WOOD FUEL IMPACT ON ENVIRONMENT IN KENYA:

A CASE OF DADAAB REFUGEE CAMPS

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REG. NO. C/50/7717/03

A Research Paper Submitted to Economics Department, University of Nairobi in Partial Fulfillment for the Award of Masters Degree in Economics Policy and Management.

September 2005

Declaration

This research paper is my original work and has not been presented for award of a degree in any other university.

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This research paper has been submitted for examination with our approval as university supervisors.

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Prof. Peter Kimuyu **Date**

Dedication

To my loving Wife Lilian, children, Victor and Michelle, parents and sisters.

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Acknowledgements

My sincere gratitude goes to all the persons who in one way or another contributed to the success of this study. First I would like to thank my supervisors, Mr. George Njiru and Prof. Peter Kimuyu for their advice and guidance that led to successful completion of the study. The UNHCR – Nairobi sub office assisted in provision of documents and gave me access to their documentation center that provided crucial information used in the study.

I also appreciate the assistance given by CARE and GTZ – Dadaab Sub offices through provision of the data used in the study. My family members stood by me during the entire research period and would like to thank them for the support and understanding.

My classmates contributed to this work through encouragement whenever I was depressed. My special thanks goes to Omondi who helped by commenting and printing my research proposal. Nthenge was there when I needed his advice on the proposal and I appreciate the concern he showed every time he failed to see me. I recognize the efforts of Florence, Mwaura and Vundi who always contacted me when I was needed in college. All the classmates in one way or another gave me morale to complete the report. I am grateful to Obisa of UNICEF for providing a computer for the entire typing.

Finally I would like to thank Jusuf Mbuno, Emma, Rebecca and Florence for proofreading my paper. I am grateful to the government of Kenya (DPM) for the support and scholarship for the masters' Programme.

Abstract

The environment is impacted by activities undertaken in most countries. In developing countries, poverty has been linked to the destruction of the environment. There are many causes of environmental destruction that necessitates strategies for reducing the rate of degradation. Fuel wood has not been regarded as a major factor in environmental degradation in many parts of the world. Many theories in the past linking fuel wood to environmental degradation have been disapproved through research that shows there has been no serious impact to the environment. These theories are based on various assumptions that have been analyzed in this paper to find out the extent of fuel wood impact on the environment.

The study focuses on Dadaab refugee camps in Garissa District. Their fuel wood practices are used as an experiment to test these theories. This focal area was chosen because it has a big settlement that can be used as an example in relation to other settlements. The area is divided into different regions to show different impacts to different areas based on the distance from the camps.

The study analyses the change in stock in different levels of harvest around the refugee camps. The area is divided into three regions to show the fuel wood use at varying distances from the camps. The first level of seven-kilometer radius indicates severe environmental degradation due to intense fuel wood harvesting. The other levels show some level of sustainability compared to the first level.

A linear model is then estimated using Ordinary Least Square (OLS) to explain the effects of issued fuel wood and stoves on the change in stock. The results of the regression on all levels indicate that issued fuel wood has a positive relationship with change in stock. This shows that increasing the amount of fuel wood issued to refugees will lead to reduced harvest which in turn reduces the

impact on the environment. These results are also applicable to issued stoves. Population has a negative impact on change in stock. However the results are insignificant at all levels.

The study shows that policies focused on issued fuel wood and stoves can be formulated to reduce environmental degradation around major settlements. Policies should also be focused on other forms of energy to reduce harvesting of fuel wood. This could include reduction of taxes on other forms of fuel and energy like kerosene, Solar panels, wind generators and electricity to enable people switch from fuel wood.

Acronyms

AFREPREN	African Environment policy Research Network
ASAL	Arid and Semi Arid Lands
DPM	Directorate of Personnel Management
FAO	Food and Agricultural Organization
GOK	Government of Kenya
GTZ	German Development Agency
KWS	Kenya Wildlife Services
LPG	Liquefied Petroleum Gas
Landsat TM	Landsat Thematic Mapper
OLS	Ordinary Least Square
RWEDP	Rural Wood Energy Development Programme - Asia
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNHCR	United Nations High Commission for Refugees
UNICEF	United Nations Children's Fund
UNPFA	United Nations Population Fund

Definition of Commonly Used Terms

Hot spots: - These are areas where the vegetation has been cleared for fuel wood or other purposes

Option Value: - This explains the value of a resource at a future time.

Existence value: - It is the value residents of a place will give for the presence of the ecosystem that may not have present monetary value.

Landsat TM: - A remote sensing technique that is used to assess, map and monitor vegetation resources to show the disparities in vegetation cover in an area.

Woody Biomass: - Explains the total weight or volume of plants in a particular area.

Fuel wood: - Unprocessed wood that is used as fuel. This is commonly referred to as firewood.

Wood fuel: - This type of energy from biomass includes both firewood and processed wood that is referred to as charcoal.

Chapter one

1 Introduction

1.1 Background Information

The evolution of energy use has been a key factor in explaining the development of mankind from primitive stage to the present modern man. Development revolutions have been based on energy use transformation through innovations, which improve efficiency e.g. from fuel wood to coal from coal to petroleum and now from petroleum to nuclear energy. The use of energy resources also affects the environment since most of them are derived from the ecosystem.

The use of wood fuel energy dates back to the evolution of man from Apes to Homo sapiens and has been used since then as the major source of energy. The majority of poor rural people in the developing world depend on this type of energy. These users of fuel wood form the majority in the continents of Africa and Asia (FAO, 2000). The percentage of wood fuel in total energy use in these countries depends on the level of development and income of the societies. The more developed and technically advanced countries tend to substitute wood fuel as a source of energy for other more efficient and higher yielding sources of energy like coal, fossil based fuels, electricity and nuclear power.

Fuel wood is the most produced and used commodity of the forests. There are at least 3 billion people in the developing countries depending on it (Persson, *et al,* 2003). The product has the highest value of all products harvested from the forests in these countries. Though this is an important forest product, Persson and FAO, (2000) agree that very little information is available on the situation of fuel wood especially in developing countries. Amazingly very few studies have been done to ascertain the true picture of fuel wood stock, demand and regeneration rate in most parts of the world.

Kenya is a developing country in which majority of its population depend on this type of energy for their daily activities. Over 67 percent of the energy requirement of the country is derived from wood based fuels. The majority of users reside in the rural areas (Ministry of Energy, 2002). The major users of the energy type are households, industries and small enterprises.

Wood fuel energy in Kenya is derived from either fuel wood or charcoal. Fuel wood is composed of logs, branches and twigs from trees and is mainly used for cooking in rural areas. Charcoal on the other hand is the main fuel used by both rich and poor urban households for cooking and firing boilers by small-scale industries.

The country's policy on wood fuel energy is to ensure adequate supplies of wood energy through sustainable yield and demand management while protecting the environment (Republic of Kenya, 2004). This policy focuses on the supply and demand side to ensure sustainable provision of this type of energy. The supply of wood fuel has to be raised to cater for the rising population to ensure that there is no environmental degradation. The demand is controlled to reduce the volume of wood fuel harvested and reduce the impact to the environment.

1.1.1 The Refugee Problem

Every year, the world witnesses conflicts in various parts of the world that result to the displacement of million of people from their home region. These displaced people add to the number of refugees who are settled in different parts of the world often in areas that cannot accommodate such population densities. The settlements are often established in a hurry without any consideration of their impact on the environment during and after their closure. No assessment is made to know whether the ecosystem can accommodate such large numbers of people.

