EFFECTS OF BRICK MAKING ACTIVITIES ON THE BIOPHYSICAL AND SOCIO-ECONOMIC ENVIRONMENT OF VIHIGA COUNTY, KENYA

BY

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ABSTRACT

Brick making is alternative source of income in many localities. Low capital and other expenses required to start the business encourages the growth and expansion of brick making in Vihiga County. Bricks remain a cheap source of building material for those engaged in building and construction. Brick making is, however, a threat to both biophysical and socio economic environment. Brick making activities leads to destruction of vegetation cover, creation of pits and valleys on the earth's surface, lowers soil fertility and destruction of settlement and agricultural land. The purpose of this study was to examine the effects of brick making activities on the biophysical and socio economic environments in Vihiga County. Therefore, the objectives of the study were to: determine the effects of brick making activity on forest cover; examine the effects of soil extraction for brick making on the biophysical environment; establish the effects of burning of bricks on soil fertility; and assess the effects of brick making on the socio-economic environment. Cross-sectional descriptive research was used. A sample size of 254 brick makers from a study population of 750 brick makers was obtained using simple random sampling technique. The study was conducted in the six divisions of Vihiga County namely: Luanda, Emuhaya, Sabatia, Tiriki East, Tiriki West and Vihiga. Primary data were collected using questionnaires, observation forms, key informants interview, Focus Group Discussions while secondary data were collected from published and unpublished information. Fifty brick sites that were identified and selected were visited to collect data across the six divisions of Vihiga County. Quantitative data were analyzed using descriptive statistics, while qualitative data were analyzed by organizing and categorizing themes and evaluating the usefulness of information to answer research questions. The study found out that brick making activities have negative effects such as: destruction of the forests and other vegetation cover through harvesting of grass for covering bricks, and cutting down of trees for wood fuel used for burning of the bricks, timber harvesting and firewood. In addition, burning activity lowers soil fertility and extraction of soil for brick making creates pits and gulleys on the earth's surface. Increased brick making activities on the earth's surface reduces farming and settlement areas. The study concluded that farmers concentrated more on brick making than farming thus decreasing farm yields. The use of wood fuel for burning bricks was higher compared to other uses like timber harvesting and firewood gathering. Furthermore, increased temperatures during burning of bricks affects growing crops and destroys microbes vital for soil formation. Increased pits on the earth surface cause accidents and reduce farming and settlement land. This study recommends that there is need to regulate brick making activity, promote environmental awareness, introduce fuel efficient technologies for burning bricks and introduce alternatives low capital business ventures so as to minimize the effects of brick making on the environment.

CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Brick making is an activity that involves various processes key among them includes extraction of soil from the earth surface, kneading then moulding and burning to produce bricks. Brick making started in Mesopotamia (Iraq) at least 6000 years ago. The activity spread to Europe afterwards. The European settlers took it to the rest of the world (Lee, 1977). Brick making involves the following five intensive steps: mining of the soil using *jembes*; preparation of the soil by mixing with water and kneading to hold together; then moulded using brick moulders made from timber from metal; the bricks are dried in the sun but not directly because grass is used to cover the bricks; and the dried bricks are arranged in kilns for burning using wood fuel (Merschmeyer, 1999).

Globally, brick making activities have been related with the destruction of the environment (Swiss Development Cooperation, 2009). Brick making is recognized as resource intensive industry (Environment and Social Report for VSBK, 2005). Liew (2004) reports the use of sewage sludge in Malaysia, generated from sewage treatment plant as a raw material in a clay brick making process because of the increased destruction of environment when soil is used. This included increased soil erosion triggered by the pits and gullies created after extraction of soil, destruction of vegetation cover especially the trees, as supported by Mason (2007). However, the effects of brick making activities on forest cover, soil fertility and socio-economic environment have not been fully understood.

