28 * 10.82 = 303 trees.

Let TR= TR (t) be the number of trees at time t, then = kTr (t). Where k is constant proportionality to k> 0, = 303Tr (t) trees at 28 years.

Tr (t) = 303 * 28 = 8484 present trees.

Tr (0) = Tr (t) - ΔTr same as 8484 - 303 = 8181 trees.

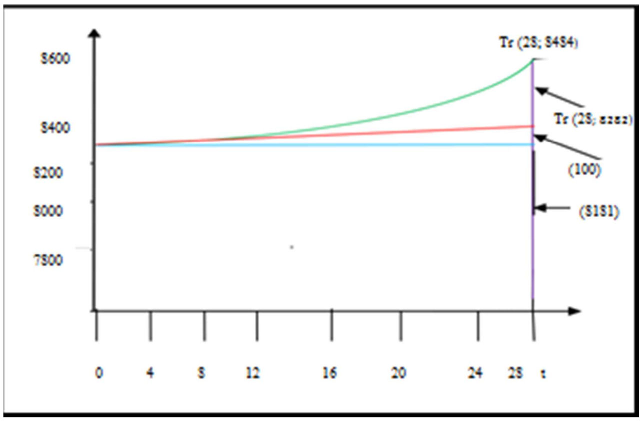

Figure 4. *Ilustrate differential equation results inform of model using the Euler's method.*

The actual point (28 8484) and the point obtained by using Euler's method (28: 8181). Because of the graph, For the graphs is of the actual function is the estimate value 8484 trees, is higher than the actual value trees at t (28, 8181$^{e\ 9.24}$) = 8484.

For death and logged trees, they were taken care by the solution in the above differential equation p is = $8181^{e\ 9.24}$.

To illustrates Euler's method to estimate p^1 = previous value of p (28) + estimate change in p = $p_0 + p^1$ (0) Δt. For the above differential equation by starting with initial value p_0 = p (0) = 8181and using the change in time (Δt) = 28. In this situation, t = 28, t-Δt = 0 and the derivative at that time was p^1 (0) =9.24 was multiply by (previous time step = 10.82) to obtain the estimate changed in p = 99.98 = 100. Consequently, the estimate for p^1 was determined = 8282 trees.

3. Results and Discussion

Increased trees in the last 28 years was found to be equivalents to = 303 trees. The present trees 28 years= 8484. Initial trees {Tr (0)} was determined as 8181 trees. If this rate had persisted for the last 28 years, the number increased trees = 303, which is 3.7%.

Modeling with differential Equations and illustrating by graph using Euler's method, the results showed that the estimate value (28: 8456) is lower than the actual function point (28: 8759) actual function is a curving up. This mean the average trees in the farm size has increased due to tree planting in the last 28 years for death and logged trees, they were taken care by the solution in the above differential equation p is = $8456^{e\ 2.48}$ which gave 8759. If this rate persisted 28 years, the number increased trees were found to be 303 which is 3.6%. However, since the population Tr was getting larger, the differential equation tells us that the growth rate Tr was also getting larger.

Increasing tree-planting means that biomasses are increasing, two major role biomass plays by biomass in climate system: an essential climate variable is due to both its role as a carbon sink during the process of photosynthesis and its role in governing ecosystem productivity and its growing use Sessa; (2009). Carbon sequestration through tree growth provides a low-cost approach for meeting national and international goals to reduce net accumulations of atmospheric carbon as compare to other methods like efficiency and conservation and carbon-free and reduced-carbon energy source

4. Summary and Conclusions

Using differential equations model, and Euler's method, the finding point out that tree planting trend in the last 28 years has increase trees from 8181 to 8484 trees equals 303 trees which 3.7%, the rate is low, and so the increase in carbon sequestration capacity is also low, as a result tree planting techniques should be strategies. Annual tree planting to continue in the farm level, however mapping of trees in the farms and tree resource inventory should be carried not only in the Division, but also in the entire county.

Generally, the concept of Participatory Planning for Eco-Commercial Tree Farming (PPECTF) is recommended in order to enhance efficient and effective afforestation programmes at farm level

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