These displaced people destroy the environment as they extract the available natural resources for food and shelter to survive the harsh environmental conditions and scarcity of food. Refugee settlements destroy the resource base of the existing local population, and distort the existing sustainability path. This results in severe environmental degradation around the camps. The increased competition for resources will also lead to conflicts between the refugees and the local community for the scarce resources. This contributes to insecurity around refugee settlements.

Refugee settlements in Kenya have been established in areas with little capacities of vegetation to regenerate to vover the amount of wood taken in a sustainable manner. This has a direct impact on the livelihood of the local community. Both natural population growth and settlement directly affect the environment. It is widely known that the quality of human life is inseparable from the quality of environment, (UNPFA 1998). The environment on its part plays a key role in the determination of poverty in Dadaab region of Garissa District (Garissa District Poverty Reduction Strategy Paper, 2001).

The United Nations High Commission for Refugees (UNHCR) acknowledges that refugees have a devastating impact in the environment. It sites the example of the impact the Rwandese refugees had on the tropical rain forests at Goma in former Zaire. Here, forests were completely destroyed for fuel wood and mountain gorillas killed for food (UNEP 2000, Wilkinson W. 2002). Although this has been identified as a problem, little has been done to reduce the effects of refugees on the areas they settle. This is because refugee settlements are established in a hurry and environmental aspects are only considered after things have gone wrong. Over exploitation of resources make local communities hosting refugees to face long-term economic implications during and after the settlements.

Refugees in Dadaab, Kenya were settled in arid areas with fragile ecosystem. Their destruction effects are worse than those of Rwandese in Zaire where the biomass is high and regenerates fast. The arid regions receive low, unpredictable rainfall and prolonged drought that makes regeneration of the vegetation slow. Plants in ASAL areas have adapted to the harsh conditions and take long to develop. It is almost impossible for the vegetation to revert to its original state once destroyed. The destruction of the environment around settlements is one of the major causes of desertification in Africa. This can be seen in form of the extension of the desert margins to once productive land (Leach and Mearn, 1988).

Environmental degradation in refugee camps occurs as a result of vegetation clearance for settlements, harvesting of firewood for domestic use, construction materials and for fencing purposes. The camps in Dadaab accommodate a total of 139,240 people within an area of 50 square kilometers (NEMA *et al*, 2003). The area can accommodate a population of at most 20,000 people given the available natural resources. Increase in population has resulted in the clearance of the nearby vegetation exposing the land to wind and water erosion, (Ministry of Planning and National Development, 2001).

1.2 Statement of Problem

The establishment of refugee settlements in Dadaab, Garissa District, North Eastern Kenya has led to vegetation depletion as a result of fuel wood harvesting. It is noted that there is a 50-kilometer radius of depleted land around the camps (Ministry of Planning and National Development, 2001). A remote sensing technique is used to assess, map and monitor vegetation resources in an area. This shows the disparity in vegetation cover and was used in Goma during the movement of refugees from Rwanda to the former Zaire. The images taken from Goma show the impact of the settlements to the surrounding environment (Wilkinson, 2002). Using the same technique of Landsat Thematic Mapper

(Landsat TM)[1] imagery for Garissa District shows wide patches of land around the camps lacking vegetation cover. There has been no research done to establish the causes of the patches around the camps. There is need to study fuel wood use by the refugees and establish what impact it has on the environment.

Deforestation is widely associated with the clearance of vegetation for agricultural expansion to cater for rising population in developing countries. Earlier studies in Kenya do not show any indication of hot spots in predominantly pastoral areas. This is because of the low population and the nomadic lifestyle of the people. The areas also have a large quantity of dead wood that is used as fuel wood by the communities (Ensminger, 1984). The region under study is part of the arid and semi-arid lands (ASAL) of Kenya that form over 70 percent of the total area of the country.

The settlement of refugees in this type of ecosystem has been a challenge to the Government of Kenya. There has been no environmental impact assessment or research done to establish the impact of fuel wood harvesting on the fragile environment. Due to lack of research on this issue, the rate of vegetation degradation as a result of refugee settlement in Dadaab region has not been established. Little is known on the major determinants of vegetation degradation around the settlements to assist in policy formulation to reduce the problem. Therefore there is an urgent need for a study to find out the rate of vegetation depletion and how various factors will respond to increasing degradation.

[1] High Resolution Satellite maps from the Department of Resource Mapping and Remote Sensing - Nairobi

1.3 Objective of the study

The main objective of this study will therefore be:-

- To find out the impact of fuel wood use by refugees on the environment around Dadaab refugee camps

Other supporting objectives in the study include;

1. Finding out whether fuel wood use by refugees in Dadaab region has any impact on vegetation cover around the region.
2. Establishing the relationship and response of various factors that may influence vegetation degradation in Dadaab region.
3. Discuss policy implications with a view to enhance conservation and sustainability of the existing biomass resources in the region.

1.4 Significance of the Study

Energy requirement by refugees is one of the basic necessities for refugee's survival. Displaced persons have always relied on the environment to provide their fuel requirement. Fuel wood remains the major source of energy for refugees in most parts of the developing world. Harvesting fuel wood is also the major cause of environmental degradation in refugee settlements. There is therefore a need to control wood harvest to a level that is sustainable (Wilkinson, 2002). It is difficult to provide refugees with other types of energy for their domestic use due to the population sizes and lack of funds. The reliance on fuel wood has led to over exploitation of vegetation surrounding their habitats.

The impact of refugees on the environment needs to be analyzed in order to come up with policies to enable the government, UNHCR and the local community to maintain a sustainable ecosystem in the area. UNHCR acknowledges that most of the camps are not rehabilitated after the repatriation of the refugees due to shortage of funds (UNEP, 2000). There is therefore a need to control the impact of the refugees on the environment and make sure there is no long-term vegetation imbalance. This will reduce the threat of desertification in the areas supporting the refugees. This can be done through identification of the major factors that accelerate vegetation degradation around the refugee camps. The factors can be used to suggest policy instruments that can assist governments in implementing programs to reduce deforestation around the camps.

The result of this study can be useful in the management of the ecosystem in areas where there are large settlements. Such areas include upcoming urban centers, squatter settlements and those of internally displaced people.

Chapter Two

2 Literature Review

2.1 Introduction

This section reviews the literature that has been put forward to explain the impact of various human activities on the environment. It looks at studies that have been attempted to explain the causes of vegetation degradation around settlement areas with a particular focus on fuel wood use and environmental degradation.

2.2 Fuel wood

Wood fuel accounts for 68 percent of the total energy requirement in Kenya (Republic of Kenya 2004). More than 80 percent of households in the country depend on this form of energy (Republic of Kenya 2001). Majority of the rural people use fuel wood because it is available within their surrounding. The high dependency on wood fuel has a direct impact on the environment as more vegetation is harvested for firewood and cleared for charcoal burning to cater for the urban population. 82 percent of the urban households depend on charcoal for their energy requirement (Republic of Kenya 2004).

Moi University Center for Refugee Studies (1998) conducted a study in Kakuma refugee camp and found that 88 percent of the total energy used by refugees came from fuel wood. Refugees find themselves without enough resources to sustain them forcing them to depend on the environment for their survival. Removal of these resources puts pressure on the environment leading to land degradation around the camps.

Increase in the oil prices locally or internationally cause increase in Wood fuel consumption. Leach (1988) argues that the wood fuel crisis in developing countries in the 1970s was as a result of the 1973/74 oil crisis. This causes households to shift from use of other forms of energy to wood fuel leading to declining forest biomass and vegetation cover. Scarcity of fuel wood led to increases in prices which were witnessed in the late 1970s after the oil crisis. The prices started declining after 1985 when oil prices fell indicating that the oil crisis had been the cause of high fuel wood prices before (Persson, 1997).