In Africa, it has been established that brick making activities cause soil, air, and water pollution, and agricultural land and settlement areas are degraded (Uisso, 2007). In his study, Uisso (2007) found out that, in Morogoro Tanzania, there is air pollution, land degradation and water pollution due to brick making. In Sudan, there is massive destruction of forests and ecosystems due to burning of the bricks (Ashrafal, 2006). The creation of burrow pits and trenches associated with brick making cause environmental hazards in the country of Chad because they are left uncovered (Omoyen, 2006). In Uganda soils are depleted increasing flooding due to brick making activities (Buyinza and Bukenya, 2002). In the report presented by GoK

(2008) indicates that 100% of the Maragoli Hill forest has been degraded while others only occupy 5% of what they were initially. In view of foregoing, the effects of brick making activities on soil fertility and socio-economic environment have not been studied.

In Kenya, brick making was previously seen as an activity for poorly educated or semi-skilled persons in the community (Neyole and Oteng'i, 2007). However, due to rising demand and readily available market, the activity has now blossomed into lucrative commercial venture, with cheaply available human and material inputs. Illiteracy and unemployment have led to activities like brick making which affect the environment negatively in Kenya (USAID, 2006). Brick making is in the same category with settlement and cultivation which is referred to as threats on the environment (Momanyi, 2003). Digging of of soil for brick making reduces agricultural land and settlement areas, the need for wood fuel to burn the bricks leads to destruction of forest cover thus increasing soil erosion while burning of bricks causes soil and air pollution (Neyole and Oteng'i, 2007). Brick making is widespread in Western Kenya and is carried out nearly in all villages of the three counties: Busia, Siaya, and Kakamega. Brick making activity is done on private farms and in communal land thus increasing the rate of destruction of agricultural and settlement areas in this counties. Brick making is one of the activities carried out on wetlands in Kisii County causing soil degradation, air and water pollution (Momanyi, 2003). However, the effects of brick making activities on soil fertility and socio-economic environment have not been studied.

In Vihiga County, brick makers use their private farms and communal land especially near road reserves for soil extraction used for making bricks (GoK, 2002). In Vihiga County, there are gullies formed due to brick making activities spread over the County (GoK, 2008). According to GoK (2008), brick makers use water from the wells and boreholes drilled, springs, harvested water, rivers and other sources. The people of Vihiga County use water from this source for domestic purposes, industrial and for brick making. Forest cover and biodiversity at large are of importance. As reported by GoK (2002) and GoK (2008) forest cover in Vihiga County is used for wood fuel for brick burning, timber harvesting and firewood gathering. In addition, grass vegetation is used for grazing animals and covering of bricks. These activities

have led to decimation of forest cover and loss of biodiversity (GoK 2008). Therefore the contribution of each purpose should be established. The use of wood fuel for burning bricks has contributed to the depletion of Ebusiekwe forest (Bunyore) and Maragoli Hills forests leaving the soil bare resulting in soil erosion which is aggravated by the fact that the place is too hilly/sloppy (GoK, 2008).Various studies GoK (2001, 2002, 2004, 2008), Walingo (2009a and 2009b) and Kristjanson *et al* (2004) have been carried out in Vihiga County on land use activities to establish their effects on the environment. However, these studies just mention brick making as another land use activity that has negative effects on the environment without explaining how brick making affects the environment negatively. Hence, there is need to study effects of brick making activities on biophysical and socio-economic environment.

1.2 Statement of the Problem

Brick making is one of the increasing land use activities in Vihiga County (Walingo, 2009b). It contributes to the well-being of the people in Vihiga County. It is a source of building and construction material for both rural and urban areas. This attracts brick making activities because the bricks are cheaper compared to concrete blocks. However, brick making activities causes destruction to the forest cover and lowers soil fertility. In addition, brick making activities affects biophysical and socio economic environments. The biophysical and socio-economic environments are important to the locals of Vihiga County but it is threatened by the brick making activities and the other land use activities like agriculture and settlement carried out in the County.

