ASSESSMENT OF SOCIOECONOMIC IMPORTANCE OF ROADSIDE TREE PLANTING IN ARID AND SEMI-ARID AREAS, CASE STUDY AT KATHOME/KAWONGO, KITUI COUNTY, FIELD REPORT

KATHOME-KAWONGO SUBLOCATIONS

By Kadenyi Nancy   I41/0940/2013

South Eastern Kenya University

July 2017

Abstract

This study investigates the organization of roadside tree planting and its derived socio-economic impact. Roadside tree planting is aimed at protecting and maintaining roads and landscapes, vital in road maintenance and management, and for its environment. This is an integral part of Road Water Harvesting activities, aiming to safeguard roads, restore landscapes and increase water availability. Trees have important functions to sustain these 3 goals. This study was aimed at examining the role of roadside tree planting in the case study area of Kathome/Kawongo sub-locations in the arid and semi-arid lands of Kitui County, Kenya. The methods used for this study includes questionnaires, key informant interviews and observation.

By planting trees there is increased road stability thus the money used to renovation of roads can be used in other business sectors. There is increased yields in adjacent farms since much of the water lost through surface run off is able to be spread in the farm by the roots of the trees, trees also add inorganic manure to the farms making the farm fertile.

Furthermore trees and their produce can provide farmers with additional income and improved well-being. Findings of this study show that trees have great socio-economic benefits to the grower in that it increased charcoal business, increased income from selling of seedlings, increased employment opportunities, fruits and timber. And also other socio-economic benefits like shade-cover, beautification, restoring ecosystems, attracting bees and medicinal use indicate the importance of trees. Overall tree planting is key to include in road development, because of improved road longevity, surrounding ecosystems and people's livelihoods.

Key words: Tree planting, road water harvesting, socio-economic impact, Arid and Semi-Arid Land

Acknowledgements

List of Acronyms

AWG   : Africa Wood Grow
ASAL   : Arid and Semi-Arid Land
EMP   : Environmental Management Plan   :
KEFRI   : Kenya Forest Research Institute
KNBS   : Kenya National Bureu of Statistics
KPLC   : Kenya Power Lightening Company
NGO   : Non-Governmental Organization
RWH   : Road Water Harvesting
UFP   : Ultra Fine Particles
UNEP   : United Nations Environmental Programme

Table of contents

List of Figures

List of Tables

CHAPTER 1: Introduction

Climate in general exerts a major role in day-to-day economic development. With one third of the people living in drought-prone areas in Africa, the continent is very vulnerable for the impacts of drought (Boko et al., 2007). Poor communities have restricted choice for their livelihoods and limited capacity to cope with climate variability and natural disasters (COM, 2007). The Annual precipitation is expected to increase, but as temperatures will rise potential evaporation will increase as well and hence net water availability is projected to decrease (Aertset al, 2006). Agricultural production and food security in many African regions are likely to be severely compromised by climate change and climate variability. At the present, there is already a high mortality risk because of water related natural hazards in many African regions including Kitui District (Boko et al, 2007).In Kitui county, there is less water available due to location of the couty.This forces the residence to use water from sand dams or scoping from the soil,the water is not treated .The water may contain water borne disease carriers.

Policy makers and water managers face the task of ensuring water availability and food security, while taking into account the possible impacts of climate change. Local storage of water is increasingly seen as an important adaptation for ensuring water availability and food security to rural and urban populations, especially in developing countries (Kashyap, 2004).This is particular the case in semi-arid and arid regions outside the reach of perennial rivers and where there is no (or little) groundwater available. The need for increased storage capacity (and thereby an increase in water security) is underpinned by the Sustainable Development Goals that specifically address storage needs to adapt to global changes such as sharply growing populations, climate change and catchment degradation(UN, 2000, 2002). It is, therefore, important to evaluate potential adaptation strategies on their efficiency and sustainability of the degraded catchment areas, climate change and the interrelation of the growing population with the resources available.

This research concerns a case study in Kitui Rural, Kenya, (Kathome/Kawongo sub-locations) on the planting of trees along the road as a way to create water catchments for the surface runoff from the road. Large parts of Kenya suffer from water shortage. Rainfall events in Kitui are short lived and the water hardly gets enough time to infiltrate the ground. People in the arid and semi-arid areas encounter frequent droughts to the extent of relying on government forrelief food. In Kitui Rural, rivers dry up fast after a rainfall event this owed to high evapotranspiration due to the hot climate of the region. The area remains largely dry for most part of the year. Given the expected increase in climate variability (Huntingford et al, 2005; Aertset al, 2006; Boko et al, 2007) and the massive potential of rainwater harvesting in Africa (UNEP, 2006), studying techniques of small scale water storage becomes increasingly important.

This case study is part of the Roads for Water program, a consortium that works on creating multi-functional roads in order to safeguard roads, restore landscapes and increase water availability through harvesting. Road side tree planting has an important function in these 3

goals. This study looks into the organization of road side tree planting with communities in Kenya, and to gain insight in the socio-economic impact of trees and grasses as an alternative source of livelihood and income for the local community.

CHAPTER 2: Background to the study

These chapter provides a theoretical and contextual background for Kenya, Kitui county and the study area (Kathome). The current state of knowledge on this topic is discussed and explained in which the relevance for this research was grounded. In addition understanding is gained in the development of roadside tree planting for socioeconomic benefits to the residence of Arid and Semi-Arid areas. This chapter focuses on the research context in geographic and socio-economic aspects. The background of Kenya, Kitui County and Kathome (study area) is described, after which the case-study area is presented including an explanation farming methods and tree planting development in the area.

2.1   Kenya

Kenya is an equatorial country in East Africa which lies between 5°N and 5°S. It has a very diverse relief with a short, low coastal plain on the Indian Ocean shore, extensive inland plateau regions between 1000m and 1500m, and several mountain ranges and peaks such as Mount Kenya, which rises to 5200m and has a permanent snow-cap.

Kenya's climatic is divided into two where some parts of the county are arid such as Isiolo, Wajir, Mandera, Turkana and Samburu and Semi-Arid areas such as Laikipia, Kitui and Machakos.

MAP OF KENYA SHOWING ARID AND SEMI ARID DISTRICTS

RED ARE ARID DISTRICTS
YELLOW ARE SEMI ARID DISTRICTS
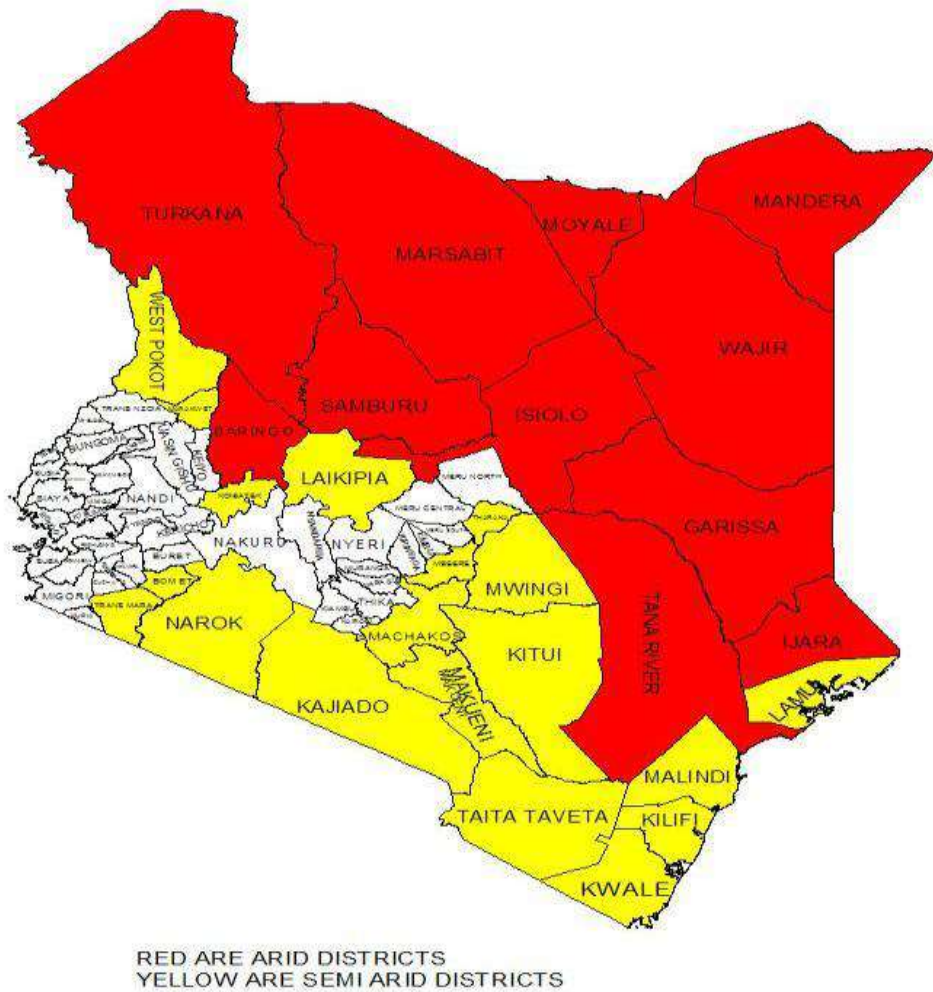
Figure 1 map of Kenya showing the climatic distribution

2.1.1 Climate

Because of the reduction of temperature with altitude, temperatures over much of Kenya are subtropical or temperate. The equatorial situation means that there is a very limited annual variation in temperature. Nairobi, in the southern inland highlands at 1800m altitude, has an annual mean temperature of 18°C, with a peak of 19°C in March and a low of 15°C in July.

The northern part of Kenya is also hot throughout the year, but with lower humidity; Lodwar in the north-west has an annual mean temperature of 29°C.Northern Kenya has an arid climate with very low rainfall. Average annual amounts are generally below 500 mm, and in some places below 200 mm. Lodwar, for example, receive only 190 mm on average, with March to May again the wettest months.Inter-annual variability of rainfall has a major impact in Kenya. Flooding can be caused by heavy rains in the rainy seasons. The failure of rains to arrive leads to periods of severe drought, especially in the arid and semi-arid regions of northern and eastern Kenya.

2.1.2 Agricultural potential

Agricultural production in Kenya is highly diverse but maize is the major staple crop. Other important food crops include beans, plantains, pigeon peas, cow peas, sweet potatoes and cassava.

Table 1 Table showing the agricultural produce in Kenya (FAO 2008)

HARVESTED AREA (ha)		QUANTITY (Metric ton)		VALUE ($1000)	
Maize	1700000	Sugarcane	5110000	Tea	374000
Beans, dry	641000	Maize	2360000	Maize	259000
Pigeon peas	195000	Sweet potatoes	894000	Tomatoes	132000
Tea	157000	Bananas	843000	Plantains	131000
Coffee, green	155000	Plantains	843000	Beans, dry	115000
Cowpeas, dry	148000	Cassava	750000	Vegetables	111000
Wheat	127000	Potatoes	600000	Sugarcane	106000

The top 7 crops by harvested area, quantity and value according to the FAO (2008) in Kenya. Crops that feature in all lists are shaded green; crops that feature in two top 7 lists are shaded yellow. Pigeon peas, beans and cowpeas are most suitable in arid and semi-arid areas.

2.1.3 Agro-climatic zones of Kenya

Table 2 below show the agro-climatic zones of Kenya showing the relevant rainfall amount, excluding areas above 3000m altitude (Biamah, 2005).Kitui county is a semi aridarea and lies under the climatic zone V.Kathome /Kawongo are in part of the Kitui rural sub-county that is believed to be the most driest part with Mwingi sub-county.Annualrainfall of Kitui county is in the range of 450-900mm.

Table 2: Agro-climatic zones of Kenya excluding areas >3000maltitute (Biamah,2005)

Zone	R/E_o* (%)	Classification	R (mm)	E_o (mm)
I	> 80	Humid	1100 - 2700	1200 – 2000
II	65-80	Sub-humid	1000 - 1600	1300 – 2100
III	50-65	Semi-humid	800 – 1400	1450 – 2200
IV	40-50	S.humid -S.arid	600 - 1100	1500 – 2200
V	25-40	Semi-arid	450 - 900	1650 – 2300

| VI | 15-25 | Arid | 300 - 560 | 1900 – 2400 |
| VII | < 15 | Very arid | 150 - 350 | 2100 – 2500 |

Notes: * R – Average rainfall; E₀- Average annual evaporation.

2.2   Kitui County

Kitui Countyis a countyin the former Eastern ProvinceofKenya. The countyhas a population of 1,012,709 (2009 census) and anarea of 24,385.1 km².The County is located in the central south of Kenya (See Figure 1), between latitude 0º 3.7' and 3º 0' South and longitude 37º 45' and 39º 0' East. Kitui County shares its borders with seven counties;Tharaka and Meru to the north, Embu to the northwest,Machakos and Makueni to the west, Tana River to theeast and southeast, and TaitaTaveta to the south(IEBC Kitui Office, 2013)

Figure 2: map showing the position of Kitui County in Kenya and its size

Kitui Sub-Counties

8 sub-counties
1. Mwingi North
2. MwingiCentral
3. Mwingi West
4. Kitui West
5. Kitui Central
6. Kitui Rural
7. Kitui East
8. Kitui South

40 Wards
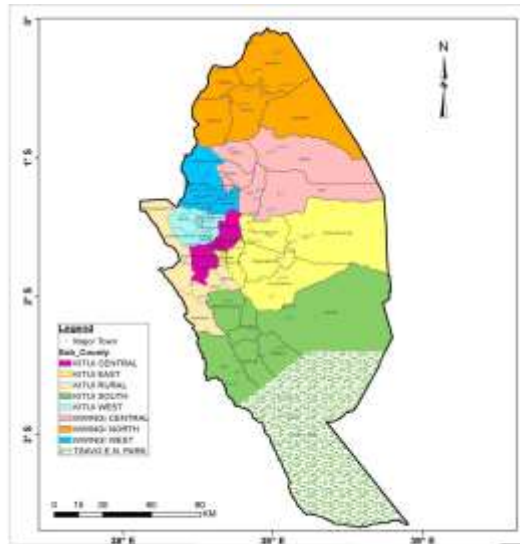
Figure 3: Kitui sub-counties, the case-study area is located in Kitui Rural Sub-County

2.2.1 Climate

The climate for Kitui countyis semi-arid; it receives roughly 71 cm (28 inches). A significant point however is that rainfall occurs practically only during the rainy seasons (Long rains occur around March & April, and short rains occur around October, November and December). Short rains are more reliable in Kitui County as compared to long rains.

Due to the difference in altitude, the climate can be divided into two climatic zones (Louis Berger International Inc., 1983). The Western part of the County has a semi-arid climate. The Eastern and Southern parts of the County have lower average rainfall and higher temperatures (approximately 4°C higher compared to the western parts); and fall within the arid climatic zone. Temperatures in the Kitui County are high throughout the year, ranging from 16°C to 34°C (District Commissioner Kitui, 2002). The warmest periods are between June and September and January and February. These overall high temperatures in combination with the low and erratic rainfall result in high rates of evaporation estimated around 1552 mm/yr (Borsten de Haas, 2006) to 1800 mm/yr (District Commissioner Kitui, 2002).