Studies on wood fuel energy in Asia in 1970s indicated that there was a doom scenario in most countries. Under the fuel wood gap theory (RWEDP, 1997), research indicated that demand for wood fuel increased at the same rate as the population of the country. These studies had used projected population and per capita fuel wood consumption that showed a widening gap between demand and supply of fuel wood. Persson and shepherd, (2003) explains that a survey in India found out that there was a demand gap of 86 million tons. This meant that there was a decrease of 1 to 2 percent of India's forests. He also indicated that Food and Agricultural Organization (FAO) had in their list 1.2 billion people facing fuel wood shortage in 1981. The number was projected to rise to 3 billion in the year 2000.

Leach and Mearn, (1988) in a study in Sahelian countries found that harvest exceeded supply by 70 percent in Sudan, 75 percent in Nigeria, 150 percent in Ethiopia and 200 percent in Niger. This meant that current stocks of forest wood were being depleted. Forests were cleared due to the high population growth rate in these countries. The fuel wood gap theory raised concerns which persuaded development agencies like the World Bank, IMF and UNDP to establish projects to avert future fuel wood shortages.

In Kenya, researchers agreed with this theory. Consumption of wood fuel was seen to grow at a rate of 4 percent, which was the prevailing population growth rate at that time (Karimi, 1988). The high population growth rate and rising poverty levels in developing countries are regarded as a major cause of increasing use of wood fuel as a source of energy. This is confirmed by Shepherd, (1990) whose work showed that population increase in developing countries was a major cause of deforestation and desertification. Following the same theory, the forest department in Garissa predicted complete clearance of vegetation in Dadaab, Jarajilla and Liboi Divisions in five years time from 2004 (Hussein, 2004).

This theory has been disputed in many forums in UNEP meetings and studies done in recent times. This is because most of the information used to come up with these conclusions were mere guesses (Persson, 1997). The data used made assumptions that were not convincing. The assumptions included lack of vegetation re-growth after the forests were cleared, no coppicing after harvesting and did not take into account biomass harvested in rangeland that is outside the forests.

They also failed to take into account the technological advancement, efficiency improvement and switching from wood fuel to other types of energy. When faced by shortages, households consume less fuel wood through reducing wastages by improving efficiency. As a result, demand for wood fuel in Kenya has been rising but not at the same rate as the population growth. High population is considered to be a cause of rising demand for wood fuel in Kenya (Karimi, 1988). However, per capita consumption has decreased from 1000 kilograms per year in 1980 to 737 kg per year in the year 2000 (Ministry of Energy, 2002). This is as a result of end use efficiency, changes in food types and substitution with other energy types by households in deficiency areas.

Wood fuel consumption per capita for the refugees in Dadaab has been declining with time (Owen and Igwe, 2004). A study conducted by GTZ in 1998 showed that the per capita consumption was an average of 1.5 kilograms per person per day while in 2004 the study by Owen indicated an average of 1.3 kilograms. Smaller households have higher fuel wood consumption per capita compared to larger families. They consume 2.4 and 0.9 kilograms respectively. The reduction in consumption can be attributed to scarcity of the commodity, use of energy saving stoves and awareness of more efficient ways of getting energy from fuel wood.

The reduction in the per capita consumption does not mean the environment is less affected by wood fuel harvesting. On the contrary, the increase in vegetation degradation has the population increases at a faster rate than the decrease in per capita consumption. This indicates that more wood fuel is consumed and harvested in the country each successive year. This has caused ecological transformation bringing changes in the ecosystems that have affected both the floral formation and the animal species balance in the country.

Poverty is a major factor in determining the type of fuel to be used in the developing countries. Majority of Kenyans are poor with 56 percent of the population living below the poverty line (Republic of Kenya, 2001). Majority of the poor and the middle class households use wood fuel for their energy needs. This is because the commodity is freely available in their surroundings. The cost of wood fuel is also lower compared to other forms of energy like kerosene, LPG and electricity. As a result, more people use this form of energy in less developed countries than any other form (McElwee, 2001).

In Kenya, the urban poor and the rural households are the major users of wood fuel energy with ninety three percent of the rural households using this form of energy (Republic of Kenya 2001). Hosier, (1984) explains that wood fuel is an inferior good and rising poverty levels will tend to increase its demand. However, increased real incomes for the population would cause households to shift from this type of energy to more efficient clean ones like electricity, liquid petroleum gas (LPG) and kerosene.

Most of the poor are unemployed and engage in all types of small scale income generating activities in order to raise money to support their families. Majority of those living in the rural areas use available environmental products to supplement their farm output (McElwee, 2001). Charcoal worth Kshs. 17.5 Billion was used in the country in the year 2000. Of this value, 11.9 Billion worth of wood ended up in urban areas through commercial selling (Republic of Kenya, 2004). The activities involving fuel wood trade occurs during droughts when farmers get fewer harvests from their farms. The refugees on the other hand engage on these activities to earn money to supplement the food ration they get from the UNHCR. Commercialization of wood fuel energy without proper checks will lead to biomass reduction.

Some studies have indicated that wood fuel energy use is not the major reason for exploitation of forests in the world. Forests are cleared as a result of population pressure and need for agricultural land in areas where intensive agricultural practice is not practiced (Kats, 1994). This is true based on the fact that clearance of forests occurs due to other purposes like agriculture expansion and timber harvesting. Fuel wood becomes a bi-product of other activities (Shelpherd, 1990). Wood fuel harvested from the cleared forests will last for a short period. The population turns to the nearby environment for their energy requirement. The remaining vegetation is cleared before regeneration can take place leading to depletion of the forests in the affected areas. Though wood fuel demand may not be the leading cause of forest removal, it is one of the major causes of vegetation depletion in most parts of high population density regions in the country.

2.3 *Literature on Environmental Impact*

Repetto and Holmes (1983) identify high demand for fuel wood as one of the causes of deforestation in developing countries. High population densities are associated with high consumption of wood fuel causing vegetation depletion around settlements. This has been noticed in Zaire (Berbier *et al,* 1991) where deforestation results in creation of centrifugal rings of bare land around the settlement centers.

Natural vegetation is a renewable resource that can regenerate (Ministry of Environment, 1994). Using this resource well with ultimate planning and conservation in practice can lead to efficiency and sustainability. However, over utilization of biomass products that include fuel wood can result to depletion of some species within the flora and fauna. Economists argue that resource allocation will be done efficiently through the market forces based on pricing system and other factors (Perman *et al,* 1999). Property ownership plays a key role in determining the use of resources in a community. In areas where there is private ownership, resources are utilized in an efficient way because there will be consideration of future use leading to better management to preserve them.

In the case of common property resources are managed through rules and regulation set communally to ensure sustainability. Perman, *et al,* (1999) explains that there are punitive measures set by the community to make sure there is no misuse or over exploitation of resources in such a situation. The establishment of settlements of non-resident population in common property areas dilute the rules and regulation leading to over exploitation of the resources. The settlers will have an open access property ownership situation where every person is free to extract resources without consideration to preserve for future use. Harvesting of resources under the open access will lead to depletion of the resources, which Pearce *et al*, (1998) refers to as the tragedy of commons.

Collection of Fuel wood is done selectively with some plant species being preferred to others. It has for example, been found that only 30 percent of tree species are preferred for fuel wood in the Miambo woodland around Lake Malawi (Abbot and Homewood, 1999). High-density wood tends to have less moisture content and burn slowly with higher energy output (Kituyi, 2002). Other plant species have chemical composition that are preferred or rejected due to health factors. These preferences will have two major effects on the environment. First those preferred may be extracted to extinction due to excessive harvesting. Their true cost may not be clear because they have option value that can be important for future use. The plants have existence value especially to the local community that is not taken into consideration. Secondly, those not preferred may regenerate and reduce the impact of wood fuel extraction. The overexploitation of the preferred species may cause high regeneration of the other species leading to colonization.