Water uses in Vihiga County has increased thus reducing water levels. The uses include: domestic purposes, industrial purposes and brick making (GoK, 2008). The reports points out boreholes in Esirulo Shamakhokho experience low water levels while water in the Boyani stream sometimes contain soil particles as a result of the muddy containers used to draw water from the stream. The use of wood fuel during brick burning has contributed to the depletion of Ebusiekwe/Bunyore and Maragoli natural forests (GoK, 2008). In Vihiga Division, brick making activities are carried out in on agricultural land (Walingo, 2009b). Therefore, the purpose of this study was

to examine the effects of brick making activities on the biophysical and socio-economic environment in Vihiga County.

1.3 Objective of the Study

The overall objective of this study was to assess effects of brick making activities on the biophysical and the socio-economic environment of Vihiga County.

Specific objectives:-

i) To determine the effects of brick making activity on the forest cover in Vihiga County.

ii) To examine the effects of soil extraction for brick making on the biophysical environment in Vihiga County.

iii) To establish the effects of burning bricks on soil fertility in Vihiga County.

iv) To assess the effects of brick making activities on the socio-economic environment in Vihiga County.

1.4 Research Questions

i) What effects do brick making activities have on the forest cover?

ii) How does soil extraction for brick making affect the biophysical environment?

iii) What effect does burning of bricks have on soil fertility?

iv) What is the effect of brick making activities on socio-economic environment?

1.5 Justification of the study

Brick making activities cause adverse effects on the environment (Uisoo, 2007). The digging of the ground to extract soil creates gullies on the ground as it is evident in Boyani and parts of Majengo (GoK, 2008). Bricks in Vihiga County are burnt using wood fuel gotten from the vegetation cover within the county contributing to the loss of biodiversity and total depletion of forests (GoK, 2008). Brick making accounts to about 10% of the land uses (Walingo, 2009b). In the findings of this study, cultivation led with 65% followed by combined cultivation and livestock keeping with 15%. Walingo (2009b) found out that brick making activities are competing with other land use activities thus contributing to the negative effects on the environment in Vihiga County.The report presented by GoK (2002 and 2008), indicates that Vihiga County

has undulating hillsand valleys compared to other counties in Western Kenya of which when excess extraction of soil is done, this state may be complicated posing more dangers to the population.

The effects of brick making have been ignored, that it cannot affect the environment (Neyoleand Oteng'i, 2007). The brick makers in Vihiga County are not aware of the effects of brick making activities on the biophysical and socio economic environment. However, the resultant cumulative ecological damage is significant in all parts in Kenya that practice brick making. This includes decrease in food production (Society for Environment and Human Development, 1998).

Given the importance of biophysical and socioeconomic environment, it was therefore important to study the effects of brick making on the environment in Vihiga County with the view of achieving various ways to regulate the activity, to provide environmental awareness among the brick makers, to introduce fuel efficient technologies like circular and square kilns from rectangular kilns. The business ventures proposed like bee farming and goat dairy farming is implemented (GoK, 2002). The ones already going on like fish farming be emphasized to locals so as they diversify their sources of income (GoK, 2002). It may not be easy to convince brick makers (Uisso, 2007). This is a strong reason to conduct research so as to find better solutions to already damaged areas and prevent further damage on the environment.

The effects of brick making vary from place to place (Neyole and Oteng'i, 2007). This is because of the different approaches brick makers apply in the processes of making bricks depending on the following variables which include; location of the brick works, soil type, and source of water, types of kilns used, amount of wood fuel used and the type of wood fuel used. In Vihiga County 69.4% of the of the population use their entire land with all the land use activities like farming, settlement and brick making, 10.5% use three quarters of their land for all the land use activities, 13.7% use a half of their land and only 5.6% use a quarter or less of their land (Walingo, 2009b). The study confirms that a bigger portion of Vihiga County is under use. The County is dominated by both well drained fertile soils and red loamy soils that support various crops (GoK, 2002). It was therefore, imperative to relate this variables and how they affect the environment.