The rainfall pattern is bimodal. The 'long rains' fall in April-May; the 'short rains' last from October to December, and are more reliable. Annual precipitation ranges from 500 to 1050 mm annually, but is highly erratic and unreliable, both spatially and temporally, as can be seen in **Error! Reference source not found.**.Overall, approximately 90% of the annual precipitation falls during the rain seasons (Hoogmoed, 2007)
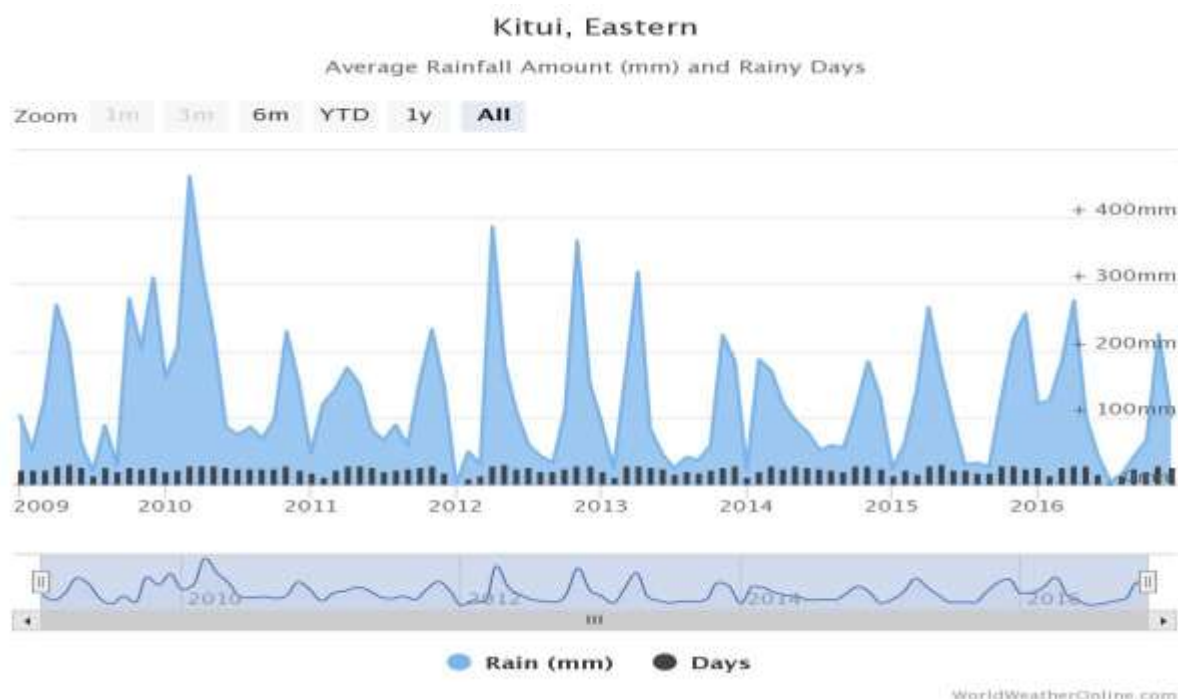
Figure 4 Rainfall distribution from 2009-2016 for Kitui County (Source: https://www.worldweatheronline.com/kitui-weather-averages/eastern/ke.aspx)

Elevation and topographical features of the landscape strongly influence the amount of rainfall at a regional scale: the higher areas and hill masses in the West of Kitui County receive most rainfall (700-1050 mm/yr), these amounts decline to the South and East where the annual rainfall is less than 500 mm (District Commissioner Kitui, 2002). It is not uncommon for rains to fail, causing long periods of drought that often result in crop failure and food shortage. Local lore states that rains completely fail at least one year in four (Thomas, 1999).

2.2.2 Geology and Soil types

Like the whole of Eastern Kenya, metamorphic and igneous rocks (also known as the basement complex system) characterize the geology of the Kitui County. This basement system consists of various types of Precambrian sediments metamorphosed into gneisses, schist, quartzite and marbles. The Inselbergs found in the County comprise of alkaline rocks and other intrusive rocks, which are more resistant to erosion than the surrounding deposits. The Southern side of the county is primarily composed of Permian deposits, while in the Western part tertiary volcanic rocks are dominant, extending into the Machakos County (Borst& De Haas, 2006).

Red soils (Lixisols) are the most common in Kitui County. They derive from metamorphic rocks of the basement complex system. Red sandy loams cover the Eastern and Central parts of the county. The soils in the East are relatively low in natural fertility but rich in sodium, making them highly suitable for grazing. The soils in the Central parts of the District are usually high in fertility, but not intensively used for agricultural production due to the lack of water.Alluvial deposits (Fluvisols) occur in isolated patches along rivers and on hill slopes. These so- called 'black cotton soils' mainlyconsist of clays (silty to silty-clay loam).The soils are found in the Western part of the county. In the South shallow stony soils exist, with rock outcrops alternated with the black cotton soils and light brown sandy-loams(Borst& De Haas,

2006).The drainage of all soils is very poor and most are easy erodible. These results in high run off and erosion: big parts of the soils are highly degraded and eroded, with gullies through the soils to the bedrock. It also results in low infiltration of rainwater on the valley sides and the banks of rivers (Borst& De Haas, 2006).

2.2.3 Hydrology

Erratic rainfall in combination with poor drainage of the soil results in scarce surface water- and groundwater resources. The county has two perennial rivers, Athi and Tana.The latter is the largest river in Kenya, draining most of the Kitui land area. Athi River forms the Western boundary of the district; both rivers discharge to the Indian Ocean (District Commissioner Kitui, 2002).

For the majority of the population in the Kitui County the ephemeral rivers are most important for water supply. The discharge of the rivers is characterized by high flows in April-May and November- December, and extremely low or no discharge in the dry periods. This strong seasonal character, in combination with immediate run-off from the hills caused by the poor drainage of the soil often results in flash floods, transporting large amounts of sand and silt. Most of the ephemeral rivers are generally dried up within a month after the rainy season (Borst& De Haas, 2006).

2.2.4   Vegetation

The vegetation in the County is drought resistant, consisting predominantly of semi-arid deciduous thicket and bush land. In the driest areas (below 900 mm/year) the thorn bushes grade into semi-desert vegetation. The vegetation consists mainly of Acacia's and other thorny bushes (for example Acacia spp., *Terminalia combretum*and*Commiphoraafricana*.) in grassland (Borst& De Haas, 2006). These trees and bushes are also the main vegetation in the study area. Close to the river more types of vegetation occur.

Forestland cover in Kitui County is less than 18.000 ha, serving mainly as water catchment areas. Most of the hills used to be forested, but have been cleared for agricultural purposes and charcoal burning. Only patches, corridors of forest and dry forest in vast grazing lands remain. (District Commissioner Kitui, 2002).

At present, local people are still cutting down trees and shrubs for firewood, charcoal burning and building material. This results in large areas of bare land, which are more vulnerable to erosion

2.2.5   Socio-economics

Farmers in the Kitui County grow both food and cash crops. They secure their subsistence needs and income generation from agricultural activities. It is therefore estimated that in a good season 292,830 acres of land are put under food crops and 6520 acres under cash crop.With 65% of the inhabitants of Kitui County living beneath the poverty line of 2 dollars a day, Kitui County is one of the poorest regions in Kenya (District Commissioner Kitui, 2002).

Agriculture is the main economic source of income for 80% of the population. Most of the agriculture is rain fed, so a majority of the people in Kitui County depends on rainfall for their income. The major food crops are maize, beans, pigeon peas, cowpeas, sorghum, cassava, green grams and millet. Maize and beans are mostly grown in the higher and central parts of the county, with relatively high rainfall. In the lower areas, millet and cowpeas are the major food crops Due to the low availability of water sources; the production of irrigated crops (tomatoes, onions, kale and spinach) is relatively low. This activity is mostly done on small isolated plots along the river. Part of the production is sold on the local markets, while the rest is grown to supplement the diet of maize and beans(De Bruijn&Rhebergen, 2006).

Keeping livestock is the second major economic activity; many people in Kitui can be characterized as agro-pastoralists. The majority of the households in the Kitui County keep cattle, goats and donkeys. Cattle and goats are mainly kept for selling in the dry period, rather than for consumption. Milk production is generally minimal, but it can be consumed or sold at the local market. Donkeys are kept for transport of goods, mainly water.

Another form of agriculture is a tree nursery, in which tree seedlings are grown on an irrigated plot until they are large enough to grow without being irrigated at set times. The trees are sold or used for fuel (firewood or charcoal), construction, windbreaks, shade on the homesteads, and for fruits, which can be sold or consumed to supplement diets. The leaves of the trees can also be used as fodder for livestock.Bee keeping, basket weaving and charcoal burning are other important economic activities practiced in the area (Ministry of Finance and Planning, 2001).

Due to the recurring drought in vast parts of the county, food deficit and food poverty are experienced most of the year. During the dry periods the harvest of the farmers is supplemented by relief food from government and donor agencies (Lasage, 2007).

The farmers have realized an increase in farm output over the past two years due to improved agricultural practices. The table below shows the production per hectare for selected food crops, industrial and horticultural crops.

Table 3Agricultural production trends and value in Kitui County

	Major Crops	Achieved area (Ha) 2012	Achieved area (Ha) 2013	Achieved production (bags) 2012	Achieved production (bags) 2013	Value in KSh(M)(2013)
Food Crops	Maize	87,970	93,600	519,063	427,347	1,154
	Green grams	60,710	91,770	178,118	258,766	1,397
	Cowpeas	52,632	87,060	220,528	478,173	861
	Beans	31,095	32,294	212,337	151,323	613
	Sorghum	62,530	76,135	326,441	282,862	535

Industrial Crops	Cotton	720	834	540 MT	650 MT	26.3
	Sisal	35	36	1050	1080	6.5
Horticultural Crops	Mangoes	1,837	4,425	18,370 MT	41,746 MT	720
	Pawpaw	191.4	257	1,873 MT	1,864 MT	75
	Kales	316.7	173	3,998 MT	3,460 MT	17.3
	Tomatoes	202	117	3,172 MT	2,925 MT	102

Source: Kitui County Agricultural Department,2013

2.2.6 Energy

Only 1% of residents in Kitui County use liquefied petroleum gas (LPG), and 2% use paraffin. 89% use firewood and 8% use charcoal. Firewood is the most common cooking fuel by gender at 87% in male headed households and 91% in female headed households (KNBS and SID,2013)
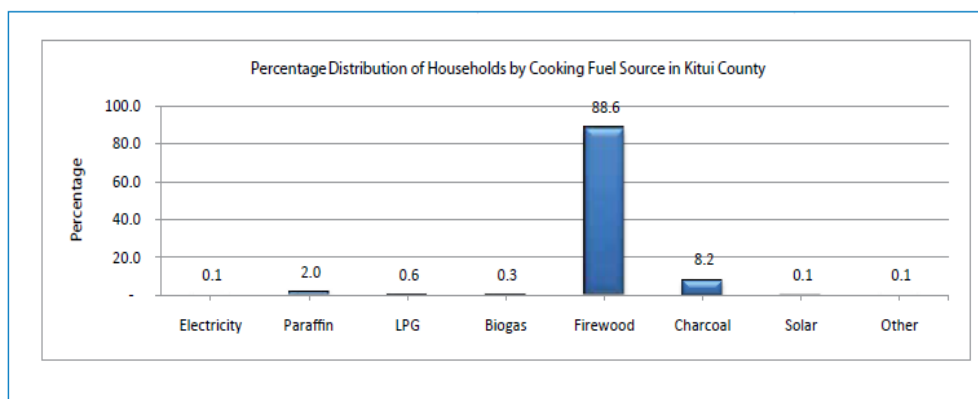
Figure 5 : Percentage Distribution of Households by source of cooking fuel in Kitui County (KNBS and SID, 2013)

Mwingi North constituency has the highest level of firewood use in Kitui County at 95%. This is 20 percentage points above Kitui Central constituency, which has the lowest share at 75%. Mwingi North constituency is about 6 percentage points above the county average. Two wards, Tharaka and Voo/Kyamatu, have the highest level of firewood use in Kitui County at 98% each. This is five times the Township ward, which has the lowest share at 18%. Tharaka and Voo/Kyamatuare are 9 percentage points above the county average.
Kitui Central constituency has the highest level of charcoal use in Kitui County at 17%.This is four times Mwingi

North constituency, which has the lowest share at 4%. Kitui Central constituency is 9 percentage points above the county average. Township ward has the highest level of charcoal use in Kitui County at 54%.This is 53 percentage points more than Tharaka ward, which has the lowest share at 1%. Township ward is 46 percentage points above the county average.

Kitui Central constituency has the highest level of paraffin use in Kitui County at 5%. That is 4 percentage points above Kitui East constituency, which has the lowest share. Kitui Central constituency is 3 percentage points higher than the county average. Township ward has the highest level of paraffin use in Kitui County at 19%.This is 19 percentage points above Tharaka ward, which has the lowest share. Township ward is 17 percentage points above the county average.

2.3 Kathome Location (case-study area)

The area of study was located Kathome/KawongoLocation, Kwavonza/Lower Yatta ward, Kitui Rural Sub-county, and Kitui County in Kenya which is within the larger Eastern Region. Part of the road stretch and the nearby institutions can be seen in Figure 6. The Road stretch from Kathome to Kamanyi is 18km .Kamani is the where the road stretch where tree planting and data collection was ending .

Road stretch

Figure 6 part of the road stretch in Kathome sub-location, case-study area

Figure 7 Map of Kwavonza/Lower Yatta ward

Kathome/Kawongo sub-locations mostly comprise the Kamba community and other tribes who have come to the place as workers in the surrounding institutions and as students. Most of the residents are entrepreneurs mainly small scale businesses with some operating large scale businesses, such as wholesales. Most of the people are low and middle income earners. The area has a few and scattered wealthy people. The larger part of the population comprises Christians.

2.3.1 Climatic conditions

The place is mostly dry and hot with temperatures ranging between 14°C, during the coldest months (July-August) and 34°Cduring the hottest months (January-March). The area receives between 500mm and 1050mm of rainfall annually, with average rainfall of 900mm annually. It has two rain seasons May- June (long rains) and (September- October) short rains. (Kenyainformationguide.com)

2.3.2 Agricultural Activities

Agriculture is the backbone of Kitui County at large. The farmers are involved in substances farming –Mainly growing mangoes, maize, beans, green grams, pigeon peas; crops which are well adapted to the climatic conditions of this area. Crops produced are consumed locally with surplus being sold to traders from neighboring towns.

Donkeys are mainly kept to carry water and other goods. Goats are least expensive, easy to keep and easy to sell. Bulls are the most valuable group of livestock. A bull is expensive but

many people have one because it is the only animal capable of pulling a plough.Donkeys and cows are used to pull carts as well, but the bull is much stronger.Crossbreed cows produce far more milk than the local cows and are therefore much more valuable. Households owning a crossbreed do not take any risks and always feed the cow at home (zero grazing), while local cows are mostly tethered or taken along by a farmer to a watering place (free range grazing).

Both the households have large groups of livestock that move from place to place grazing and going to water points. This poses a big insecurity on young trees since goats tend to feed on the small growing trees, hence a great maintenance must be taken into consideration to enhance the survival of the tree along the roads. Households in dryer areas generally own more livestock because it is easier to keep livestock than to grow crops. Livestock eats weeds while underway to a watering place and so hardly needs feeding.