Forests and woodlands act as home for a wide range of flora and fauna that forms the biodiversity of the country (KWS, 1999). The ecology is based on interdependence between different species that explain their coexistence to form the ecosystem. Excess wood fuel harvesting results in destruction of ecosystem through removal of plants that make are a vital link in the maintenance of the ecological balance. The coexistence is based on the linkages existing between plants and animals.

When done well, Fuel wood collection has minimal negative impact on the environment. This is because destruction is not widespread as compared to commercial harvesting for timber. Studies on collection of dead wood indicate low destruction of vegetation, a theory that ha been used to come up with this conclusion (Berbier *et al,* 1991). This happens when women and children, who focus on dead wood, twigs roots and leaves, do the harvesting. Sekhwela, (1997) in a study of biomass use in Botswana concluded that collection of fuel wood by women and children for domestic use leads to little deforestation compared to harvest for commercial purposes. This has led to many studies making conclusion that fuel wood collection has no impact on the environment.

Rising population leads to competition for the fuel wood causing shortages. The shortages are noticed though the longer distance traveled to the source, commercialization of the activity, change of roles of gender and nutritional changes (Hossier, 1984). In Kenya, reduction in the availability of dead wood has resulted in commercialization of wood fuel activities and men taking over the business (NEMA *et al,* 2003). A study in Vietnam indicates that women and children collect fuel wood at short distances from their homes. For longer distances, men engage in business through mechanization of the trade. Commercial wood fuel results in cutting of live trees in the nearby available woodland to reduce costs and make profit at the expense of the environment. The wood is dried and sold in the market as fuel wood. It can also be processed as charcoal for urban and some rural based users.

Depending on the part of the country, cutting of live trees is done during some periods of the year to prepare for certain seasons. McElwee, (2001) found that harvesting live wood in Vietnam took place early enough before the wet and cold seasons. Wet seasons were avoided as transportation was hampered by poor infrastructure because it was done using mechanized means. The harvesting is done in both commercial and household harvesting to meet high demand experienced during these seasons.

Excess harvesting of fuel wood leads to depletion of vegetation species that make the best wood fuel supply. This forces the communities to use young trees, small plants and perennial vegetation that are important in the control of service runoff. Shortage of fuel wood forces the population to use other forest products like tree barks and dry leaves for their energy requirements (Kirubi *et al, 2002*). These forest products are important in vegetation regeneration and completing nutrient cycle of the soils. The large settlements in the high potential areas with diminishing supply of wood fuel have resulted in the use of these products. This has led to serious soil erosion and lack of vegetation in most parts of the country.

The impact of the depletion of the vegetation cover includes acute soil erosion as the land is not protected and all agents of erosion will degrade the land. Moi University Center for Refugee Studies (1998) made some studies in Kakuma refugee camps and found wide spread erosion, which they attributed to the removal of vegetation. This was noticed in form of gullies and collapsing riverbanks in the affected areas.

The silt finds its way into pans and dams that are the major sources of water for domestic and livestock use. This leads to lower capacity of pans and dams reducing the livestock holding capacity of the region during the dry seasons. The government of Kenya has already spent a lot of money to excavate the pans for use, (Ministry of Planning and National Development, 2001).

Major rivers and waterways are filled with silt from water catchments areas causing floods at lower levels of the river course. Floods destroy the agricultural produce and other investments of the population living along the rivers (Ministry of Agriculture, 2002). This result in increased poverty in the affected areas as government is forced to abandon development projects to provide relief food to the affected population. The silt is also deposited in reservoirs that store water for power generation and thus lowers the hydroelectric power generation capacity. This affects the manufacturing sector that rely on energy from the power stations hence has a negative impact on the economy of the country.

UNHCR (1998) acknowledges that lack of proper environmental management around refugee camps would lead to lack of continuous flow of water that forms part of the ecosystem in the affected areas. The destruction of this ecosystem can lead to destruction of the resources that constitutes their source of livelihood of both the local people and the refugees. The impact may threaten the security of both the host community and the refugees. This situation may threaten the institution of asylum as hostilities develop.

The ecosystems in the ASAL areas form part of the national and globally complex and fragile ecosystem that needs to be conserved (Ministry of Environment, 1994). Conservation of these ecosystems depends on many factors including the climatic condition, types of soil, cultural factors, and the resources used by the local people. Disturbance of these ecosystems could have irreversible effects on the local population. Population growth rate and harvesting rate of resources in these areas should be balanced to ensure sustainability of the ecosystem.

The populations in the rural areas depend on resources from the natural environment for their economic activities. They harvest fruits, construction materials, herbal medicines and pasture for their livestock. The trees that provide these products are part of the vegetation harvested for wood fuel energy. Destruction of the environment through wood fuel harvesting reduces the availability of these resources forcing the people to look for other alternatives. In most cases, the people resort to looking for jobs in urban areas thus creating more settlements. These settlements further affect the environment through high demand for charcoal and overpopulation with regard to both human and livestock in the region.

2.4 Policy Literature

The country's policy on wood fuel energy is to ensure adequate supplies of wood energy through sustainable yield and demand management while protecting the environment (Republic of Kenya, 2004). This policy focuses on the supply and demand side to ensure sustainable provision of this type of energy. The supply of wood fuel has to be raised to cover the rising population to ensure there is no environmental degradation. The demand is to be controlled to reduce the volume of wood fuel harvested and reduce the impact to the environment.

The government has banned the production and transportation of charcoal while the sale and use of the commodity is legal (Kituyi, 2002). This policy forces illegal production at the rangelands and dry areas mostly owned by the government. The activity is done in haste with no consideration of its impact on environment of these marginal areas.

Kituyi, (2002) further explains that, the illegal production involve indiscriminate cutting of trees to produce a given amount of charcoal. Those who produce use inefficient kilns that require many logs to make a ton of charcoal. Use of efficient kilns can reduce the wastage. This can be realized when the activity is legal and if producers are trained on the production. The impact has always been an environmental degradation in the source areas.

The country has put up policies aimed at the reduction of the impact of wood fuel use to the environment. The policies are formulated through different sectors that are involved in the production and use of biomass from the environment. These policies have had mixed effects on the impact on the environment of the country and need to be studied to come up with the actual impact of wood fuel use to the environment.

The removal of wood fuel from different parts of the country before 1970 was so intense such that there was a negative impact on the environment (Karimi, 1988). There was a need to act through formulation of policies that would guide the supply and demand of this type of energy. The focus was on the improvement of supply to minimize the impact to the environment. Wood fuel supply can be improved through various interventions that are aimed at making sure that the required amount of wood fuel is available for the country population.

This forms the basis on which the policy was developed to reduce the negative impact of the inability of the environment to supply enough wood fuel as required by the population. The country through the Ministry of Environment and Natural Resources focused on the planting of trees through community forestry in the early 1970s (Karimi, 1988). The plantations were outside the gazetted forest areas that were the major government focus before then. This was aimed at increasing the availability of wood fuel around the communities with acute shortages while at the same time improving the environment.

Major users of fuel wood as a source of energy had established their own forests especially tea factories for drying tea leaves, tobacco factories for curing of leaves and Kenya railways for their steam engines (Kaale, 1990). These plantations were established in Kericho, Kisii, South Nyanza, Thika and Kiambu Districts that were near the factories and point of use. The forests helped in the preservation of forests and other sources of fuel wood in the surrounding districts. They were important in the control of environmental degradation caused by high demand for fuel wood by the factories.