1.6 Scope and limitations to the study

The study was conducted in Vihiga County which is one of the four counties of Western Kenya. Generally the county has undulating hills and valleys with streams flowing from northeast to the southwest and draining into Lake Victoria. The study was limited to determining the effects of brick making activity on vegetation cover on environment in Vihiga County. The study also examined the effects of soil extraction for brick making on environment in Vihiga County. The study established if burning of bricks lowers soil fertility and also had a major focus on the effects of brick making activities on the socio-economic environment of Vihiga County. The study was conducted in the six divisions where samples were taken to represent each division. There were various limitations encountered:

Personnel limit was encountered during the study. Conducting a study in Vihiga County requires extra personnel. Some parts of Vihiga County like; parts of Vihiga, Tiriki West, Tiriki East, Sabatia and Luanda divisions are hilly and rocky making various places impassable, hence forcing the researcher to walk long distances of about 5-10 Kilometres so as to access them. This would require more personnel to cover the study on the scheduled time. In addition some of the brick makers could not read and write. They required assistance to fill questionnaires. This resulted in handing in some questionnaires that were incomplete leading to generalisation of some issues using fewer filled questionnaires.

The study also encountered time limit. Some brick makers were reluctant to give information because they thought the researcher was investigating them, and then arrest them for extracting soil from communal land hence forcing the researcher to use more time to convince the brick makers. In addition some key-informants also claimed to be too busy and were unable to spare some time hence forcing the researcher to keep on fixing a different appointment so as to get the required information of which some never turned up forcing the researcher to generalise using information from only those who turned up.

Finally the study encountered tools limit especially the secondary sources. The literature on brick making is very scarce forcing the researcher to source online books. This has resulted to the reference section to look like the the study was purely online.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

Relevant literature on impact of brick making on the physical and socio economic environment has been reviewed in this section. The section starts with the impact of brick making activities on the atmosphere, on the soil productivity; land surface and vegetation cover which comprise of the physical environment. The chapter also reviews the socio economic environment. The chapter ends with an outline of the conceptual framework and a figure that explains further how the theories are related to brick making.

2.2 The brick making activities and forest cover.

Brick making is recognized as a resource intensive and highly polluting industry that consumed a lot of wood fuel from the forests (Environmental Social Report for VSBK, 2005). According to the VSBK report the activity involves extensive energy usage; resource depleting or inefficient resource utilization of wood fuel. Brick making consumes more woodfuel in India contributing to air pollution and destruction of vegetation (Moore, 2008).The invention of the VSBK led to development of cleaner technology that consumes lower fuel thus reducing air pollution and destruction of vegetation. The VSBK technology was first invented in China because China was highly affected by air pollution, then it spread to India because it is the second after China in brick making activities (Moore, 2008).

In United States of America and Mexico border, air pollution was cited whose major source was approximately 400 brick kilns (Lowery and Octavo, 1995). The increased number of brick kilns called for a project by NGOs that provided courses to brick makers like fuel, combustion and pollution. This project led to development of energy technology that turned from burner kiln design to solar drying devices thus reducing the use of wood fuel and air pollution. The traditional kilns in Mexico have been a concern to everyone in Mexico, government agencies, NGOs and private companies (Lowery and Octavio, 1995). From a study conducted during the training of 140 brick makers selected randomly in Mexico, the shapes of kilns was changed from

rectangular and square to circular kilns, which released reduced carbondioxide in the atmosphere (Lowery and Octavio, 1995). The circular kilns confirmed that gases released in the atmosphere were reduced by 50% (Lowery and Octavio, 1995). The square kilns were reported to consume less wood fuel compared to the rectangular kilns (Lowery and Octavio 1995). In United States of America and Mexico border, solar drying is being applied (Lowery and Octavio, 1995). In the book 'Fuel Free' by Mason, has suggested to substitute wood fuel with coal dust, waste oil husks, and sawdust in Peru.