CHAPTER 3: Research Design and Methodology

3.1   Problem statement

Where the semi-arid lands of Kitui County often face water shortages, roads act as water catchments when it rains. Often now leading to erosion, gully-formation and washing away of fertile soil. Most of the roads in Kitui county especially KwaVonza-Kiusyani road are very bare along the edges, and are prone to erosion and gully-formation, washing away fertile top-soils. Also roads now Communities living along the roads have not engaged themselves in harvesting water from the road, and planting trees to protect and safeguard their roads and environment. And to enable recharge and water storage in their farms. Today, Kenya is facing decrease of tree cover, road side tree planting can contribute greatly to increase tree cover and at the same time provide socio-economic benefits to people living near roads.

There is a lack of knowledge on the organization of road side tree planting activities and its socio-economic impact for farmers. Therefore this research aims to gain more understanding in conservation activities of tree planting along roads in which road side communities can invest to earn a living. At the same time curbing negative impacts of roads, retaining water in the area and improve micro-climate conditions.

3.2   Objectives

The main objective of the study was to provide insight in the socio-economic impact and health benefits (opportunities) through road side tree planting alongKathome-Kawongo road. The sub-objectives include:

a) To find out on ways of increasing knowledge on how we can enhance various techniques of road side tree planting, as part of road water harvesting activities.

b) To investigate the socio-economic benefits of road side tree planting for local communities, for preferred tree species.

c) To provide insight in health benefits, and other related benefits of road side tree planting.

d) To provide an insight in the organization of road side tree planting.

3.3   Research questions

The socio-economic benefits were examined using the following research questions:

Main Question:

What is the socio-economic importance of roadside trees to the local communities, and how is roadside tree planning managed in Kathome/Kawongo location in Kitui County, Kenya?

Sub Questions:

 I.   How is road side tree planting taking place along the road with the roadside communities?
 II.   Which trees are being planted, at what cost and how is labor organized?

III.   In what way do roadside trees impact the socio-economic activities of people?
IV.   What are the challenges and opportunities of roadside tree planting?
V.   How will roadside tree planting be beneficial to the communities along the road?

3.4   Data collection methods
The following methods were used in collection of the data.

3.4.1 Literature review
This involved viewing of past studies on tree planting to identity the tree species, characteristics and their benefits. This also involved viewing the research gaps in the researches that have ever been done so as to enhance better achievement of the objectives.

3.4.2 Participative Observation
This involved visiting various places using a checklist. The checklist comprised of farming methods, types of crops grown, common tree species within Kathome and the road stretch without the knowledge of the residents. The main aim was to observe if the farmers were practicing roadside tree planting and road water harvesting activities. Also throughout the activities on road side tree planting with AWG and the farmers the progress was followed up closely.

3.4.3 Questionnaires
Questionnaires were designed in a simple and clear manner and distributed to the target population. Both closed and open ended questionnaires were used. The main aim was to get more information from the people living adjacent to the road in Kathome sub-location about roadside tree planting and the socio-economic impact to their households.

Questionnaires were conducted at households with trees along the road and those without trees along the road. Systematic sampling method was used to get the number and names of farmers along the road through the assistance of the area chief and sub-chief.Under my guidance and assistance of Mr.Oliver Mulatya Muvea, questionnaires were distributed to the households to obtain their views in roadside tree planting. This was done ina period of one month.

Furthermore, households with trees along the road interview locations (23 in total) were observed and checked on the type of trees, state, size and year of planting. A distinction was made between trees still well surviving and those that were not well adapted or surviving.

3.4.4 Interviews
The interview method is a face-to-face meeting of a questionnaire and a respondent. Key informant interviews were conducted to research institutes like KEFRI,AWG and the Ministry of Roads. In order to obtain data on type of tree species, how tree planting from other organizations is conducted and the road stretch and conditions.

3.5   Data analysis
Data was analyzed by use of Microsoft excel that resulted to various graphics, pie-charts, bar graphs and tables means and ranking. Together with the qualitative data from interviews, observations and in-depth questions, this brought out a clear understanding on the best methods

and tactics to use in road side tree planting as away to collect water from the roads and enhance socio-economic benefits to the community. Households with trees and the households without trees were compared by reading all the information in the questionnaires. Simple descriptive statistics was also used in data analysis after the field notes, interviews and all other information collected,.

Though people can accurately estimate the amount of water they use on a daily basis when it comes down to small quantities, the estimate of large quantities is biased. If 20Lcontainers are used the number becomes easy to count; if a generator is used it is impossible to estimate the amount of water unless the capacity of a generator is known. The amount of water used for irrigation is therefore just indicative and cannot be used for further calculations on the exact water use in Kitui County.

The water-use bias counts for both households with various sources of water and households without different sources but only one source. It was chosen not to treat the households using large quantities of water as outliers, because of several reasons. First of all, there are many of them. Second, it is hard to distinguish the outliers from 'regular' households because of the inequality concerns; one should not ignore the fact that there are households who increased their water use by tremendous amounts.

CHAPTER 4: Road water management concept

4.1   Road water harvesting

Road water harvesting is important in that; It reduces road damage, avoids erosion and flood damage to local communities, turns a negative into a positive (creates local water sources).Planting trees along the road can also enhance road water harvesting, the water can be used in agricultural practices hence leading to increase in agricultural yield harvest that can be sold to the marked and domestic use. Roots of vegetation like grass, Neem, "Mukau" tend to hold water hence increasing the moisture of water in the soil (Mekelle, 2014).

Due to increased demand in transport from one area to another, the county intends to expand roads for easier transport system both for vehicles and motorcycles. During road construction, farms near the road tend to get destroyed whereby trees and vegetation on the path of the road are cut, excess soil heaps are discharged to the neighboring farms during road maintenance and construction. All theseinterfere with farming and other activities within the farm. Also, the Kenya Power and Lightening Company (KPLC) cuts a lot of trees when they are setting up the routes and poles for electricity transmission. This discourages the locals to plant trees along the road.

4.2   Road side vegetation and benefits

Roads are vital in improving agricultural productivity and raising living standards in poor rural areas. Roadside vegetation enhances high water flow tothe neighboring farm andcrops can use the water to grow. Trees and grass provide good water catchment s with the farm.Thus rural roads allow farmers to achieve additional non-farm employment opportunities, leading to a rise in income and reduce rural poverty (Ali and Perria, 2003).

Reduced photosynthesis leads to loss of plant yield and growth, increased pest and disease incidence causing yield losses and reduced quality of horticultural produce, dust contamination reducing fruit production and vegetable attractiveness, dust hindering the pollination of small seeded fruits by insects causing flower abortion and deformed fruit. Planting of trees leads to reduction of these effects, in dry areas like Kathome, *Berchamiadischolar*and*Senna siamea* trees have proved to be growing better in these areas .Neem tree attracts a lot of dust thus enhancing photosynthesis of crops grown beneath them and other plants, the canopy of neem enhances better water distribution in the farm hence increased water availability for plant growth(McCrea, 1984).

Roadside tree planting is an activity that involves planting trees along roads with an aim of protecting and maintaining roads and landscapes. Roadside tree planting is vital in road maintenance and management. It is for this reason that road managers should realize its impact on operational performance in order to realize good roads for transportation and provision of other services. In this section several benefits of road side tree planting are discussed in more detail.

4.2.1 Ecological benefits

Leaves have the ability to trap a large part of dust and particulate matter generated by traffic thus enhancing low dust release to people's homestead and health.

Vegetation can improve water quality by trapping sediments that would otherwise flow to adjacent land/streams. Trees along road also increase road stability by absorbing water and increase soil compaction and stability of the immediate road surroundings. It can thereby also reduce flooding by slowing and absorbing road run-off.Grass acts as a good cover crop on land adjacent to roads, it enables water to infiltrate and filters at the same time (Griffins,P.J et al 2000).

Contribution to soil formation by shedding dead leaves; for example Neem tree, despite it being medicinal, it lives tend to for good manure in the farms hence increasing the organic matter in the soil. Organic matter in the soil increases soil structure hence high water infiltration to the soil. A place with high organic matter content attracts more decomposers and nitrogen fixing bacteria that break down the dead organic matter. Through this process, there is increase in soil pre size hence increase in water flow and infiltration in the soil.

Increase water quality by reducing sediment flow ;Vegetation(both grass and tree),holds the soil particles together reducing the loss of soil sediments into rivers that is caused by soil erosion more so on bare lands.

Reduced erosion by holding soil in place; Some grass species like African Foxtail have a good root system that holds soil particles reducing the rate of soil erosion mostly caused by wind erosion hence planting trees and suitable grass species will enhance soil water holding capacity thus improving the growth of pants and soil structure (Marta A. P,et al., 2016).

4.2.2   Socio-economic benefits of roadside tree planting

Improve people's health by reducing dust; a lot of illness like allergy and asthma are mostly increased by issues of duct. A lot of money is spend on medication. By planting trees along the road, there will be less dust entering houses (mostly affected are roadside communities).If enough trees are planted, the amount of used in treatment can be used in buying food, paying fees and improving farming practices since one can confidently work in the farm freely. The shade enhances and motivates the farmer to keep working hard in the farm.

Increase yields in adjacent farmland; Farmers tend to abandon the farm along due to low or no yield production from the farm, for example during the previous harvest season in kathome, farmers were not able to harvest hence causing a discourage in farming. From the ecological benefits discussed, they enhance yield production since the plants will be able to used the nutrients fixed in the farm by the rotting tree leaves. Water holding capacity of grass and trees enhances water availability to be used by plants for growths, hence the increase in crop yield production (Kubbinga, (2012).

Increased employment; Different personnel and experts can be trained who will later train other farmers on roadside tree planting, for example, during my field study, one of the farmers was chosen to assist in measurement of tree distance from the other and distance from the road, he also assisted in helping the farmers on various guidance during planting and fencing. This can also enhance self-employment where farmers can produce various seedlings and sell to the market and other farmers, timber production will lead to lumbering industries (Kubbinga,B, 2012).

Increasing road stability: vegetation helps to lower local water table that may affect the road formation and pavement hence reduction in road maintenance and management (Bahir Dar (July 2008).

Provide shade and keep the road cool for road users; this enhances faster and comfortable movement by road users without being affected highly by the sun burns or strong heat from the sun related effects. This makes tree planting along the road much relevance, for example during by study and moving from farmer to farmer I really experienced tough movements on the road due to scourging sun. (Marta A. P, et al., 2016).

Provides direct benefits such as timber, fuel and fruits; timber can be used in construction, fuel like charcoal and fire food used in cooking and fruits that are importance in diet. All this direct benefits can be sold to market hence earning income to buy other household good (Selma N.E et l., 2005).

Infrastructure investments related to rural road development facilities access to markets for inputs such as fertilizers and improved seeds and enable farmers to sell their produce to nearby markets through a reduction in transport fare and time (Raballad et al, 2010)

4.2.3   A summary of benefits:
-   Reduce dust particles hence improving people's health
-   Provide shade and keep the road cool for road users (vehicle and people)
-   Lowers road maintenance coast; Trees helps to lower local water tables that may affect the road formation and pavement
-   Increases yields from farms; Leaves from the trees make good manure in farm that enhances crop growth.
-   The trees will provide timber, fuel food (fruits) and medicine that can be used by the roadside communities in several ways.
-   It enhances good landscape of the road.

CHAPTER 5: Characteristics of common trees and grass species in Kitui

In this chapter a number of tree species is discussed more elaborate, being trees that occur often in the area. Furthermore, the characteristics and uses of eight tree species are summarized in table 4 in this chapter.

5.1 Trees

Five tree species were selected for this project. The criteria was based on medicinal, nutritional economic, ecological, adaptability and cultural values of the trees. The purpose of the project was also considered. The trees were chosen because they are: evergreen so they will trap dust throughout the year and especially during the dry season when dust is a nuisance to farms and households located near the road. Some trees provide edible fruits to the communities living along the road and passersby such school children. Shade is also very key to the passerby who walk long distances on their way back home in the desiccating sun.

All tree species selected have environmental benefits. They will ameliorate the climate of the area especially along the roads. Some tree species have medicinal value. They will be utilized by the local communities to treat some diseases for themselves and livestock. Firewood is also obtained from the branches of the trees at home and schools or churches that benefit from the project. The tree species are adapted to arid and semi-arid environments.

They are resistant to termites and nematodes and therefore no chemicals were applied during the planting. This saved insect and other microorganism biodiversity.
No chemicals will be required so spray on the trees upon establishment. Almost all the species are resistant to droughts and have high levels of survivability and establishments.

5.1.1 Berchemia discolor

The species is distributed across Angola, Botswana, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Namibia, Somalia, South Africa, Swaziland, Tanzania, Uganda, Yemen, Republic of Zambia and Zimbabwe. B. discolor grows naturally in various climates, from semi-arid areas to areas receiving rainfall in 4 years out of 5. It is found scattered in semi-desert grassland, open woodland or at lower altitudes along river valleys, especially on termite mounds. It is common in riverine forests, Acacia-Commiphora-Balanites woodland and

wooded grassland, Acacia woodland and bush land, and the miombo woodlands of Tanzania. It tolerates drought but is not resistant to frost or cold wind.

Humans find the sweet, date-like taste of the fruit quite pleasant. The fruits are eaten fresh and the pulp can be used for a drink. Both are quite nutritious as the fruit is very high in ascorbic acid and sugar. The fruit and leaves can be used as fodder and bees are attracted to the small yellow-green flowers found in loose clusters on the tree. The roots have various medicinal uses.

The yellow-brown wood is one of the hardest in East and Central Africa. The sapwood is pale brown; heartwood hard, heavy (air-dry 992 kg/m³) and fine grained, yellow-brown with a reddish tinge. The wood is excellent for making furniture such as tables, chairs and benches and is also used in making poles, pestles, hair combs, ladders and is used in general construction. The spreading branches and heavy, rounded crown make B. discolor an effective shade tree; it can also act as a windbreak. The tree improves the soil through leaf fall.

5.1.2   Azadirachta*indica* (Neem)

Neem is a fast-growing tree that can reach a height of 15–20 metres (49–66 ft), and rarely 35–40 metres (115–131 ft). It is evergreen, but in severe drought it may shed most or nearly all of its leafs.

Fruits are eaten fresh or cooked, or prepared as a dessert or lemonade-type drink. The young twigs and flowers are occasionally consumed as vegetables. The leaves, though very bitter, are used as a dry season fodder. A. indica fruit is an important source of food for some wildlife, especially birds and bats, although they digest only the pulp, not the seed.

Charcoal made from *A. indica* wood is of excellent quality and the wood has long been used as firewood. Its oil is burned in lamps throughout India. *A. indica* is a species of the mahogany family, and although it has some of the characteristics of a cabinetry wood, its grain is rough and does not polish well. The wood is, nevertheless, used to make wardrobes, bookcases and closets, as well as packing cases because its insect repellent quality helps to protect the contents

from insect damage. The main stem of the tree is also widely used to make posts for construction or fencing because the wood is termite resistant. The density of the wood is 720-930 kg/cubic m at 12% mc.