The energy policy through the Ministry of agriculture has focused on agro forestry practices in the high potential areas. These areas have large settlements and experience acute shortage of wood fuel. Trees planted for other purposes are finally utilized for wood fuel (Leach and Mearn, 1988). This includes trees planted for fodder, food, fruits and for building materials. Once the trees are used for the original purpose, the residue is then used as firewood or for the production of charcoal. This effort saw an improvement of woodlots contribution to fuel wood from 47 percent in 1980 to 64 percent in the year 2000. Majority of these came from high potential areas (Ministry of Energy, 2002). The ASAL areas have low survival rate of seedlings reducing the success of agro forestry and forest plantations in the country.

The forest department has put policies that focus on the protection and production of woody biomass in different ecosystems. The department takes care of gazetted indigenous forests, woodlands, bush lands and mangrove to preserve them (Ministry of Environment, 1994). The policies ensure the forests are managed professionally to preserve the biodiversity, conserve soil and water and for continued supply of services and products to the local community on subsistence level.

Forests and other types of woodlands that fall under the county council are supposed to be managed professionally to sustain the local communities. However, in most ASAL regions the councils lack professionals to manage their woodlands causing over exploitation of resources without proper controls. In areas of large settlements, the councils lack scientific ways of analyzing the impact of the environment and make decisions to address the issue.

Reduction in the use of fuel wood could be done through use efficiency where more energy is recovered from the same amount of wood. The fuel wood efficiency of most traditional stoves ranges from 10 to 12% in Kenya and Vietnam (Kituyi, 2002, McElwee, 2001). Improvement of stoves can lead to more energy from less wood and cut the amount of wood used by 10 to 50%. Reduction in the amount of wood used can be an important step in the campaign to reduce environmental degradation. Reduction in wood fuel consumption will improve the environment because less biomass will be harvested from the environment. This is a policy that has been on trial in most countries in mitigation of the gap theory of the 1970s. This has not been successful in rural area because households find fuel wood cheap and within reach in their environment. In the urban centers and high population density areas, the campaigns have been successful because wood fuel is not free and part of the income is spent on energy.

Charcoal burning causes between 0.05 ha and 0.1 ha of woodland depletion depending on the type of kiln used (Kituyi, 2002). This may be higher in the Arid and Semi-arid environment due to the sparse population of notable plants that can be used for charcoal production. Charcoal produced in the country is done using inefficient kilns that require large amount of biomass to produce a lorry load of the product. This has been a major cause of environmental degradation in the Arid and Semi Arid regions of the country. Policy actions have been based on the efficiency of charcoal production through training the producers to use new technology and reduce wastage of biomass during production.

The production of charcoal illegally has led to inefficiency as producers do it in haste and use low efficient kilns that require large quantities of biomass to produce a certain amount of charcoal. The traditional earth kilns have 10% to 20% efficiency (Kituyi, 2002), which may be worse when production is illegal.

The improved kilns have an efficiency of over 30 percent and can reduce the harvesting of trees for charcoal production thereby saving the environment (Ministry of Energy, 2002).

Wood fuel prices do not represent the actual cost of producing the trees that are harvested for use. Fuel wood in the rural areas is readily available and is collected free of charge without considering the cost of raising an equivalent biomass producing trees to maturity. The only cost reflected might be the scarcity cost, which is travel cost of those sourcing for the commodity (Hossier, 1984). Wood fuels harvested in government forests were formerly based on government rate of Kshs. 107 per ton while in the farmlands cost up to 1250 per ton. The price at the farmland could have some scope of maintaining plants from the time of planting to harvest (Ministry of Energy, 2002).

2.5 Overview of the Literature

Wood fuel has been the primary source of energy since the beginning of civilization. This type of energy can regenerate with time and is regarded as renewable energy. It has been able to sustain population until the civilization period. For ages, the population has been low enough for regeneration to offset the demand. Use of this type of energy with increasing population explains the negative effects on the environment seen in most parts of the world. In Kenya, this has contributed to the reduction of forest cover and to a greater extent desertification process in the Arid and Semi Arid areas of the country.

Empirical literature suggested that there was a crisis in most of the developing countries. This was as a result of excess demand of fuel wood over the supply provided by the vegetation growth rate. The argument was based on fuel wood consumption per capita being linked to population growth rate. This argument has been disputed because it was based on data that was not accurate and did not cover some factors that determine the use of fuel wood. Research has found out that the population will react on fuel wood shortages by switching to other types of biomass like farm residues and fossil based sources of energy. These copping mechanisms were not considered in the gap theory.

Studies in mid 1980s indicated low level of environmental degradation. Researchers based their argument on collection of dead wood for fuel wood by women and children. They found out that collection of dead wood did not affect the standing stock of biomass in any region.

Resent studies using high-resolution satellite pictures indicate an increasing clearance of vegetation around major settlements in Africa. There is debate on whether fuel wood use has any part to play in this vegetation degradation. The new evidence has led to many studies being done on other causes of vegetation depletion around settlements in Africa. Though fuel wood use is a probable major cause of vegetation degradation, little has been done to ascertain this. Studies in different parts are required to find out whether there is an impact of wood fuel use on the environment around these settlements. There is need to focus on different effects at different level in the areas surrounding the settlements.

Chapter Three

3 Methodology

3.1 Model Formulation

The concept of fuel wood use and the environment is pursued through analyzing data in two ways. First the rate of biomass degradation within a radius of 50 KM from the camps is calculated using the reduction in stock in different levels. This is shown by the difference between current stocks based on the growth rate and the harvest during the period. Secondly, the reaction of the various factors that may affect the rate of harvest is regressed to find out their impact on biomass removal from the refugee surrounding.

According to Baumol and Oates, (1988) the stock of wood is taken determined by the growth rate $\mathbf{g(t_1)}$, harvest rate $\mathbf{h(t_1)}$ and the previous stock $\mathbf{S(t_0)}$.

$$S(t_1) = f[g(t_1), h(t_1), S(t_o)]$$

$$S(t_1) = S(t_0) + \int \{g(t_1) - h(t_1)\} dt$$

$$\Delta S(t_1)_i = g(t_0) - h(t_0)$$

Where;

$S(t_1)$ – Denotes stock at the end of the end of the period.

$S(t_0)$ – Denotes stock at the beginning of the end of the period.

This change in stock is the difference between the growth of biomass and the harvest. If the harvest rate is higher than the growth rate that is h (t_1) is greater than $g(t_1)$ it means that the stock is decreasing and there is degradation of the environment and no sustainability in future.

Biomass stock change is expected to be a function of the population (**POP**), number of energy saving stoves supplied (**IS**), fuel wood brought from outside the study area (**IF**). A regression is carried on to find out the correlation between the change in stock and the other variables that are assumed to affect the biomass stock in the refugee environment.

$$\Delta S(t)_i = [POP_t, IS_t, IF_t]$$

The study uses a linear model based on the notion that the independent variables have a linear relationship with the dependent variable.

$$\Delta S(t)_i = a_0 + a_1 POP_t + a_2 IS_t + a_3 IF_t + e_t$$

Where:

- $\Delta S(t)_i$ is the change in stock of woody biomass at time t in tons
- POP_t is the population of the refugees at time t.
- IS_t is the number of improved stoves issued to the refugees.
- IF_t is total amount of fuel wood issued to refugees by GTZ in tons
- e_t is the error term.
- a_0, a_1, a_2, and a_3 are coefficients of the independent variables.
- i = 1, 2, 3 and 4 and represents different levels.

Where - Level 1 is 7-kilometer radius from the camp, Level 2 is the next 10 km after first level, Level 3 is the next 15 km after second level and Level 4 is 50-kilometer radius in the camps.

The study uses Ordinary Least Square (OLS) technique in the regression to find the response of these factors to the decrease in vegetation cover. The study uses Eview programme to regress the model.