In Vietnam, the government has tried to reduce the use of wood fuel via eliminating traditional brick making kilns by 2005 in peri-urban and by 2010 in all areas so as to curb pollution and forest destruction (UNDP, 2008). The UNDP projects encourage countries and link them to action under the Kyoto protocol to reduce emission of harmful greenhouse gases which result from burning of bricks in kilns (UNDP, 2008). Draaisma (2009) confirms that bricks can be made without burning which will reduce the use of wood fuel. He proposes mixing soil with sand and cement which will result in a durable brick. This technology has helped to protect the vegetation and reducing the amount of carbonioxide released in the atmosphere by burning of bricks. The improved brick kilns project would also fit in environmental programs that will aim at reducing rural poverty and sustain economic growth so as future generation benefit from the environmental resources of a country (UNDP, 2008).

In Africa, brick production is the major consumer of wood fuel (Mkoka, 2003). Mkoka, (2003) confirms that in Malawi, forest cover on Ndivande and Michiru mountains has disappeared due to brick making supported by charcoal burning and wood gathering. The reduction of vegetation cover either on private farms or forests contributes to increased soil erosion (Mkoka, 2003). It is a challenge to human life (Padmalal *et al* 2004), because apart from brick making, woodfuel is used for cooking and for building and construction.

In Tanzania, the brick kilns are poorly organized causing excessive use of woofuel from forests for burning the bricks thus emitting around 15% of the carbondioxide that pollute the air (Uisso, 2007). But because Tanzania belongs to developing countries in Africa, the issue of air pollution from brick kilns has not been reduced, thus giving room for more studies to find solutions for African countries in cases

where technology is expensive (Uisso, 2007). The Lutheran Church Tanzania (2006), is creating public awareness in an effort to replace bricks with cement bricks and motor due to the emissions of carbondioxide in the atmosphere and destruction of vegetation cover.

In Sudan and Zimbabwe the substitute for wood fuel is cow-dung, biogas and boiler waste (UNDP, 2008). This attempt is calling for more study and research about the above substitute which may be a remedy to deforestation and loss of vegetation cover. Presently, the Savanna woodlands surrounding Khartoum have shrunk (Ashrafal, 2006). Brick production in Sudan has risen 4 to 5 times using more than 57,000 trees per year (Bromwich and Smith, 2008). The use of wood fuel in brick making kilns is the most damaging cause of deforestation (Mkoka, 2003). Improper construction of brick kilns contributes to inefficient energy usage, which results in excessive wood fuel consumption (Neyole and Oteng'i, 2007).

Brick making activities deplete the forests and vegetation around the Lake Victoria Basin (EAC secretariat, 2006). In some countries like Peru and Zimbabwe, brick makers are a step ahead because some of them do not depend on wood fuel thus saving forests (UNDP, 2008). A key feature of most of the UNDP conservation projects is encouragement of community engagement in forest protection and ecosystems conservation (UNDP, 2008). The projects will enable those who live in natural resource areas become part of the solution for their sustainability. Loss of vegetation cover also leads to destruction of water catchments areas of Maragoli Hill forest and Ebusiekwe making it a critical issue in human life, thus there is need for research to establish the effects of deforestation and removal of vegetation cover on private farms to human life (GoK, 2008).

Forests generate substantial income and employment at local level as well as providing economic goods which are used at local level (Mogaka *et al* 2001). Fuel wood for brick burning used mostly comes from the forests. The forests suffer a great deal because the fetching of fuel wood has moved to another level (Howard, 1986). The activities in various countries especially in Africa that affect the environment have increased because of lack of laws or if they are there they are not being implemented (NEMA, 2009) The African countries should borrow from developed countries which have put mechanisms in place to save the existing forests by

introducing energy saving kilns and improvising other sources of energy (Lund University, 2009). Government of Malawi (2002) has put mechanism of involving the community to save the remaining parts of Ndivande and Ndiru forests. The vegetation on people's farms and communal land has been ignored as all researchers are concerned with the forests only.