Being drought resistant with a well-developed root system capable of extracting nutrient from the lower soil levels, it is a suitable tree for dune-fixation. The large crown of A. indica makes it an effective shade tree, planted widely as an avenue tree in towns and villages and along roads in many tropical countries. Because of its low branching, it is a valuable asset for use as a windbreak. Farmers in India use Neem cake (the residue left after extracting oil from the seeds) as an organic manure and soil amendment. It is believed to enhance the efficiency of nitrogen fertilizers by reducing the rate of nitrification and inhibiting soil pests including nematodes, fungi, and insects. *A. indica* leaves and small twigs are used as mulch and green manure. The neem trees are of great importance for its anti-desertification properties and possibly as a good carbon dioxide sink.

Products made from neem trees are used for their medicinal properties against fungi, bacteria and virus. Neem oil is also used for healthy hair, to improve liver function, detoxify the blood, and balance blood sugar levels. Neem leaves have also been used to treat skin diseases. Neem is a key ingredient in non-pesticidal management (NPM), providing a natural alternative to synthetic pesticides. Neem seeds are ground into a powder that is soaked overnight in water and sprayed onto the crop. To be effective, it must be applied repeatedly, at least every ten days (OrwaC,et al., 2009).

5.1.3   Tamarindusindica (Tamarind)

The tamarind tree produces edible, pod-like fruit which is used extensively in cuisines around the world. Other uses include traditional medicine and metal polish. The wood can be used in carpentry. Because of the tamarind's many uses, cultivation has spread around the world in tropical and subtropical zones.

The foliage has a high forage value, though rarely lopped for this purpose because it affects fruit yields. In the southern states of India cooked seeds of Tamarind tree are fed to draught animals regularly. Flowers are reportedly a good source for honey production. The second grade honey is dark-colored.

Provides good firewood with calorific value of 4 850 kcal/kg, it also produces an excellent charcoal. Sapwood is light yellow, heartwood is dark purplish brown; very hard, durable and strong (specific gravity 0.8- 0.9g/cubic m), and takes a fine polish. It is used for general carpentry, sugar mills, wheels, hubs, wooden utensils, agricultural tools, mortars, boat planks, toys, panels and furniture. In North America, tamarind wood has been traded under the name of 'madeira mahogany'.

The extended crown of the tamarind offers shade so that it is used as a 'rest and consultation tree' in villages. Because of its resistance to storms it can also be used as a windbreak. It should be considered, however, that *T. indica*is not very compatible with other plants because of its dense shade, broad spreading crown and allelopathic effects. It is thus more commonly used for firebreaks, as no grass will grow under the trees. The evergreen habit and the beautiful flowers make it suitable for ornamental planting in parks, along roads and riverbanks.

5.1.4   Senna siamea

It is a medium-size, evergreen tree growing up to 18 m with beautiful yellow flowers. It is often used as shade tree in cocoa, coffee and tea plantations. *S. siamea* is widely grown for fodder, but the trees can be browsed.

The dense, dark-colored wood of *S. siamea* makes good fuel, although it produces some smoke when burning. The energy value of the wood is 22 400 kJ/kg, and the density is 600-800 kg/m³. The wood was formerly preferred for locomotive engines. Its charcoal is also of excellent quality. *S. siamea* yields a medium-weight to heavy hardwood with a density of 6001010 kg/m³ at 15% mc. Heartwood is black-brown with paler streaks, sharply demarcated from the 6-cm wide, pale sapwood; grain is interlocked and occasionally straight; texture is slightly coarse but even. The wood is hard to very hard, resistant to termites, strong, durable, and difficult to work, with a tendency to pick up in planning and it takes a high polish.

When used as a hedgerow, it effectively increases topsoil infiltration, reducing runoff and combating soil erosion. S. siamea is grown as a shade tree along roads and in cocoa, coffee and tea plantations. It is also planted as a dense windbreak and shelterbelt. It is used extensively for rehabilitation of degraded land, for example, to re-vegetate aluminum mine tailings. Leaves are used as green manure, and a well-grown tree can yield 500 kg/year of fresh leaves.*S. siamea* forms ecto-mycorrhizae and provides very useful mulch, especially in alley-cropping systems. It is pruned into hedgerows and used as a live fence around food crops. And although not a

nitrogen-fixing tree, *S. siamea* has been increasingly used in alley cropping systems, largely because of its coppicing ability and high biomass production.

Table 4: Tree species characteristics and their uses (OrwaC,et al., 2009;Maundu, et al.,2005).

	Local Name (kamba name	Scientific name	Common name	Ecology/Soil type	Characteristics	Management system	End Use	Remarks
1	Mwaa		Acacia	Sandy to sandy-clay soils to riverine clay/sandy soils	Drought resistant,	Mixed, woodlot, riverine plantings	ewood , charcoal and food to the goats, gum arabic production, poles	The tree is limited to desert areas. Its pods are popular feed for livestock - are even collected and saved for dry season and even sold in northern Kenya. Should not be planted near homes due to its thorns and the likelihood of attracting caterpillars that feed on it.
2	Kithumula	*Tamarindusindica*	Tamarind	It is indigenous to tropical Africa; Found in Ecozones III-V Grows in most soils, but prefers well-drained deep alluvial soil; often	A very adaptable species, drought hardy, preferring semi arid areas and wooded grasslands, tolerating salty, coastal winds, even monsoon climate26 Drought resistant,	Mixed/ agroforestry systems amenity Good mother trees are chosen for vegetative propagation. Seedlings, wildings, direct	Firewood, charcoal, timber, furniture, poles, posts, utensils (pestles and mortars, carts), boat building, food (edible fruit pulp, pulp also used for	The fruit has many uses and is important for nutrition in many parts of the world

			riverine in very dry areas	Edible fruits	sowing at site, grafting and budding for best varieties. They are slow growing but long lived; pollarding, coppicing and, pruning may be used.	souring porridge, drink, fried seeds, seasoning, flavouring), medicine (leaves, twigs, bark), fodder, apiculture, shade/shelter, boundary/barrier/su pport	
3	Mukau	*Melia volkensii*	Melia	A valuable tree in the ASALs .In Kenya is found in Kitui, Mwingi, Machakos, Embu, Taita, Samburu, Isiolo, Makueni, Voi, Tsavo National Park and Moyale in dry bushland or woodland and drier wooded grasslands. Ecozones V-VI. Does well in sandy to sandy-clay soils to riverine clay/ sandy soils	Deciduous, Drought resistant, Grows fast, Hardwood	Mixed/ agroforestry systems, It may be propagated by seedlings, root cuttings or root suckers, wildings. The tree grows faster if propagated using root suckers. Young trees needs to be protected from goats and coppicing can also be done	Firewood, timber (construction, door frames), medicine (bark), fodder (fruit), bee forage, shade, mulch, soil conservation.	Wood hard, brown, and makes good timber, resistant to attack by borers. It is a highly prized tree in the dry areas where it is intercropped with food crops with no adverse effects and occasionally improved yields.

4	Kimuu	*Vitexpayos*			drought resistant, found near rock outcrops ,high water table		Fruits, fodder, fuel, timber, medicinal
5	Mwarobaini	*Azadirachtainidca*	Neem	Sandy to sandy-clay soils to riverine clay/ sandy soils	Fast growing (short time to mature) Evergreen, Resistant to Pests, Medicinal, Drought resistant.	Mixed/ enrichment planting system	Traditional Medicine, fodder, fuel, timber, erosion control, shade/shelter, soil improver, pest and disease control, toiletries, land restoration, cosmetics, bird repellant, lubricant and fertilizers,poles
6	Kisaaya	*Berchemi adischolor*			Grows naturally , found scattered in semi-desert grassland, open woodland or at lower altitudes , common in riverine forests, Acacia-Commiphora-Balanites woodland and wooded grassland, Acacia		Fruit ,fodder, apiculture, timber, shade, ornamental, soil improver

#	Local name	Botanical name	Common name					
					woodland and bush land, tolerates drought but is not resistant to frost or cold wind.			
7	Ikengeka	*Senna siamea*	Senna		Medium-size, evergreen tree (drought resistant) ornamental, fast growing.		Fodder, fuel, timber, erosion control, shade,	
8	Muvaliti	*Grevillea robusta*	Grevillea	The *Grevillea robusta* originated from Australian and is widely used in Africa, 0 - 3000 m. It does well on neutral to acidic loam or light sandy soils but is not tolerant to waterlogging or heavy clays. .Found in Ecozones II – V	The *Grevillea .spp* may be found in; Plantation, Hedge planting, Agroforestry (coexisting with food-crops), Woodlot and, Shelterbelt system	The *Grevillea .spp* may be propagated by use of wildings or seedlings. Pollarding, lopping, coppicing and pruning optimizes their benefits if used in their management. **Note;**Only young trees coppice well Maturity takes 6 yrs for poles and 30 yrs for timber	Firewood, charcoal, timber, furniture, poles, veneer, fodder (leaves low quality), bee forage, shade, ornamental, mulch, soil conservation and, windbreak	Some communities believe the species attracts lightning in homesteads. However, it is an extremely important tree in the Kenyan highlands and has become an integral part of the farming system in many areas.

5.2   Grasses

Table 5 Suitable grass species and their significance (Mganga, et al.,2011)

Scientific name	Common name	use
Cenchrusciliaris	African foxtail grass	It is mostly used as cut and carry fodder, but also well suited to grazing. This provides very good hay since it retains nutritive value. For silage, the grass should be harvested at flowering or seeding stage
Enteropogonmacrostachyus	Bush rye grass	It is palatable, thus its re-introduction in degenerated swards is of obvious value to grazers. It has proved an excellent grass for reseeding the rangelands in Kenya (5-7 kg/ha seeding rate), especially rock slopes or bushland.
Themedatriandra	Red oat grass / Kangaroo grass – T. australis)	It is a very important and well known grazing grass that is highly palatable when young Very useful for soil erosion control, since it is aggressive due to its spreading growth and has good soil binding capacity.

*Cenchrusciliaris (*African foxtail grass)

Enteropogonmacrostachyus
(Bush rye grass)

Themedatriandra(Red oat grass / Kangaroo grass)

CHAPTER 6: Project implementation of road side tree planting inKathome, Kitui

6.1 Partners and Stakeholders

6.1.1 MetaMeta – Roads for Water

This is a research organization based in the Netherlands, working on practical solutions in water management and lead partner of the Roads for Water consortium. Roads for Water is a team of partners who work on the promotion, monitoring and co-ordination ofimplementation of road water harvesting techniques in a systemicway. The main aim of the program is to increase developing countries' adaptive capacities by including climate change and adaptation considerations in water management at the local scale.The Kitui County government and Africa Wood Grow (AWG) in Kenya are selected as one of the pilot areas for the project.

6.1.2 Africa Wood Grow

AWG's mission is to champion dry land innovations in order to enhance sustainable livelihoods among the Arid and Semi-Arid Lands communities. AWG's work in agro-forestry and sustainable development seeks to find synergies where environment, and socio-economic activities can be mutually beneficial, and to help the local communities to exploit these opportunities for sustainable development. Africa Wood Grow works closely with the local communities in ASAL regions to establish ways in which the communities can ensure food security and economic growth without adversely affecting the environment. The major role is to establish agro-forestry models that can be replicated to communities and other arid environments, research on which agro-forestry components is done to ensure synergy and complementarities in AWG's operations. Development of water harvesting structures on the farms has been important since rainfall events in these regions areerratic and a combination of the best technologies would yield the best results.

6.1.3 The Community

This comprised of the major beneficiaries from the project. It comprised of interested roadside communities along the selected road stretch. The community took part in attending the trainings, hole preparation, seedling collection, planting and maintenance of the planted trees. Each farmer took the responsibility of taking his/her own trees.

6.2 Roadside tree planting activities

A majority of the population of Kitui Rural and the county at large depend on ephemeral rivers for water supply. In the dry periods the water level is very low and water can only be found in scoop holes (holes dug in the riverbed). During prolonged dry periods there is no water left in the river at all in some catchments (like Kathome), forcing people to walk long distances to larger rivers that still contain sub-surface water, making harvest fail and causing famine. Roadside tree planting is one way to deal with these problems.

Roadside tree planting is vital in road maintenance and management. It is for this reason that road managers should realize its impact on operational performance in order to realize good roads for transportation and provision of other services.

6.2.1 Species selection

Five tree species and three species of grass were identified. The criteria were based on medicinal, nutritional economic, ecological, adaptability and cultural values of the trees. The purpose of the project was also considered. The trees are evergreen so they will trap dust throughout the year and especially during the dry season when dust is a nuisance to farms and households located near the road.

Some trees provide edible fruits to the communities living along the road and passersby especially school children. Shade is also very key to lower primary school children who walk long distances on their way back home in the desiccating sun. Most families are poor and thus many children walk barefoot in the sun back home from schools since they attend school half day (from 7.00AM-1.00 PM). At school, during lunch time when the sun is hot, students take shade under trees. Trees will provide shade and fruits during lunch time.

Some tree species have medicinal value. They will be utilized by the local communities to treat some diseases for themselves and livestock. Firewood can also be obtained from the branches of trees at home, schools or churches. The tree species are adapted to arid and semi-arid environments. They are resistant to termites and nematodes and therefore no chemicals will be applied during the planting. These will safe insect and other microorganism biodiversity. No chemicals will be required so spray on the trees upon establishment. Almost all the species are resistant to droughts and have high levels of survivability and establishments.

Table 6 list of tree species selected

S/No	SCIENTIFIC NAME	Common Name	Kamba Name(local name)
1	*Berchemia discholor*		Kisaaya
2	*Azadirachta indica*	Neem	Mwarobaini
3	*Tamarindus indica*	Tamarid	Kithumula
4	*Vitex payos*		Kimuu
5	*Senna siamea*	Senna	Ikengeta

6.2.2 Community mobilization

AWG and MetaMetastaff were present to support the community with technical knowledge after the community had chosen on the suitable tree species they would wish to plant. Holes 2 by 2 by 2 feet were prepared. The work was done by each farmer living near the roadside. The planting took approximately 2 months. The number of trees planted by each farmer depended on the length of the farm, the number of suitable locations and the availability of funding

Community mobilization began on August 19th 2016 at Kawongo Chief's camp. Here, Meta Meta and Africa Wood Grow teams met with the Chief Kawongo/Kathome Location and the two assistant chiefs-one for Kathome Sub-location and the other one for Kawongo/Kamanyi Sub-locations. The Meta Meta team explained to the administrators the aim of the meeting and the end goal of the roadside tree planting project. The chief and the assistants were pleased with

the project and promised their full support. They also acknowledged Africa Wood Grow for what it had been doing in the area. With their help, we mapped out the landowners which border the road from Kasonzove stream (the border between Kawongo and Yatta Locations) and Kwa- Muthusi stream (the border between Kawongo and Kanyangi Locations- the far end of Kamanyi Sub-Location). It was estimated that the distance between these two points is about 18 kilometres. It was agreed that the assistant chiefs would mobilize the land owners to meet with Meta Meta and Africa Wood Grow team on 8th September 2016.

The second meeting was held on 8th September 2016 at Kawongo Chief's camp. The intention was to explain to the landowners the idea of tree planting project. The community exhibited full support for the project and promised that they would fully participate in the project. They also promised that would dedicate their lands bordering the road for tree planting. It was agreed that the trees belonged to the land owners and they were obliged to take care of the trees.

A third meeting was held at Kathome assistant chief's camp for the landowners living in Kathome sub-location. 25 farmers were given each KSh 3000 for the land preparation (e.g. digging and refilling holes, and collecting wood for tree protection). Those farmers who would have spent more money or man-hours would be compensated (since some landowners have longer stretches of land bordering the roads than others).