A diagnostic test using unit root test is done to test for stationarity.

3.2 Hypothesis testing

In order to find the impact of variables on the change of biomass, the study tests several hypotheses namely;

H_0: $a_i = 0$ That is the independent variables have significant impact on the dependent variable.

H_1: $a_i \neq 0$ That is the independent variables have no significant impact on the dependent variable and are as good as zero.

For i = 0, 1, 2 and 3

3.3 Expected Results

The regressions were expected to show various reactions to change in the biomass in the surroundings of the refugees. A strong positive relation was expected between change in vegetation cover and number of energy saving stoves supplied and fuel wood brought from outside the study area. Population was expected to have a negative relation with the change in vegetation.

3.4 Definition and Measurement of Variables

Change in stock (ΔS)

This is the change in woody biomass stock in tons due to fuel wood harvesting in four levels within a radius of 50 kilometers from the camps. This was calculated based on the fuel wood consumption of the refugees.

Population (POP)

This is the number of refugees in a particular year. The population is influenced by growth rate and registration of more refugees in the camps. These figures are available from the UNHCR.

Energy Saving Stoves Supplied (IS)

This includes the number of energy saving jikos made for the refugees through the rescue programme under GTZ. These are stoves that use fuel wood.

Issued Fuel (IF)

This includes all fuel wood in tons issued to the refugees under the rescue project under the GTZ. The wood is brought from over 60 kilometers outside the study area.

3.4.1 The Study Area

Dadaab refugee camps are found in Garissa District in North-Eastern Province of Kenya. The inhabitants of the district are predominantly nomadic pastoralists. The environment of the area is arid composed of bush land vegetation (Ensminger, J. 1984). The region receives low and unreliable rainfall causing low vegetation growth rate compared to the high potential areas in the country. The soils in this part of the country are also sandy mixtures that are not fertile enough to support intense vegetation.

The area experiences frequent droughts and low rainfall of about 434 mm per annum (Ministry of Planning, 2001), which is not enough to encourage vegetation regeneration. The rainfall is unreliable with some short periodic torrential down pours that do not support high vegetation growth rate. High temperatures and long periods of sunshine cause high evaporation rates making it difficult to retain moisture leading to low survival rate of seedlings once planted. This environment is fragile and given the low vegetation cover requires conservation measures to avoid desertification.

3.5 Data Source

The study uses secondary data based on information collected on monthly basis by the organizations dealing with the refugees in Dadaab refugee camps. This is time series data from documents prepared by the following organizations;

1. GTZ annual reports and environmental monitoring surveys provided refugee energy consumption and the number of stoves given out.

2. UNHCR reports on the status of refugees in Dadaab camps provided data on the population of refugees at different time.

3. Ministry of Environment and National Resources provided the woody biomass growth rate in the district.

4. Ministry of Energy provided information on the conversion rates of different wood fuel.

3.6 Scope of the study

The study covers a period of four and a half years from 2001 to 2005 based on monthly data as recorded during monthly rations. It focuses on four levels of harvest within a 50-kilometer radius from the refugee camp, which is expected to be the major harvesting zones of refugee household fuel wood requirement.

Chapter Four

4 Findings

4.1 Introduction

This section analyses the data as indicated in chapter three to show the behavior of each variable. The chapter gives the findings of the regression indicating the impact of the independent variable to the dependent variable.

4.2 Data Analysis

The first phase focuses on the change in the stock of biomass as a result of fuel wood harvesting. Harvesting is done in different levels depending on the part of the family engaged on the exercise. Women and children tend to collect fuel wood at the precinct of the camps up to an average distance of seven kilometers from the camp. This is based on the distance they have to travel to the source and the degree of insecurity as they move further from the camps.

Beyond the seven-kilometer radius men take up the activity with semi mechanized ways of transporting the commodity. Wheelbarrows and donkey carts are used to carry fuel wood due to the distance involved. This area of harvest stretches up to seventeen kilometers from the camps, which is ten kilometers beyond the zone of women and children area of harvest. Harvested fuel wood for sale in the camps is done beyond fifteen kilometers from the camps. This is because high quality fuel wood is required for sale and the quality improves as one travels further from the camp. The study has a fourth level that combines the three levels above to get the impact of fuel wood harvest on the 50-kilometer radius within the camps.

4.2.1 Change in Stock

The change in stock is calculated based on the four levels stated in section 4.2 above. Considering the fuel wood consumption rate provided by the GTZ and UNHCR in Dadaab refugee camps, there is an acute deficit in the stock of fuel wood.

Calculating the change in stock is done in four levels as indicated in the methodology section. The first section of seven kilometers shows heavy harvesting as most of the fuel wood consumed is collected by women and children who cannot go very far from the camps. The section shows acute deficit when considering the biomass growth and harvest rate in the section. The harvest is three times more than the growth rate of biomass of this section. This can lead to acute land degradation in the region based on the mean biomass loss of 809.597 tons per month compared to the harvest of about 2518.597 tons leading to over harvest by a mean average monthly deficit of 1709 tons. The deficit indicates that the standing stock will be harvested and may lead to complete lack of vegetation if not checked.

The second level depicts the next ten kilometers after the first seven kilometer section. Men who use mechanized means to transport the commodity harvest this section. They use wheelbarrows and donkey carts for the transport from the source to the camps. The area seems to have less pressure with a monthly mean harvest of only twenty five percent of the woody biomass growth rate being harvested as fuel wood. Based on this finding the section is seen to be sustainable with little impact on the vegetation of the area. However, the acute shortage in the first section may lead to increased harvesting in this section causing some impact in the woody biomass stock.

The third section covers the next fifteen kilometers from the previous section. Traders who harvest fuel wood to sell to other refugees in the camp using mechanized means harvest the section. There is little impact with only 12.2 percent of the monthly mean growth rate being harvested. The little impact can be explained by the expansive area and the distance involved. Given the small change in the stock, involved in the section, there can be sustainability assuming the deficit in other sections do not increase harvest in this zone.

Combining all the sections to give the picture of the whole area affected and the total harvest indicate that there is enough growth rates to support the refugee population in Dadaab region. Harvest is only 45.1 percent of the woody biomass growth rate meaning that vegetation is not in danger of depletion. Many researchers have used this argument to come to the conclusion that fuel wood use has no meaningful impact on the environment without considering different levels of harvest.

4.2.2 Regression Analysis

The regression is done in four levels where each section is analyzed separately to identify the relationship between the variables and different changes in stock of the sections of fuel wood harvesting.

4.2.3 Stationarity Tests

For successful use of time series data, stationarity is important for dependable results. A test of stationarity of the variables using unit root test produces the following results.

***Table* 1; Unit Root Test Results**

	IF	IS	POP	DPOP
ADF Test	- 5.448	- 6.555	- 1.951	- 7.206
Critical Values 1%	- 3.555	- 3.555	- 3.555	- 3.555
5%	- 2.9157	- 2.9157	- 2.9157	- 2.9157
10%	- 2.5953	- 2.5953	- 2.5953	- 2.5953

Stationarity tests using unit root tests indicates that population is non-stationary with absolute figures below the critical values at 1, 5 and 10% levels. The variable had to be differenced once to make it applicable in the model. The other variable exhibited stationary trends using the graphical and unit root test.

4.2.4 Regression Results

The first regression for the seven-kilometer radius indicates that there is strong relationship between the independent and the depended variable. The results are given in the table 1 below.

Table 2; Dependent Variable $\Delta S(t)_1$

	Constant	POP	IF	IS
Coefficient	- 224.651	- 0.026	0.605	0.199
T- Statistics	- 58.972	- 1.596	21.257	2.087
S.e	38.012	0.016	0.029	0.095
Probability	0.000	0.117	0.000	0.042
R^2	0.90347			
Adjusted R^2	0.8977			
Durbin Watson Stat	1.1492			
Prob (F statistic)	0.0000			

The results for issued fuel wood are significant at all levels indicating that this variable is significant in explaining the variation of change in stock. The results of the issued stoves are significant at 5 and 10 percent levels. Results for the population are insignificant at all levels meaning that the variable does not explain the variation in changes in stock well.

The estimated coefficients results conform to the hypothesis that issued fuel wood and stoves have a positive impact on reduction of stock. This means that increasing the number of stoves issued to refugees will indicate less harvest and more stock left in the region. Increasing the amount of fuel wood issued to the refugees will also reduce the rate of fuel wood harvest and improve the biomass stock in the zone.

The population has a negative impact on the environment as expected. This means increased population will cause more damage to vegetation in the region. The constant at this level is negative indicating that intercept takes place below zero. The result has a R^2 of 0.903 and adjusted R^2 of 0.8977, which means that the independent variables explain about 89.77 percent of the variations in the change in stock at this level.

The results of the second zone show the same characteristics as in the first 7-kilometer radius. The relationship of the variables exist and the results are as in table 2 below

Table 3; Dependent Variable $\Delta S(t)_2$

	Constant	POP	IF	IS
Coefficient	2789.085	- 0.011	0.252	0.083
T- Statistics	176.098	- 1.596	21.257	2.087
S.e	16.838	0.007	0.012	0.040
Probability	0.000	0.117	0.000	0.042
R^2	0.90347			
Adjusted R^2	0.89768			
Durbin Watson Stat	1.1492			
Prob (F statistic)	0.0000			

The results for issued fuel wood are statistically significant at the second level, meaning that the variable is important in explaining change in stock at this level. However, the coefficient is less than that of the first level. This shows that increasing the amount of fuel wood given to refugees will reduce the impact to the environment but at a lower magnitude compared to the first level.

Results for issued stoves are statistically significant at 5 and 10 percent level. This implies that the result explain up to 95 percent of the changes in stock. Issuing stoves to the refugees will reduce the consumption of fuel wood that means low harvests and small changes in stock.

The coefficient of population shows a negative relationship to the change in stock as expected. However, the results are statistically insignificant at 1, 5 and 10 percent levels. This shows that the variable has minimal significance in explaining change in stock at this level. The constant is positive indicating a positive intercept as compared to the first level.

The results show that the independent variables explain about 89.77 percent of the changes in stock. This is shown by adjusted R^2 of 0.8977 as in the first level.

The third level regression shows same relation but the coefficients are different in each level indicating that variables have different impact on change in stock in the four levels. The results are given in table 3 below

Table 4; Dependent Variable $\Delta S(t)_3$

	Constant	POP	IF	IS
Coefficient	4408.349	- 0.006	0.151	0.050
T- Statistics	463.892	- 1.596	21.257	2.087
S.e	9.503	0.004	0.007	0.024
Probability	0.000	0.117	0.000	0.042
R^2	0.90347			
Adjusted R^2	0.8977			
Durbin Watson Stat	1.1492			
Prob (F statistic)	0.0000			

The results are an indication of the expected results with positive relationship issued fuel wood, issued stoves and the change in stock. The population has a negative relationship as expected. The results for issued fuel wood are significant at all levels while those of issued stoves are significant at 5 and 10 percent level. Population results are insignificant at all levels.

The regression result at this level indicates that the independent variables explain 89.77 percent of the changes in the stock. The probability of F statistics indicates that all variables significantly explain the changes in stock at the four levels of regression.

The final regression combines the impact for all the zones within 50-kilometer radius of the camps. There is clear indication that issued fuel wood has strong impact on the change in stock and can be used as a mitigating factor in the reduction of vegetation degradation in the refugee camps.

Table 5; Dependent Variable $\Delta S(t)_4$

	Constant	POP	IF	IS
Coefficient	4955.784	- 0.0425	1.009	0.133
T- Statistics	78.225	- 1.596	21.257	2.087
S.e	63.353	0.0266	0.047	0.159
Probability	0.000	0.117	0.000	0.042
R^2	0.90347			
Adjusted R^2	0.8977			
Durbin Watson Stat	1.1492			
Prob (F statistic)	0.0000			

Results at this level of regression show same reactions as in the first three levels. The coefficients at this level are higher compared to the others. This is an indication the variables have strong effect on the combined the region compared to the individual levels.

In the first level, changes in the independent variables lead to a bigger influence in the dependent variable. This shows that a greater change in the independent variable will have a larger change in the dependent variable compared to the results of levels two and three. The combined analysis indicates a higher response compared to level two and three.

4.2.5 Assumptions and Limitations of the study

The study made some assumptions that include: -

1. Biomass growth rate remains the same and there is no significant climatic change during the study period.

2. Population of the local community is small and the nomadic nature of their lifestyle makes them not to have any significant impact on the environment.

3. The tree seedling planted and the land protected for regeneration will take long to mature and have influence on the woody biomass change because the indigenous trees planted take long to mature.

The study used secondary data that could have been collected for other purposes without the idea of the impact of fuel wood on the environment. It could have been more encouraging to collect primary data to capture all the required parameters of the study. However, this would require a lot of funds and time to cover the surveys.

There are also other variables that are important in determining the rate of harvest of fuel wood in Dadaab region that have not been considered. These include security in the region, use of other types of fuels among the refugees and other uses of forest products in the region. It was assumed that these variables have no major influence on the model.

Chapter Five

5 Conclusion and recommendations

5.1 *Introduction*

This chapter gives the conclusion reached after the data analysis and regression of the variables in the previous chapter. Areas with probable Policy recommendations are identified and explained as indicated in the objectives of the study section. The section will also show the areas of further research that is related to the topic discussed.

5.2 Conclusion

The results of the changes in the stock of wood indicate that there is some level of degradation especially in the region surrounding the camps. Harvesting fuel wood can explain the presence of degraded land surrounding major settlements in the third world. Though recent researchers have argued against a wide spread environmental degradation, it is clear that there is impact when considering different levels of harvesting. Prolonged fuel wood harvesting can therefore extend areas of vegetation clearance to within the stated 50-kilometer radius.

Results of the regressions show that, some mitigation factors can be used to reduce the impact of fuel wood harvesting on environment near large settlements. Increased fire wood provision or harvesting of fuel wood from outside the area would reduce harvesting of fuel wood in the vicinity of the camps. This will allow re-growth of degraded land and reduce the environmental impact that already exists. Fuel wood can also be substituted with other types of fuel like kerosene and liquid petroleum gas.

The population has a negative impact on the stock level of any ecosystem. The regressions clearly show that increase in population leads to declining stock of biomass in any area. This requires that settlements be well planned and the population should not exceed the land carrying capacity of the ecosystem.

The refugees have been in Dadaab region since 1992 while the fuel wood programme started in 1998. Harvest has been higher than the growth rate a situation that explains the extent of vegetation degradation around Dadaab region. The persistent negative growth of woody biomass in the first 7-kilometer radius will affect the other areas with time.

5.3 Policy Recommendations

The results of this research indicate that refugees have a substantial impact on the environment especially through the fuel wood collection. This is seen in the first seven-kilometer radius. There is therefore need to employ strategies based on the variables that have a relationship with the change in the biomass cover to reduce the impact of fuel wood collection on the environment.

Refugees should continue to receive fuel wood from outside the study area to supplement their requirements. This will reduce the rate of harvesting the natural vegetation especially in the first seven-kilometer radius from the camps. The amount issued should be increased to a rate that will reduce harvest to be equal to the regeneration rate.