The fourth meeting was convened in November where tree planting and protection demonstrations were held. Seedling distribution was done on the same day and those farmers who were not fully prepared to take the seedlings were advised to pick their seedlings at their convenient time.

6.2.3   Seedlings production and preparation

Seedlings were produced at Africa Wood Grow's Kathome farm. The nursery had a capacity of producing 100,000 seedlings per year. Seedling production involved purchasing of seeds, nursery establishment, treatments, and germination, pricking out and after care till they were ready for transplanting into the fields.

Figure 8 tree nursery at Africa Wood Grow's Kathome farm

The farmers dug holes for tree planting. The holes dug were of 2ft by 2ft by 2ft dimensions and 6 m away from the road (to ensure that the tree will not be destroyed in case of road expansion, there is no well-defined road reserves in rural area) but on the side where electric power lines pass, the distance measured was 8 m from the pole to enhance the security of the tree and also not interfering with electricity or raising issues with the Kenya power and lighting company (KPLC)This measurements were done by use of a tape measure.. This brought about big challenges since most of the farmers did not understand why it was to be that way, they thought we were taking their land and adding to the road. In involved the farmers in a clear discussion explain to them as to why it was done that-To present further destruction from road construction, KPLC and the passer bys. The holes were refilled and planted with trees after two weeks of preparation.

The distance from one tree to the other in a row was decided at 4 metres to allow the trees space for canopy formation and aeration in the underground and light entrance to the soil to allow undergrowth since the crops also require sunlight for growth. This means that a total of 9000 trees would be required to cover the distance from Kathome to Kamanyi (18kmx 2 =36 Km,which converted to metres you get 36000 hence 36000m/4m = 9000 trees).

Those farmers who were unable to dig the holes and plant trees hired casuals to do so and this is why a constant figure for this activity was allocated across all farmers so that no complaints of favoritism would arise. Later we explained to the farmers that each hole should cost at least ksh.30 of which the farmers were comfortable with that. Farmers with more than 30 holes were added some cash to sum in respective to the amount needed in preparations.

The seedlings were transported from the nurseries to the community's farms by ox-carts to prevent damages. The transportation was done the AWG to the central point (MusangiMuvali's farm) where those farmers who were not able to reach where the seedlings were could collect from there.

6.2.4 Tree planting

After the onset of rains, farmers and heads of institutions along the roads, the administration (chief, assistant chiefs and village heads) were invited to one of the farms along the road so as to demonstrate to the how the trees would be planted and protected. The farmers participated in the tree planting and protection exercise and promise to do the same at their farm

Figure 9 Launch of tree planting with local officials and community

The farmers established tree protection systems from browsing goats and other damages. The farmers erected sticks around each planting hole. Protection is necessary since the trees are young and palatable hence they if not protected they can be eaten by the livestock like goats and cows that tend to be moving freely.

Figure 10 tree protection by erecting sticks around the holes

After demonstrations were done, the seedlings were distributed to some farmers as they had requested for various types of trees during the community visitation and questionnaire sharing. Those farmers who were not yet prepared, they would collect their seedlings later, but within the rain season. This was done during the long rainy season in December 2016(the distribution was done according to the dates in my filled work days).

6.2.5 Monitoring and documentation

Monitoring started from the time of holing and developing water harvesting techniques to ensure that all the farmers selected will participate in the project activities. It ensured that only

those farmers who had dug holes and water harvesting structures get seedlings for planting. Small channels were diverted to the hole of the tree, a guide was given to the farmers before refilling exercise after the first rains, after distribution of seedlings, a follow up was done to ensure that the trees are planted, watered and protected. I made farm to farmer visitation to check on whether the tree had been protected. Watering was done by the AWG.

6.3 Tree survival

The table 5 below shows the comparison of trees that were planted and those that survived per farmer and the total number of trees that survived.

Table 7 comparison of trees that were planted and those that survived

No	No.Of Trees	Trees Planted	Trees Survived	Lost	Survived %	Lost %
1	51	51	51	0	100.00	0.00
2	58	42	42	0	100.00	0.00
3	27	20	19	1	95.00	5.00
4	12	12	10	2	83.33	16.67
5	31	31	25	6	80.65	19.35
6	27	27	16	11	59.26	40.74
7	19	19	11	8	57.89	42.11
8	17	17	8	9	47.06	52.94
9	24	24	10	14	41.67	58.33
10	47	47	18	29	38.30	61.70
11	14	14	5	9	35.71	64.29
12	67	30	9	21	30.00	70.00
13	44	44	7	37	15.91	84.09
14	56	56	6	50	10.71	89.29
15	41	41	4	37	9.76	90.24
16	36	36	2	34	5.56	94.44
17	26	26	1	25	3.85	96.15
18	45	0	0	0	0.00	0.00
19	25	0	0	0	0.00	0.00
20	40	40	0	40	0.00	100.0
21	35	0	0	0	0.00	0.00
22	22	0	0	0	0.00	0.00
23	18	0	0	0	0.00	0.00
24	14	0	0	0	0.00	0.00
25	41	0	0	0	0.00	0.00
TOTAL	**837**	**577**	**244**	**333**	**42.29**	**57.71**
AVERAGE	**33.48**	**23.08**	**9.76**	**13.2**	**32.59**	**39.41**

In Table 7 comparison of trees that were planted and those that survived, a total of 577 seedlings were planted. The targeted trees were 837 seedlings to be planted, this leads us to 72.89% planted of tree seedlings and 27.11% unplanted seedlings. In these cases the holes were prepared but the farmers did not collect the seedlings for planting. A reason can be that the farmer wanted more money; therefore they would take the seedling and get money for the preparations. However, after receiving the money they were not willing to plant the trees. This case of being money-oriented will be discussed in later sections of this report.

The table below shows the types and number of tree species that survived.

Table 8 amount of trees survived per tree specie

No	Scientific Name	Common Name	Kamba Name(Local Name)	Trees planted	Trees survived
1	*Berchemiadischolor*		Kisaaya		80
2	*Azadirachtaindica*	Neem	Mwarobaini		0
3	*Tamarindusindica*	Tamarid	Kithumula		35
4	*Vitexpayos*		Kimuu		0
5	*Senna siamea*	Senna	Ikengeta		106
6	*Melliavolkensii*	Melia	Mukau		23
	Summation				**244**

A number of trees did not survive due to lack of enough funds and water; in some cases the farmers did not water the trees at all. Only the drought resistant trees like Sienna siamea and *Berchemia discholar* survived in large numbers. *Berchemia discolor* survived because it tolerates drought and *Sienna siamea* survived because it also drought resistant and fast growing. The trees would have survived all but due to lack of care by farmers (watering and protection) this is why most of them head to wither and die. Most farmers after planting did not have look after the young growing trees that need much care for them to grow.

6.4   Other projects

Community mobilization and sensitization on farming methods and also tree planting, farm management of natural resources, conservation agriculture and soil conservation techniques are currently being done ADRA with the area. Farmers learn different skills on how they can use the available resources within their premises. Interested groups are formed thereafter a training is organized together with demonstration in one of the farms. Through this farmers also get to learn from each other during their visitations to each other and appreciation to one another thus enhancing environmental sustainability. Farmers are able change together with the changing climate year after year.

Creation of markets to sell the farm produce like green grams and maize is emphasized by the county Agricultural department with the area. Farmers get motivated to plant more crops so

that they can sell to the buyers thus enhancing better farming methods and hardworking of the farmers since hard work pays.

Currently KEFRI is trying to educate people on the modern means of making charcoal so as to keep on protecting the tree cover within the county. KEFRI is also producing propagated seedlings like propagated *Berchamia discholar* that grows fast to enhance the spread of the trees within the county because most of the farmers are not planting due to its high time before maturity. Training of trees more so to those seedling vendors to enhance them with equitable knowledge in preparation and selling strategies. In addition, KEFRI is also producing various seedlings that those of mukau, acacia and neem so as to spread to the seedling vendors and also those that are unable to reach the market properly (personal discussion with Luvanda Albert, KEFRI).

KFS is also providing seedlings to sale to farmers and also enhancing forest cover by providing policies and regulations on the tree. It is also advising farmers at which age the tree is supposed to be harvested.

All this efforts combined (ADRA, KEFRI, KFS and other environmental organizations and county government) can increase high tree and forest cover within the county thus improving the environmental status of the county. One of the challenge like ignorance from farmers ,for example, in trainings conducted by KEFRI on Modern Charcoal processing farmers fail to adopt it because it seems expensive and time consuming. There is a need for all these organizations to combine in sensitization about charcoal burning. There is need for the county also to start investing in tree planting in various sub-counties so as farmers can get more inspired by tree planting and also providing of incentives to those farmers who do tree planting and conservation agriculture.

CHAPTER 7: Socio-Economic Impacts of roadside tree planting

Currently, tree planting in Kitui County is mostly done for benefits at a household level. Due to improved technologies and relevant personnel, farmers have started forming small groups that practice the tree planting by making seedlings for sale to other farmers. Examples of tree seedlings sold include crafted mangoes and oranges for fruit production. Currently there is a big community in Tiva (Kitui rural sub-county, Lower/Yatta ward) that is practicing on growing of *Melia volkensii* for timber under the assistance of KEFRI. Nyumbani village has also improved in tree planting of various species by establishing a farm for only tree growing.

Some of the socio-economic benefits that farmers get from trees include:

- Profit from selling burnt charcoal and seedlings. But due to high rate of charcoal demand, trees are cut down without replacement and hence leading to decease in the number of trees available in the County.
- Increased employment; different personnel and experts can be trained who will later train other farmers on roadside tree planting, for example, during my field study, one of the farmers was chosen to assist in measurement of tree distance from the other and distance from the road, he also assisted in helping the farmers on various guidance during planting and fencing. This can also enhance self-employment where farmers can produce various seedlings and sell to the market and other farmers, timber production will lead to lumbering industries.
- Increasing road stability: vegetation helps to lower local water table that may affect the road formation and pavement hence reduction in road maintenance and management.

Box 1: Charcoal Business

Charcoal is a wood fuel produced in rural areas and consumed in cities and towns. Some of the factors influencing the choice of using charcoal instead of firewood in urban areas include: Charcoal has a higher calorific value per unit weight that firewood, it is therefore more economic to transport charcoal over longer distances as compared to firewood; Storage of charcoal takes less room as compared to firewood. Firewood is mainly used for cooking, water heating, house heating, lighting and other home businesses. Others include small restaurants/hotels and kiosks and learning institutions. In income and employment generation and wealth creation at the rural population, their energy requirements need specific attention to ensure their sustainability.

Growing energy requirements is one of the major challenges facing the world today. The poor and middle income populations who are the majority of wood charcoal users cannot afford to use electricity and/or liquid petroleum gas (LPG) for cooking because of the high investments needed in fuel and cooking appliances (Mugo et al. 2007). As living standards rise and urban areas expand, households and small-scale industries are using charcoal more and more for cooking, as other sources of energy such as electricity are expensive. Charcoal production and trade contributes to the economy by providing incomes and employment for men, women, and children at the community level and saves foreign exchange that would otherwise be used to import cooking fuel. Compared to firewood, charcoal has several advantages. Charcoal is easy to transport as it has lower weight in respect to energy content, burns evenly for a long time,

and is less smoky. Hence there is no doubt that the charcoal trade will expand in the foreseeable future. It will continue to be the main and, in some cases, the only source of energy for millions of people for a long time (Mugo et al. 2007).

Selling of charcoal mainly takes place in the urban areas, providing highly needed income to low income women whose sales involve small quantities measured using tins, but to a large number of buyers. Producers earn an average monthly gross income of Ksh4, 496 (US$60), vendors Ksh7, 503 (US$100), and transporters Ksh11, 298 (US$151). Kenya's deficit in biomass energy rose from 46 per cent in 1980 to 57 per cent in 2000. In Kenya it is estimated that commercially-grown trees can produce 18 tons of charcoal from one hectare. About 135,000ha of fast-maturing tree species will be required every year to meet the current demand of 2.4 million tons (Mugo et al. 2007). Other countries both in the developed and developing world are also promoting the production of charcoal briquettes from biomass waste to supplement charcoal.

However, charcoal has been kept out of the formal economies of many countries, partly due to lack of supportive data and information. Charcoal production is a big threat to biodiversity because it targets specific preferred species found in natural forests and woodlands, most of which are poorly managed, leading to unsustainable harvesting. In drier areas, where the regenerative capacity is lower, unplanned and unmanaged charcoal production accelerates the processes that lead to desertification The absence of replanting practices accelerates desertification and land degradation (Mutimba and Barasa 2005). Most charcoal producers in the country use inefficient carbonization processing, leading to wastage of wood and greenhouse gas emissions.

Charcoal production from people's own farms is carried out by landowners in high potential areas who grow trees for various purposes ranging from fruit production, crop shade, firewood, fodder, live fencing, building, and construction. Prunings and stumps are mostly used for charcoal production at a small scale. Apart from own farm sources of charcoal, other sources include Private land Government or county council land and Communal land .

Charcoal producers for example destroy the forests as they use traditional kilns which are poor in biomass conversion and cause fires which in most cases destroy the areas surrounding the charcoal production sites. Factors that affect charcoal production efficiency in this technique include: design of the kiln, tree species used, moisture content of wood, arrangement of wood in the kiln, and monitoring of carbonization process, which explains the wide productivity range of 10–20 per cent obtained in earth kilns. Charcoal producers in Kenya use traditional earth kilns, which are cheap as they require only labor to construct.

KEFRI has developed a manual based on four charcoal processing technologies, and this indicates that improved earth kilns, a portable metal kiln, a drum kiln, and the Cassamance kiln could give yields ranging between 27–30 per cent. Improved production techniques require more labor and cost, but the quality of charcoal is better compared to earth kilns, as the newer methods have better control of the carbonization process.

7.1 Direct impact of tree planting for farmers

Farmers have indicated a number of direct impacts of trees planted along the road on their farm. First a number of commonly indicated impacts are listed below, in the following sub-paragraphs the main benefits will be discussed in more details.

Generally mentioned benefits mentioned by farmers include:
- Provide shade and keep the road cool for road users and thus there is comfortable and better movement from one location to another.
- Provides direct benefits such as timber fuel and fruits; timber can be used in construction, fuel like charcoal and fire food used in cooking and fruits that are importance in diet. All this direct benefits can be sold to market hence earning income to buy other household good.
- Increase yields in adjacent farmland; Farmers tend to abandon the farm along due to low or no yield production from the farm, for example during the previous harvest season in Kat home, farmers were not able to harvest hence causing a discourage in farming. From the ecological benefits, they enhance yield production since the plants will be able to use the nutrients fixed in the farm by the rotting tree leaves. Water holding capacity of grass and trees enhances water availability to be used by plants for growths, hence the increase in crop yield production.
- Tree growing has enhanced bee keeping that leads to harvesting and selling of honey to the markets. Due to high demand of bee keeping, bee hives are also made from the tree logs that are easily accessed by the locals (Personal discussion with one of the farmers-Peter Kinyili whose main business is to make bee hives and cooking sticks(Mwiko).