Fuel wood is not the only type of energy that the refugees can use. Other forms of efficient fuels should be used to supplement fuel wood. These substitutes include Kerosene, coal and charcoal imported from other parts of the country that are not threatened with land degradation. Research on the use of wind and solar energy can be carried out. This technology should be used in the region to supplement the use of fuel wood.

Establishment of any settlement in the future should be guided by the availability of resources to support them. The settlements should be well planned with environmental impact assessment done before the camps are established. Plantation of fast growing trees should be established in settlements where resources are inadequate, to support them with fuel wood.

The bare land around the camps should be replanted with trees that can cover the area at a faster rate than the indigenous trees. More research is required to establish such vegetation that can be used for both fuel wood and fodder as the area falls under pastoral zone. In mitigation against lack of vegetation in heavily settled areas, people should be encouraged to plant trees in their homesteads. The plants can be for fruits, fodder, shade, hedges and wind break. These emphases would lead to improved coverage of bare land surrounding the refugee camps. This will help by providing fuel wood during trimming and improve food security.

Buffer zones in heavily harvested land should be established to help in natural vegetation regeneration in the affected areas. The zones involve seclusion of land from fuel wood harvesting, grazing, cultivation and all other forms of land use in the ecological zone. A system of shifting harvesting should be employed through seasonal allocation of different areas for fuel wood collection.

The refugee population has some little effects on the environment as seen in the findings. Population in the camps should be kept at a level that will sustain the environment. Excess population in the camps can be linked to the declining vegetation around the camps. The population above the sustainable level should be relocated to other areas to ease land pressure. This will also encourage cordial relationship between the local communities because resources will be enough for both.

Efficiency is important in the reduction of fuel wood consumption in the refugee community. All the refugee families should be provided with energy saving stoves to further reduce the consumption. Solar cookers should be promoted with training on their use to improve the utilization rate. They are friendly to the environment and applicable in the area since enough sunshine of over eight hours per day (Republic of Kenya, 2001).

Based on the fact that substituting fuel wood harvest in the vicinity will have impact on the rate of environmental degradation, the government should encourage the use of other types of fuel through policies that will reduce their prices. Reduction in taxes and sometimes subsidization of substitute fuel should be done to steer people away from use of biomass as a source of fuel.

Training of both the refugee and the local communities should be intensified to enable them manage and conserve the environment. The training should focus on harvesting, use, preservation of energy by the refugee families. Use of other bi products like cow dug and farm residue should be promoted.

To improve the vegetation cover, more plants should be planted to replace those harvested. However, the sustainability is not certain because of frequent droughts, while the indigenous plants take ages to mature. With the change in the climate patterns experienced in the past 20 years, this may never revert to the original state.

5.4 Areas of future research

The UNHCR identifies fuel wood, construction material and agricultural activities around the camps as the major causes of vegetation clearance in settlement areas (UNHCR, 1998). Further research on the combination of these factors should be contacted to get the actual impact of refugees on the environment.

Other woody biomass use combined with the wood fuel harvesting will increase the impact of each variable as compared to analyzing the variables separately.

Research is required in the field of changing vegetation growth rate when woody biomass is harvested for the various uses. Once the vegetation is harvested, the stock growth rate will decline and may not be constant as assumed in the study. This assumption should be relaxed through contacting a research to establish the actual growth rate in the region after fuel wood harvesting.

Growth rate based on the standing stock was not a factor in determining the change in stock in the affected area. Evaluation of the impact of the standing stock should be done physically to see whether it has any impact on the growth rate.

Monitoring and evaluation of wood fuel consumption should be done to find the extend of efficiency caused by issued stoves. This will also indicate whether the reduction in per capita consumption is as a result of scarcity or use efficiency in the refugee camps.

This study focused on the impact of woody biomass harvesting on the environment. More research on effects of fuel wood harvesting on other inhabitants of the ecosystem should be carried to establish the ecological impact of the settlements. These inhabitants may include the animals and microorganisms that form the ecosystem of the region.

The economic impact of the settlements should be studied to assist in the formulation of policies that can reduce the exhaustion of resources in the region. This can include the value of plant products like fruits, gums and resins and medicinal plants destroyed.

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Appendix 1 change in stock per section

2001	Month	Level 1 ($\Delta S(t)_1$)	Level 2 ($\Delta S(t)_2$)	Level 3 ($\Delta S(t)_3$)	Level 4 ($\Delta S(t)_4$)
	January	-2300.867	2764.412	4393.546	4857.091
	February	-1377.828	3149.012	4624.305	6395.489
	March	-1545.449	3079.169	4582.400	6116.120
	April	-2201.893	2805.651	4418.289	5022.048
	May	-2308.219	2761.349	4391.707	4844.837
	June	-1510.594	3093.692	4591.114	6174.212
	July	-1693.590	3017.444	4545.365	5869.219
	August	-1661.369	3030.870	4553.420	5922.921
	September	-1649.750	3035.711	4556.325	5942.286
	October	-1691.582	3018.281	4545.867	5872.566
	November	-1690.448	3018.753	4546.150	5874.455
	December	-2377.789	2732.361	4374.315	4728.887
2002	January	-2373.819	2734.016	4375.308	4735.505
	February	-1379.914	3148.143	4623.784	6392.013
	March	-1638.854	3040.251	4559.049	5960.446
	April	-1682.630	3022.011	4548.105	5887.486
	May	-2401.702	2722.398	4368.337	4689.032
	June	-939.082	3331.823	4733.992	7126.732
	July	-1753.308	2992.562	4530.435	5769.688
	August	-1889.191	2935.944	4496.464	5543.218
	September	-1045.255	3287.584	4707.449	6949.778
	October	-1782.813	2980.268	4523.059	5720.513
	November	-2225.964	2795.622	4412.271	4981.929
	December	-2339.623	2748.264	4383.856	4792.496
2003	January	-2345.769	2745.703	4382.320	4782.254
	February	-1322.976	3171.867	4638.018	6486.910
	March	-1624.950	3046.044	4562.525	5983.619
	April	-2081.822	2855.681	4448.307	5222.165
	May	-2167.725	2819.888	4426.831	5078.994
	June	-1362.160	3155.540	4628.222	6421.602
	July	-1466.672	3111.994	4602.094	6247.416
	August	-776.817	3399.433	4774.558	7397.173
	September	-1373.356	3150.875	4625.423	6402.943
	October	-1448.207	3119.687	4606.710	6278.191
	November	-626.444	3462.088	4812.151	7647.796
	December	-1502.676	3096.992	4593.093	6187.410
2004	January	-2155.258	2825.083	4429.948	5099.773
	February	-1959.449	2906.670	4478.900	5426.121
	March	-1437.951	3123.961	4609.275	6295.285
	April	-1334.729	3166.970	4635.080	6467.320
	May	-1421.249	3130.920	4613.450	6323.121
	June	-1358.665	3156.996	4629.096	6427.427
	July	-1396.396	3141.275	4619.663	6364.543
	August	-1414.721	3133.640	4615.082	6334.001

	September	-1505.546	3095.796	4592.376	6182.626
	October	-2124.473	2837.910	4437.644	5151.081
	November	-2025.373	2879.201	4462.419	5316.248
	December	-2095.478	2849.991	4444.893	5199.406
2005	January	-2111.622	2843.264	4440.857	5172.498
	February	-1140.934	3247.718	4683.529	6790.312
	March	-2154.691	2825.319	4430.089	5100.717
	April	-2042.132	2872.218	4458.229	5288.315
	May	-2127.943	2836.464	4436.776	5145.297
	June	-1251.327	3201.721	4655.930	6606.324
	July	-1364.931	3154.386	4627.530	6416.985