7.1.1 Impact on Water Access and Use

Most of the households can accurately calculate their daily water use because it is collected in 20L containers and carried home either by members of the households (men, women and children), a donkey or a worker. The accessibility of water depends on both the availability of water in the primary water source during the year and the distance to walk to reach this source. If the primary source gets depleted before the end of the dry season, it also depends on the same properties of secondary source.

On average, the trees and grasses make a location significantly hold water 2.5 months longer.For example, in Nyumbani village, Kwa Vonza ward,the area receives more rainfall since 2008 when they begun tree planting and planting of napier grass along on the terraces in their farms.The harvest of yield has also gone up ,forexample green grams and beans,this cereals are enough to serve the students and children who have been adopted the area.Farmers close to this area say they have seen a difference since the tree planting exercise begun,more so in the wetness of the land and harvest of food from farms. Twelve of the 30 households claim the source holds water for a shorter period now than five years ago. It can possibly be explained by increased water usage. The water table rose in areas with relatively less rainfall,Numbani village have been able to drill borehole at a place where it was said the water table is not near,the borehole will be auctioned soon to be used by the residence in the compound.In comparison of other farmers with Mr.Ndolo from Kitui Central,there is a big

difference in the farms.Mr.Ndolo's farm has enough trees of all kinds and even vegetables and crops.This is due to proper management of the land.

Water use for rain-fed crops is irregular and only applied when crops are at risk of water stress. Most farmers therefore do not know how much water they use for this purpose. It can be assumed however, that the amount of water used to irrigate crops in times of water stress is a small share of the total water use. By planting trees and grass, this enhances soil cover increasing moisture content in the soil. Grass act as good cover crops and trees reduce the rate of evaporation from the soil. Trees increase the water table by the trees that uptake water from the soil to the stem.

7.1.2 Impact on Crop performance

The value of the harvest of the households with trees showed an increase while the harvest of households without trees showed decreased or constant; this significant disparity shows what people already mentioned during the interviews: 4 of the households without trees actually claimed they had no harvest at all; 3 others said their harvest decreased. None of the households with trees had no harvest at all; only seven claimed their harvest decreased.

Farmers with trees like Neem on average grow 1.39 new crops. The new crops mostly include crops that need irrigation (e.g. tomatoes, kale,onions). New rain-fed crops are less common, but include e.g. pumpkins, maize, pigeon and cowpeas. Farmers who do not do road side tree planting indicate no growing of new crops and grow fewer cash crops in general. The difference between the two groups is significant. Overall, due to increased irrigation, new crops and higher crop yields in households with trees increased their profit gain per acre. The households without trees struggled with bad rains but could not irrigate, their income per acre decreased. Increased yield production in the farms with trees is clearly indicated in comparison to those farmers that do not have trees in their farm and Mr.Ndolo who has really invested in tree planting and water harvesting. The harvest of beans between AWG (intercrop beans and Neem) is higher compared to those farms that do not have trees.

Most fruit is for own consumption (children eat fruit for lunch); a few households consider selling fruit as part of their income. This might however change in the future, for many new trees were planted but most trees are still too young to produce any fruit.Fruit trees need approximately five years of irrigation before they grow on themselves.Fruit trees like *Berchamiadischolar* (muu) are liked by children and are nutritious, despite them providing shade to pass bys they also provides fruits to the children after school on their way back home thus improving the nutrition in children.

7.1.3 Tree nursery owners

Another form of agriculture is a tree nursery, in which tree seedlings are grown on an irrigated plot until they are large enough to grow without being irrigated at set times. After reaching this point, the seedlings are sold or planted higher up in the valley.

Full grown trees are used for firewood, charcoal burning, construction, windbreaks, shade, and for fruits, which can be sold or consumed to supplement diets. The leaves of the trees can also be used as fodder for livestock. The nurseries are often kept as a group who divide the earnings after selling the trees.

Besides economic benefits for the households involved, the planting of trees in the area is also beneficial to the environment, for example because of the necessary shade they provide for shrubs and plants.

One tree can produce as many as seedlings that are sold as drafted seedlings, for example buying one tree of traditional tree is Ksh.50 but when it grows, from one branch one is able to draft traditional as many as seedlings and sale one seedling at Ksh.200.Figure shows a farmer in Kitui who planted his tree in 1982 and now he is still planting all kinds of trees and fruits, despite that he also has a tree nursery and his farm is well equipped with cereals (maize, cowpeas, beans and green grams)and bananas. He sales one seedling at Ksh.200.

Figure 11 Tree nursery and fruits trees (oranges),maize and beans plantation.(Mr.Ndolo's farm)

7.2   How roadside tree planting provides socio-economic benefits to the communities

Roadside tree planting provides several socio-economic benefits, below some examples of production of fruits and timber, and enhanced agriculture are explained:

- Providing source of income from the sale of fruits, firewood and timber and seedlings. On log of a pruned tree is equivalent to ksh.20.Mr.Ndolo,a farmer in Kitui who plants so many trees and earns a lot of income from the sale of the pruned branches, one

branch can even produce 10 logs hence one brunch = 20*10=Ksh.200.What about if prune as many as branches depending on the number of trees you have!

- Selling of timber to hardware shops for example, the buying price of one *Grevelia robusta* tree is Ksh.25 and one tree can produce 30 pieces of 1ft timber being sold at Ksh.30per 1ft compared to the past where selling 1ft was equivalent to Ksh.7 hence ; 30*30=Ksh.900, this clearly shows that from one tree one is able to make a good profit,
- Fruits of *Vitex payos* goes at Ksh.50 per package and yet only one seedling goes at ksh.35 yet it bears many fruits. From one tree many packages can be sold.
- Enhancement of commercial agriculture; Trees retain moisture content in the soil and also spread water in the soil through its roots, despites only that, rotting leaves from trees also provide manure to the soil that increases the fertility of the soil thus enhancing high growth of crop in the farms such as green grams, beans and cowpeas. lot of harvested these cereals can be sold to the market improving the living life style of the community hence solving the issue of food insecurity.

The table summarizes how trees are great income if well taken care of:

Table 9: Summary of expenditure and gain from trees (Official interviews with farmers)

TREE TYPE	B.P (Ksh. @)	MAINTEN ANCE (Ksh.)	TOTAL EXPENDIT URE(K.sh)	ITEM GAINED	Quantity	S.P @ Ksh.	Total S.P
MUKAU	50	100	150	Timber	10	100	1000
MWAA	25	100	125	Chacoal	4 bags	600	2400
MIKENGE KA	25	100	125	Firewood	50 logs	20	1000
GRAVELLI AROBUSTA	50	150	200	Timber	30 @1 ft timber	30	900
MANGIFER AINDICA	30	250	280	Mangoes	100	10	1000

For Mangoes, Oranges and Mikengeka, the trees require only one year to start producing the harvest under proper maintenance.It is rewarding to wait for one year and reaping the fruits afterwards. These trees can sustain a livelihood for a long time if they are maintained in a proper way.

Trees also attract bees thus enhancing bee keeping. From the sale of honey(owner of bees) and buying of bee hives(the one does the business of beehive vendoring),both the farmers are able to earn a living since they are able to money from the sale of the commodities thus enhancing socio-economic benefits in their life styles.

7.2.1 Challenges of roadside tree planting

Due to increased demand in transport form on are to another, the county intends to expand roads for easier transport system both for vehicles and motorcycles. During the construction, farms near the farmer tend to get destruction like cutting near vegetation on the road; excess

soil heaps discharged to the farm hence interfering with farming and other activities within the farm.

Insecurity; This is mainly caused by lack proper fencing around the farms hence enhancing random movement of livestock like goats and cows all over the farm. Trees planted along the road are mostly destructed by the animals when they feed on them or even sometimes by people passing by.

Insufficient water; Due to lack of water for watering the trees, the communities prefer to look for water for domestic used rather than watering the trees also.

Lack of knowledge; Most of the farmers lack skills and knowledge on how they can use water from the roads to maintain their trees.

Electric poles and wire; This is mainly caused by the Kenya Power and Lightening Company KPLC when they are setting various poles for wire to supply electricity to the locals. Trees nearby the poles or the wires are cut off. This poses a discouragement to the people to plant trees along the road (Juliana Wanyamo-farmer in Kathome)

Expansion of roads; Due to increased demand in transport form on are to another, the county intends to expand roads for easier transport system both for vehicles and motorcycles. During the construction, farms near the farmer tend to get destruction like cutting near vegetation on the road, excess soil heaps discharged to the farm hence interfering with farming and other activities within the farm.

Lack of market;Majority of the farmers are trying to invest in the fruit tree farming but they do not have a good market strategy to sale there fruits. For example when it is mango season many farmers sale the mangoes at a through away price in the markets and even some just rot in the farm.

Ants and insects; Are dominant in the area and tend to interfere with the growth of trees for example, *Grevillea Robusta* is highly affected with ants in the farm. Fruit trees (mangoes/oranges are invest in the fruits making the fruits o rot and drop before majority. Farmers find this a great challenge since those who do have enough funds fail to purchase the pesticides leading to low and poor quality produce.

7.3   Opportunities of roadside tree planting to the community, a summary

By planting the trees along the road, the community is able to access many benefits and opportunities. Some of the opportunities include:

- Shade
- Utilization of the water from the road
- Source of income
- Increased conservation agriculture hence commercial agriculture
- Improved tree cover hence clean environment
- Synthetic beauty of the road

- Increased road stabilization hence the money used in maintenance of the road can be used for something else.
- Reduced surface runoff hence decreased soil erosion in farms
- Increased seedling and seed vendoring activities in the market

CHAPTER 8: Cost Benefit Analysis of Tree Planting

Cost-benefit t analysis (CBA) is a tool used to determine the worth of a project. It is used to assist in making judgments and appraising available options. It identifies and attempts to quantify the costs and benefits of an activity and converts available data into manageable information. With a CBA one is able to identify the return on investment for individuals and for a community when it comes to the economic benefits derived from trees and grasses. Because of the span of years before the benefits can be seen, it is important to get more insight into the possible returns at the start. This makes farmers and communities aware of the economic opportunities it provides in the long term. This helps to get farmers' involvement in order to ensure proper maintenance and investment in trees from the start.

It also adds more data/information to the project evaluation because, among other things, it makes the links between inputs and outcomes, clarifies the underlying assumptions, and points to gaps in information. By endeavoring to express outcomes (benefits) and inputs (costs).

However, planned urban forests are not without costs. Planting and maintaining trees requires an investment of not only monetary resources but human resources as well. It should be noted that without proper planning and maintenance, trees can have negative impacts: uprooted sidewalks, leaf collection in such areas as streets and culverts, disrupted utilities and tree damage. These effects all incur costs to the community and private landowners. However, the costs of planting new trees and maintaining existing trees are tangible and the benefits of trees are often diffused and enjoyed as "public goods" by society at large.

The residence of the arid and semi-arid lands (ASALs) depends heavily on woodland resources for their livelihood needs. The available woodland resources cannot sustainably meet increasing demand caused by increase in the population as well as migration of farmers from high rainfall/potential areas to the ASALs hence accelerating degradation of natural resources and affecting living standards of local people. Tree planting offers a solution to curb degradation as well as assisting in diversifying income sources for the ASAL population.

However, in development of tree planting programs for ASALs, selection of commercial tree species would provide alternative income generating options for the inhabitants. Several trees have been recognized as an important tree species because of its adaptation to dry land conditions, fast-growth and production of high quality timber, fuel and fruits.

Two species from each category have been used to find the socio-economic benefits of trees planting. *Melia volkensii* and *Greveliarobusta* (timber trees).*Mangiferaindica (Mango)* and oranges as fruit trees.

Below are some of the factors to be considered when planning to invest in tree planting,both fruit trees and timber trees.

8.1   Planning and Design

Planning and designing a tree plantation is both time-consuming and expensive, but quality design and careful planning will result in a more successful project. This will add value that far

outweighs the expense and brings a sense of pride and accomplishment to not only those involved in the establishment, but those that get to enjoy the results as well.

Some important elements to consider in the cost of a successful tree plantation include:

i. Tree inventory – knowing what you already have will help you to further enhance the existing design.
ii. Quality stock for planting – purchasing good, quality trees reduces the need for future replacement and maintenance costs.
iii. Tree maintenance – pruning regularly will ensure safety, tree health and longevity;
iv. Monitoring and protection – effectively reduces chances of damage from construction activities, storms, utility line installation/repair and pest problems; and
v. Tree removal – while this is an expensive aspect when dealing with large trees, this is necessary when trees die or decline beyond improvement.

8.1.1 Costs

Community trees have costs associated with their establishment, maintenance and conservation, but have the potential to provide many benefits and add great value to communities. The costs involved in tree planting development include tree purchase and planting, tree and stump removal and disposal, annual trimming, irrigation, pest and disease control, litter and storm cleanup, infrastructure damage, litigation and program administration. An often overlooked cost is neglect, abuse or poor maintenance of the trees which result in the poor health of the tree and becomes an additional liability for the tree owner. While there are many costs associated with establishing urban and community forests, the benefits far outweigh the expense.

1. There may be a need for additional tree protection materials, such as root padding, trunk wraps, fencing, posts andsigns.
2. Trees should be inspected while trees are being mulched, pruned and watered. This maintenance refers to new trees during thefirst 3 years following planting.
3. There should be routine and periodic maintenance for established trees in urban/community forests.

8.1.2 Site Preparation

Poorly-sited plants are doomed from the start, so trees and shrubs should be selected according to how well they will adapt to conditions of individual planting sites.Soil drainage can be tested before planting. One can also consider using more water-tolerant species such neem, melia,moringa,*Berchamia discholar*, *Virtex payos*, acacia,sennaand other plants that do not like "wet feet" should be avoided where drainage is poor.

While the costs associated with site preparation can be high, it is very important to properly prepare the site where trees are to be planted to help keep maintenance and replacement costs to a minimum.

8.1.3 Management

There are many costs involved with managing trees to maturity. These costs include the initial and subsequent tree inventories, the purchase of trees, tree care practice, securing permits if necessary and maintaining the integrity of the tree species selected

The cost of the initial tree inventory, as well as subsequent inventories, depends greatly on how detailed the inventory will be. Tree inventories can range from simple to very complex. Simple inventories can be handled by volunteers to hold the cost of inventory to a minimum. However, when an inventory is being taken for management purposes, those experienced in tree inventory should be called upon.

One should consider the cost of purchasing trees, you should always invest in higher-quality stock. These trees will have been cared for in such a way that they will have a good foundation and will cost less in maintenance fees. Tree care can be a major part of ones budget as it is necessary to properly care for the trees within the plantation to prevent a rise in future costs associated with the trees. Some costs involved with caring for roadside tree plantation include trunk protection, protection from pests, diseases and animals, pruning and even tree removal.

The cost of securing can also depend on the policies of the municipalities involved. Therefore, it is hard to expound on any costs that may or may not be associated with this aspect of establishing roadside tree planting and plantations.

Finally, when considering cost of maintaining trees, all of the above should be factored into the equation. Roadside tree can be quite expensive but the benefits are tremendous and well worth the expense and effort expended.

8.1.4 Hazards

There are many hazards associated with trees, such as those produced when trees fall during storms or die and begin to fall. However, falling trees are not the only potential for problems.

Roadside trees should never be allowed to grow in designated clear zones for utility lines, pedestrian walkways, buildings, streets and travel lanes. When trees are allowed to grow un-checked into these areas they reduce clearance and sight distance and increase costs to maintain public safety. Additionally, if the upper portions of the tree are left to tower over property it can cause power outages, damage to homes, vehicles and other property. There is also an increased risk for personal injury.

An often overlooked liability is the root structure of the tree. Tree roots that surface above ground can pose a tripping hazard or damage equipment such as lawn mower blades.

In many cities, communities are finding themselves spending millions of dollars to resolve conflicts caused when trees impose on sidewalks, sewers, power lines and other elements of municipal infrastructure.

Unfortunately, when these repairs become necessary municipalities are sometimes forced to shift these costs to residents. Typically, this leads to a downsizing in roadside tree planting as small stature trees are planted to replace the larger trees removed due to their damaging effects.

8.2 Cost benefit analysis

Data was collected from different farmers who are investing both in timber and fruit trees within Kitui County. To compute the CBA total costs and benefit were determined. For example total costs comprised of the costs for land preparation, seedlings, pitting, manuring and pit refilling, seedling planting and mulching, watering, fertilizer/manure, pruning, fungicides, weeding, security, transport, processing and other miscellaneous needed throughout the period of implementation and management until the tree riches maturity annually.

The total benefits comprised of all the income the farmer gets from the plantation for example intercropping when the trees are young sale of fruits and timber.

8.2.1   Fruit trees

In Kitui county majority of the farmers are planting paw paws, oranges and mangoes. Oranges and mangoes (grafted) are the leading fruit trees within the county. For management of these trees, the techniques are the same, the total costs for implementation and maintenance are the same. For example, pesticides used for mangoes are also used for oranges.

Farmers either sale the fruits in bags (90kg) to those who purchase on a whole sale or a single mango or orange to the market depending on the quantity of mangoes in the farm. The table below was calculated using the price per bag 0f 90kg.To get the income for each year, total costs were subtracted from total benefits (sale of fruits).

Table 10: Cost benefit analysis for fruit tree farming

COST BENEFIT ANALYSIS FOR FRUIT FARMING;ORANGES AND MANGOES

YEAR		Total costs	Total benefit	Income
(year of implementation)	**0**	45077	920	-44157
	1	8167	11500	3333
	2	8167	23000	14833
	3	7167	46000	38833
	4	7167	46000	38833
	5	7167	69000	61833
	6	7167	69000	61833
	7	7167	69000	61833
	8	7167	69000	61833
	9	7167	57500	50333
	10	7167	57500	50333
Cumulative totals		118747	518420	399673
Average		10795.18	47129.09	36333.91

%income=cumulative total income/cumulative total benefits*100%	77.0944

Figure 12: Graph for cost benefit analysis for fruit tree plantation
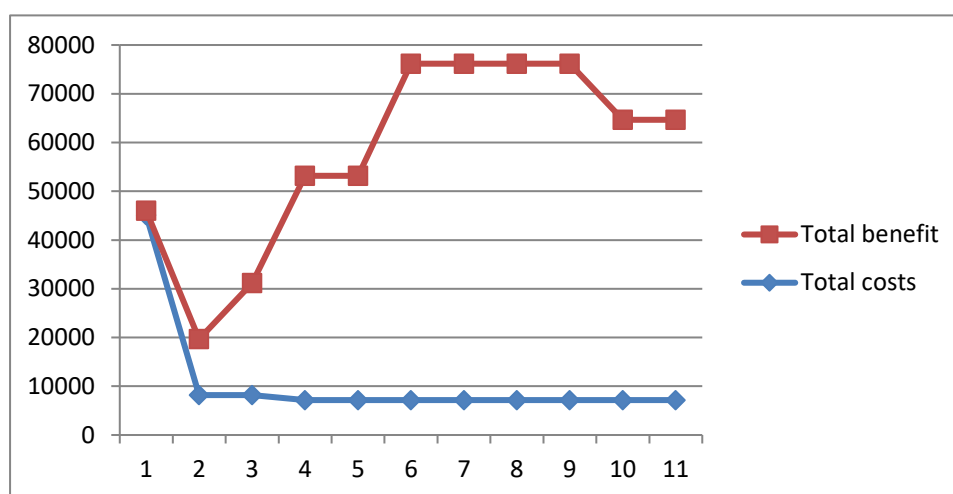
From year 1 to year 2 there are more costs than benefits, this is because the trees have not reached maturity and have not started bearing fruits but the years later, the benefit is higher compared to the previous years. The yields increases up to year 10and starts declining since the tree is old and cannot bear many fruits.

Figure 13: Pie chart for comparison of total costs and income of fruit trees over 10 years
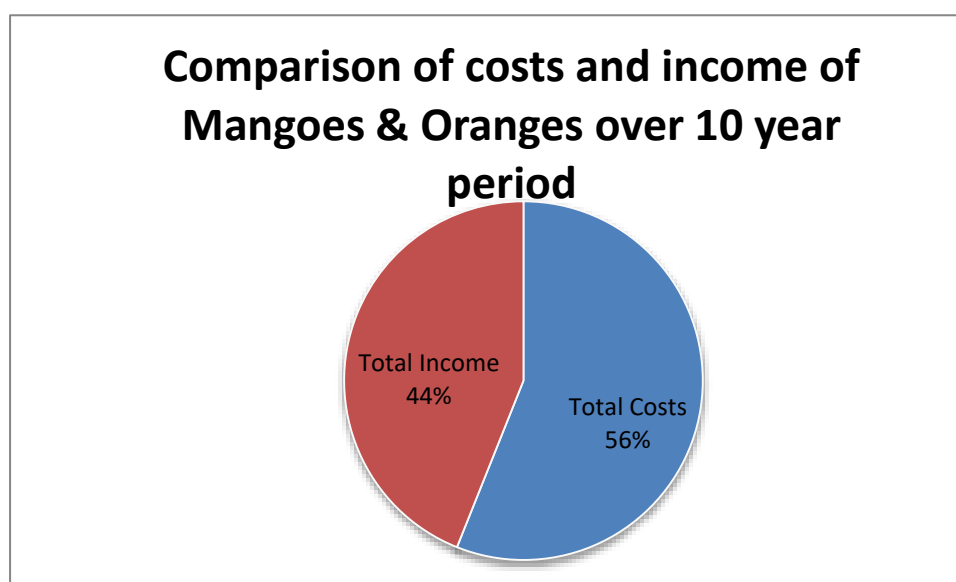
8.2.2   Timber trees

Kitui County is rapidly growing in form of infrastructure and development, majority of the farmers have really invested in the timber tree plantations where they process timber and sale to the market or sell as round wood. The trees in most of the farms include grevelia, eucalyptus and melia. Grevelia is the leading since its maintenance and management is cheaper compared to melia. To get the income for both timber trees, all the costs were added and subtracted from

the benefits such as sale of round wood or timber. Cumulative totals represent the total costs and benefits for all the 12 years respectively. Total benefits represent all the totals from the sale of timber and intercropping such as maize and beans. Majority of the farmers are intercropping maize/beans in between the spacing of the trees.

Table 11: Cost benefit analysis for melia timber plantation

Cost benefit analysis for timber plantation; Melia volkensii			
YEAR	**Total costs**	**Total benefits**	**Income**
0	175575	20550	-155025
1	33175	16440	-16735
2	33175	12330	-20845
3	33175	8220	-24955
4	33175	8220	-24955
5	24625	8220	-16405
6	24625	8220	-16405
7	0	0	0
8	0	0	0
9	0	0	0
10	0	0	0
11	0	0	0
12	392,500	2935500	2543000
Cumulative totals	750025	3017700	2267675
Average	57694.23077	232130.769	174436.54
%income=cumulative total income/cumulative total benefits*100%			75.1458

From year 1 to year 6, there is little income since the farmer is able to do intercropping that earns him/her the benefit. As you move up from year 6 to year 11 there is no benefit since the trees are big and one is unable to any intercropping. The tree competes with the crops for nutrients and water available. Melia timber tree takes 12 years to mature, by the end of the 12 years would have spent a total of Ksh.750025 and after the sale of timber one is able to get Ksh.3017700.This gives and income of Ksh.2267675 (total benefits-total costs) After 12 years, the farmer is able to harvest the timber and a sale to market that earns him/her more income compared to the implantation costs that he used. The total average income for after harvest is Ksh.174436.54 giving a 75.14% income compared to the investment costs.

Table 12: Cost benefit analysis for Grevelia timber plantation

Cost benefit analysis for timber plantation; *Grevelia robusta*			
YEAR	Total costs	Total benefits	Income
0	175575	24000	-151575
1	33175	24000	-9175
2	33175	12330	-20845
3	33175	8220	-24955

4	33175	8220	-24955	
5	24625	8220	-16405	
6	24625	8220	-16405	
7	2500	0	-2500	
8	2500	0	-2500	
9	2500	0	-2500	
10	2500	0	-2500	
11	2500	0	-2500	
12	393,500	2935500	2542000	
Cumulative totals	763525	3028710	2265185	
Average	58732.69231	232977.692	174245	

%income=cumulative total income/cumulative total benefits*100%	**74.79**

Grevelia take the same shorter period to mature compared to melia. The cost benefit analysis was done for over 12 years for both the trees so as to get a clear comparison on investment. The total income of investing in grevelia timber plantation over 12 years is KSH 2.265.185 compared to the investment costs.

Figure 14: comparison of total costs and income of timber trees (Melia & Grevelia) over 12 years)
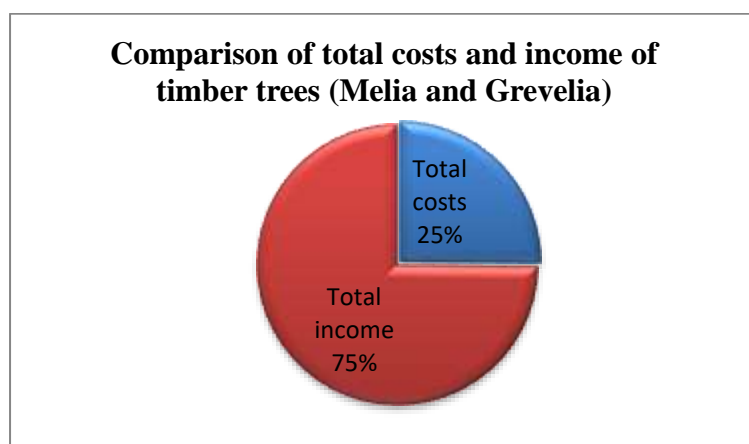
8.2.3 Summary Comparison of investment in both fruit trees and timber trees

Investing is fruit trees is better than investing in timber tree since fruit trees start producing fruits as early at the age of 2 years compared to timber trees to where the tree is left to up to 12 years where it can be harvested for timber. This is better for a fruit/conservation agriculturalist farmer whose main aim is of commercial benefit in the agricultural activities.

After a period of 12 years on who invested in timber trees is able to get more income since timber is of high value thus giving a 75% income for timber trees and a 44% income for fruit trees.

After growing trees on my land once, I was sold

MS IRENE NJERI, a businesswoman in Nairobi who had Greenscape Tree Ltd plant trees on her land, shared her experience.

"For my initial investment in timber, I planted trees on my two acres in Laikipia County back in 2006," she says. "A total of 1,300 trees were planted on each acre. However, only 1,000 trees on each acre made it to maturity in 2014 and were sold on the market. At that time the market price for one tree was Sh3,500. So from the total sales of trees on my two acres I made Sh7 million,

She adds that, given that she had invested an initial amount of about Sh220, 000, the Sh7 million she got from the sale of her trees was certainly a very big profit.

Ms Njeri says she found investing in the Greenscape project a venture with minimal stress, and which was worthwhile since it gave her good value for her money.

"That was the first time I was investing in timber because I was employed," narrates Ms Njeri. "Luckily for me, this project was mostly hands off, so I was able to strike a balance between my work and the investment. But after the first returns, I quit my job to venture into business full-time and at the moment, I have eight acres of land planted with trees. Kenyans should embrace this venture."

From Ms.Njeri's experience we find it more profitable and sustainable in investing in tree plantations since trees are of great benefit and can change one's life the way they have done to Ms.Njeri.

CHAPTER 9: Discussion

9.1   Discussion on research methods

Though people can accurately estimate the amount of water they use on a daily base when it comes down to small quantities, the estimate of large quantities is biased. If 20L containers are used the number becomes hard to count; if a generator is used it is impossible to estimate the amount of water unless the capacity of a generator is known. The amount of water used for irrigation is therefore just indicative and cannot be used for further calculations on the exact water use in Kitui County.

The water-use bias counts for both households with various sources of water and households without different sources but only one source. We chose not to treat the households using large quantities of water as outliers, because of several reasons. First of all, there are many of them. Second, it is hard to distinguish the outliers from 'regular' households because of the inequality concerns; one should not ignore the fact that there are households who increased their water use by tremendous amounts.

9.1.1   Questionnaire consideration

Whilst conducting a study, there is always the possibility of people giving false answers on questions. People can do this for many reasons, but in this case the main cause was that people hoped that we, from a Western country and comparatively rich, came to bring money or other support to families. However, not many households gave false information, and even if they did, there are several ways to deal with it.

Most lies were very obvious and fortunately our interpreter was very keen on this. She kept repeating questions in a different formulation until the right answer was given. Another strategy was to start asking questions or confirmations to another member of a family when one seemed to be lying. Furthermore, in the questionnaire (see Appendix I) several questions were specifically added to crosscheck the answers given. Many other questions are usable for crosschecking. Type of tree species and reasons for selecting the questions, for example, is a direct subject of questions. If any ambiguity exists about the given answers, however, there are possibilities for clarification in questions in the next section of the questionnaire. This accounts for every important subject. Still, some lies must have passed unnoticed. However, the dataset is considered trustworthy and that the amount of interviews is sufficient to clear out false information.

9.2   Discussion of the results

The results of this research indicate that roadside tree planting has a positive impact in the sense that they provide its users with more water, closer to their farms. Trees have great socio-economic benefits to the farmer in that it increases charcoal business, increased employment such as selling of seedling to farmers, sellers go as far as Meru to bring suitable seedling to sell the community that is unable to reach Meru or get the seedlings from their farms and timber.

By planting trees there is increased road stability thus the money used to renovation of roads can be used in other business sectors. There is increased yields in adjacent farms since much of the water lost through surface run off is able to be spread in the farm by the roots of the trees,

trees also add inorganic manure to the farms making the farm fertile. Flowers like those of the Neem tree attract bees, thus promoting bee keeping business. Traditional bee hives, cooking stick and other art crafts can be modeled from the wood of tree thus enhancing art crafting business.

A few farmers are practicing roadside tree planting for socio economic benefits due to insecurity caused by random movement of livestock, expansion of roads and lack of proper skills. This calls upon the County Governments, NGO, Research and Forest institutes to collaborate with farmers to enhance roadside tree for better achievement of the socio-economic importance of tree. This will also increase the living standards of the people with the regions at large and the country.

Trees have many hidden treasures that, if exploited in conservation and management, will lead to greater improvements for sustainable development. But even though the results prove more reliable than the results from previous studies, points of discussion remain.

9.2.1   Equal benefits and chances of future water scarcity

Within the project of road side tree planting with AWG, most people know that every person owns trees. Despite this, 29% of the households say that its benefits are not equally shared. This feeling of inequality is caused by a difference in ability to farming methods and tree species. The households owning land close to the road can and will benefit more of road side tree planting.

9.2.2   Impact on the environment and erosion

The drainage of soils in Kitui County is generally low, resulting in high overland run-off and erosion. Cutting of trees can easily lead to erosion, for soil compaction is no longer ensured by the trees. Moreover, trees and vegetation cover can increase the drainage capacity of the soil and slow surface run-off. Thereby increasing the water storage capacity of the soil and reducing sheet erosion.

Due to the increase in population and competition for the resources available, people in the area of Kitui often resort to cutting of trees for firewood and charcoal production. This has resulted in clearance of hill sides from its trees, leaving the soil bare and prone to erosion. Therefore it can be considered to adopt a sustainable charcoal business, planting and replanting trees on a large scale to provide for timber and firewood.

CHAPTER 10: Conclusion and Recommendations

This chapter concludes upon the findings from this report,on the socio-economic importance of roadside trees to the local communities and how road side tree planting can be managed Furthermore recommendations are provided, both for a research perspective and project management perspective.

10.1 Conclusion

10.1.1 Socio-economic importance of road side tree planting

- Source of income e.g. from the sale of timber, firewood, seeds and seedling.
- Increased conservation agriculture and diversification of agricultural production. This leads to more food supply and also commercial crops to be sold locally.
- Increased road stabilization hence the money used in maintenance of the road can be used for something else.
- Increased seedling and seed vendoring activities in the market thus earning income to the sellers
- Profit from selling burnt charcoal and seedlings. But due to high rate of charcoal demand, trees are cut down without replacement and hence leading to decrease in the number of trees available in the County. Sustainable production of trees to be used for charcoal is one of the opportunities to diversify and increase income opportunities for the long term.
- Increased employment; different personnel and experts can be trained who will later train other farmers on roadside tree planting, for example, during my field study, one of the farmers was chosen to assist in measurement of tree distance from the other and distance from the road, he also assisted in helping the farmers on various guidance during planting and fencing.
- This can also enhance self-employment where farmers can produce various seedlings and sell to the market and other farmers, timber production will lead to lumbering industries.

10.1.2 Improved farming, social and health conditions

Other benefits include increased yields in adjacent farmland. Farmers tend to abandon the farm along a road due to low or no yield production from the farm. For example during the previous harvest season in Kathome, farmers were not able to harvest any produce. Tree planting can help to increase water holding capacity of soils, reduce erosion and retain fertile soil in place. During drought, trees and grasses can buffer the harsh conditions. From the ecological benefits, they enhance yield production since the plants will be able to use the nutrients fixed in the farm by the rotting tree leaves. Water holding capacity of grass and trees enhances water availability to be used by plants for growths, hence the increase in crop yield production.

Tree growing has also enhanced bee keeping that leads to harvesting and selling of honey to the markets. Due to high demand of bee keeping, bee hives are also made from the tree logs that are easily accessed by the locals.

The increased water use and the saved time due to tree planting, bring about positive social and economic changes. Many of these are agricultural. The households without trees, water harvesting methods all saw a decrease in their harvest of rain-fed crops, while many had no harvest at all in the dry season. At the same time, the households with trees and water harvesting methods increased their harvest and diversified their income: they increased the number of different crops they grow and many also were carrying out irrigation.

Furthermore, households with well-educated skills planted more different species and a higher number of fruit trees. Many households also started non-agricultural (group) activities to boost their income.

These examples indicate that trees in this way provide direct benefits as an alternative source of income to farmers. As a conclusion this means that roadside tree planting can make a difference in economic benefits, demonstrating direct benefits of the sale of products from trees, as well as indirect benefits improving agricultural production, health and livelihood conditions.

10.1.3 How roadside tree planting is taking place

Many farmers mostly plant trees along the road as a fence. For example, Euphobia trees are planted closely since they provide a good fence and boundary (Farmers in Kathome).Trees are also planted on a straight line with a difference of 4ft from on tree to another to enhance good canopy formation and also reforestation before cutting down the matured tree like Ndolo-farmer in Kitui and along Mulutu-Syiongila road –trees planted by JICA (see photos in appendix 3)

Trees being planted mostly along the road include; *Sienna siamea*, Jacaranda tree species and Euphobia. This is because these trees grow fast, are drought resistant and are hardly destructed by the moving livestock and children.

Some of the challenges hindering the adoption of roadside tree planting include; insecurity, insufficient water, lack of knowledge, electric poles and wire, expansion of roads andAnts.

There are a number of options in order to manage trees in such a way to overcome the challenges and enable farmers to reap their fruits, these were faced during the road side tree planting project by AWG in Kathome/Kawongo sub-locations.
- Trees can be managed by fencing the farm on the road so as to protect them from animals who feed on them. One can protect the trees either by use of a meshed wire or sticks around the tree too.

- On the issue of water, the farmers can be trained and enhance the use of roadwater harvesting so that they can store for watering the trees during the dry seasons.
- Research institutes such as KEFRI can enhance a research on how the farmers can easily get measures on how they can protect the growing trees from ants.
- Create a competitive mechanisms to the farmer such as awarding the farmer who has planted and managed a lot of trees in a period of 1-2 years depending on the tree species, The awards can be terms of water tanks to harvest roof water or being constructed for a small dam to divert the water from the road to the dam or the zai pits. This will motivate farmers to plant more trees since they know there is reward hence enhancing the environment in the communities. The trick of award was used in Makueni county, Mayuni village and this has really converted the whole village with lot of trees well managed.

10.2   Recommendations

In this section recommendations are provided on organization and maintenance of road side tree planting activities. Based on the analysis of the actual project in Kathome/Kawongo and the results of the socio-economic impact. First of all it is important to consider that, with the planting of trees, regulations need to be implemented on how to be managed with the households that participated in the tree planting.

Second, future users should be well-educated about the operation of roadside tree planting and how to use and maintain it, with a special focus on protection of the planted trees.

This research proves that trees provide benefits, in the sense that they provide users with better social and economic standards. They prove an excellent technique of coping with drought and climate variability, and are therefore recommended to be planted in areas that face drought periodically or that will be under water stress due to future climate change.

Whereas the consequences of future climate change in combination with reduced forest cover are unclear, more research is needed in how tree planting can contribute in mitigation these effects and reviving ecosystems. Especially on micro-climates trees and vegetation has a big impact, communities could sustainably develop tree planting as an alternative source of livelihood. I therefore recommend for further studies to be done on the socio-economic importance of trees, how to make tree planting a valuable and sustainable business, and on relevant fast growing species.

I would like to recommend the following to AWG on the implementation of the project;

- Not to mix the issue of money and project for example, a few cases arose after the money was given to the farmers before whole preparation hence making the farmers be "Money oriented" rather than concentrating to the main project. This led to the decrease in number of trees being planted compared to the holes prepared really recommend the money issue to rise after the farmers have completely done the exercise as a token to

their hard work and appreciation rather than missing money issues and the project to make the project a success.

- If money is to be involved, let the first step be completed and then the farmers given the money (Money for the whole poject-Ksh.3000 was given to the farmers in advance but later on the farmers started again claiming for more money.
- Meet the farmers at least after a fortnight to get back their views and more ways to improve the project.

The following recommendations goes to all the stakeholders (AWG, KEFRI, KFS, MetaMeta and County Government at large);

- The county to enhance the effect of tree planting to the locals by planting trees for the local interior communities.
- The remuneration of community is also a major issue that can either facilitate the success or failure of the project. The farmers have to be paid the money in phases. So the whole project should be divided into phases like holing, acquiring the seedlings, and planting the seedlings (for instance they be given 20% of the money for hole making, 30% on acquiring the seedlings, 20% after planting the trees,10% for protection and 20% for watering). This would at least encourage them to move from one step to the next when they know they will get something small in the next subsequent phases).
- Introduce an incentive program where possible as a way of encouraging the community to support the project through taking care of the project. This can be attained through subsidizing the cost of taking care of the trees (giving Ksh. 5 for every successful tree per month).
- Success of this project can also be realized though sensitizing the local administration such as chiefs, sub-chiefs and village heads to encourage the community during their normal barazas and gatherings to support the project through their active participation.

REFERENCES

Bryceson, D.B, Bradbury, A.andBradbury, T. (2008) ''Roads to poverty reduction, exploring rural roads'' impact on mobility in Africa and Asia.

De Grassi, A. (2005) 'Transport, poverty and agrarian change in Africa, models, mechanisms and new way forward.'

Griffins, P.J, Hird, A.B and Tomlinson, P. (2000) "Rural road drainage design for environmental protection"

Kubbinga, B, (2012) Road runoff harvesting in the Dry lands of Sub-Saharan Africa: It's potential for assisting smallholder farmers in coping with water scarcity and climate change.

Kenya Forest Research Institute (KEFRI) through personal communication with him on 18th July 2016 and 26th July 2016

Africa Wood Grow (AWG) through personal discussions with them on 21stJuly 2016

ANSI a 300. 1995. Standard practices for tree, shrub, and other woody plant maintenance. Washington, DC: American National Standards Institute.

Fazio, et al., 1992. Don't top trees. Tree City USA Bulletin No. 8. Nebraska City, NE: The National Arbor Day Foundation.

Selma N.Elago, LisiusTjeripoTjaveondja (2005),''Socio-economic importance of indigenous fruit tree"

Bahir Dar (July 2008), Bureau of Agriculture & GRP, Road Water Road Side Plantation and management Training Report.

Katharina Welle, Rossella Alba, Jonathan Demenge, AlemuAddisu and KebedeManjur, "Where does the water flow? Roads runoff, soil erosion, groundwater, livelihoods and poverty alleviation in Tigray, Ethiopia"

Marta Agujetas Perez1, FreduNega Tegebu2 & Frank van Steenbergen1 "Roadside Planting in Ethiopia: Turning a Problem into an Opportunity"

Tony greening "Quantifying the impacts of vehicle-generated dust: a comprehensive approach "

Abdulllahetal (March 2014) the influence of roadside vegetation barriers on airborne non-particles and pedestrians exposure under varying wind conditions.

Mugo, F., R. Nungo, F. Odongo, N. Chavangi, and M. Abaru. 2007. An assessment of the energy saving potential and heat loss pattern in fireless cooking for selected commonly foods in Kenya.

Mutimba, S., and M. Barasa. 2005. National charcoal survey: Summary report. Exploring the potential for a sustainable charcoal industry in Kenya. Nairobi: Energy for Sustainable Development Africa

Orwa C, A Mutua, KindtR,Jamnadass R, S Anthony. 2009 AgroforestreeDatabase: a tree reference and selection guide version 4.0

(http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp)

APPENDIX 1: questionnaire to roadside communities

This is the question that was used to collect data from the roadside communities.

MODULE 1: HOUSEHOLD DEMOGRAPHICS

(a) Name of household (HH) head

_____

(b) Sex of HH head _____   1.Male. ⬚   2. Female ⬚

(C) Age of HH head (in years)   _____

(d) Marital status of HH head _____

    1. Married.   2. Single   3. Divorced   4.Widowed   5.Others

………………….

 (e) Level of education

1. Illiterate.

    2. Primary level (Completed) (Not Completed)

    3. Secondary level (Completed) (Not Completed)

    4. Tertiary Level (Masonry, Carpentry, Tailoring)

    5. Certificate level

    6. Diploma level

    7. Degree level

    8. Above Degree level

(f) Household members (including the head) _____

    i.   Male adults _____
    ii.   Female adults _____
    iii.   Male children _____
    Female children _____

MODULE 2: ROAD-RELATED ISSUES

    (1) Has the road construction increased the occurrence of any of the following issues?

a)   Flooding

b)   Sedimentation of farmland

c)   Dust

d)   Erosion

e)   Others: please name

2)   Has crop production decreased because of the dust from road? (No. of bags not harvested due to the effect- Specify Kgs in bags 90 or 100 kg bags)

        a. Cereals Yes, (_No. of Bags)

        b. No

3) Which crops are affected by the dust?

        a. Cereals
        b. Vegetables
        c. Fruit trees
        d. Other:

MODULE 3: SOCIO-ECONOMIC DATA

10. Do you harvest any crop? Which ones?

11. For each crop harvested during the last season can you answer the following?

CROP	How much was your harvest from last season's crop?	
	Quantity	Total value of production in KES

12. Do you have any permanent trees in your farm?

Type of tree	2 How many trees does the farm have?	3. How much did you earn the previous year from the sale of trees and/or fruits from the

		trees (amount in KES)

13. Why did you choose those trees?

14. Do you have any trees by the roadside?
YES ☐   NO ☐

Type of tree	Number of trees roadside	Type of benefit (economic, wood, medicinal…)	How much did you earn the previous year from the sale of trees and/or fruits from the trees (amount in KES) by the road	How much did you pay for each tree/seedling?

15. Why did you plant the trees by the roadside?

16. Why did you select those species?

17. Where did you get the seedlings from?

18. Did the presence of the trees reduce the dust in your farm/home?
19. When did you start emphasizing tree innovation as an inherent measure for achievement of your long term objectives? (Please tick)

Prior to 2000   2010 to 2014

2000 to 2005   2014 to 2016

2005 to 2009

   20. Did you receive any advice on which trees to plant and how to plant them?

   21. Would you like to plant more trees by the roadside? If so, which species?

   22. In your own opinion, do you recommend the county to be investing in roadside tree planting?

Yes   No

If yes, give reasons;

_____
_____
_____
_____

   23. What are some of the factors that hinder the adoption of roadside tree planting in your farm/household?_____
     _____
     _____
     _____
     _____
   24. How would you like to participate in road side tree planting?

   25. What type of maintenance/operations do you want to do in order to take care of the trees?

   26. Do you work in groups/individual?

   27. Are there any issues with the road reserve, or electricity poles and wires?

THANKS FOR TAKING YOUR TIME TO FILL THIS QUESTIONNAIRE

Below some of the question guidelines that used to do my key informant interviews.

- How do you see roadside tree planting?

- How can tree planting be part of water harvesting activities within the region?

- What benefits do you likely expect for your county by adopting roadside tree planting?

- How does the county invest in tree planting?

- When did your county start emphasizing tree planting as an inherent measure for achievement of your long term objectives

   -What kind of products have you achieved from roads construction, and environment and natural resource management, Africa wood grow, KEFRI?

- What kind of Service and/or progress has your county experienced since you started emphasizing on tree planting innovation?

- In your own opinion, do you recommend the county to be investing in roadside tree planting?

- What are challenges in the adoption of roadside tree planting in your county?

- To what extent has your organization/office derived the following benefits from the implementation of tree planting activities?

i   Expanded the rate of tree planting
ii   provided farmers with valuable information about your tree planting activities

iii   Reduced charcoal burning and wastage of tree by cutting them down

iv   Increased the life of people in the county through innovation in trees

V   Enabled you to reach narrow paths of the villages

VI   What are the benefits your county office may have derived from completing in roadside tree planting?

Seedlings from this tree are propagated and sold

Trees along the fence on the road

Stocked firewood for sale

(a) MR.Ndolos home stead

Fodder plantaion (Red oat grass)

Grapes &*Greveliarobusta*

(b) Mr.Mwova's farm.

(a)   (b)   (c)   (d)

(a) Workshop(beds, seats and bee hives are made)
(b) Road to nyumbani village where there are tree along the road
(c) Road to nyumbani village/market where there are no trees along the road
(d) Part of the farm where agroforestry is taking place (napiergrass,meliavolkensii and green grams)