A study conducted in Nyando by Mungai *et al* (2004) reported that extraction and processing of natural resources which include bricks and papyrus mats affects the vegetation cover. Vihiga County has two gazetted forests; Kibiri and Maragoli Hill while others fall under pockets of cultural and religious forests (GoK, 2008). The Table below shows the forests that exist in Vihiga County. The table clearly indicates the extend of the forests in hectors, their location, and the percentages degraded. Table 1 clearly indicates that Maragoli Hills forest has been completely destroyed. Kibiri manmade forest has been encroached whereas the cultural and religious forests still survive because of their cultural and religious functions (GoK, 2004).

Table 1: Area covered by Forests in Vihiga County and their location

NAME	AREA COVERED (HA)	LOCATION
Maragoli Hills	469	Vihiga
Kibiri	3691	Tiriki East
Kaimosi Mission	1000	Tiriki East
Tiriki Cultural	50	Tiriki East and West
Bunyore Cultural	18.4	Luanda

Source: Vihiga County Environment Action Plan (2008).

The report indicates that activities like timber logging; fire wood gathering, charcoal burning and wood fuel for burning bricks have contributed to the degradation of the forests in Vihiga County and to biodiversity lose (GoK, 2008). Natural vegetation has decimated not only through brick making wood fuel but also through small scale intensive agriculture (GoK, 2004). Walingo (2009b) identified three major land use activities that contribute to the destruction of vegetation cover. They include cultivation, brick making and mixed farming (cultivation and livestock keeping). GoK

(2008) found out that there are various environmental issues among others clearing vegetation cover for brick making and timber logging.

2.3 The brick making activities and soil extraction.

The areas dominated by brick making activities, the land are degraded (Padmalal *et al*, 2004). The removal of topsoil for brick making creates burrow pits and trenches on the land surface which are normally left uncovered contributing 5% to 10% of accidents to human life and also increases erosion making them more dangerous in some areas in Chad (Omoyen, 2006). Increased pits increase animal accidents by 50% of whicha half of this accidents are due to pits created by brick making. Burnt clay is permanently damaged and cannot be recovered (Omoyen, 2006). The ecosystem is affected because land is dug and soil extracted causing alteration to the surface thus removal of soil destroys local flora and fauna (Ashrafal, 2006).

The digging out of soils by brick makers causes more degradation of the land (Uisso, 2007). The soils are extracted in large amounts. Soils are part of the environment that cannot be replaced easily. The more the land is degraded, the more ecosystems are being damaged. The gullies and pits may lead to soil erosion and landslides (Neyole and Oteng'i, 2007). In Malaysia, there are bricks made from sewage treatment so as to reduce soil degradation (Liew, 2004). The suggested solutions like mixing soil with sand and cement seem to be environmental friendly, thus there is need for research to widen our understanding on effects of brick making on the soil putting in mind variables like the type of soil and the location of brick works, may led to more alternative ways.

In Sudan, brick making is the most dependent on business across the country (Hamid 1994). But the effects of the activities from digging the ground to burning of the bricks are adverse. The pits left behind are dangerous to man in that they cause up to to about 5% to 10% of accidents. There is soil reduction on the earth's surface during extraction of soil for brick making (Hamid, 1994). Issues of brick making are too complex as confirmed by Lowery and Octavio (1995). They found out that people are involving in brick making activities because they are unemployed together with increasing levels of poverty. Apart from poverty and unemployment, there could be

other reasons why people engage in brick making activities, thus there is need for more research. Gullies exist in Vihiga County whose cause might be of various land use activities. This is the reason why the study is necessary to establish the contribution of various land use activities. The activities include clearing of vegetation for farming and settlement, overgrazing, encroachment and unsustainable exploitation of wetland resources.

2.4 The brick making activities and soil fertility.

Land degradation has been observed in India as a result of brick making thus lowering land productivity that is affecting rice farming (Sigit and Suharjo, 2007). Department of Agriculture Extension of Bangladesh conducted a research established that presence of brick fields made agriculture impossible in 2,000 acres of land in Slayer near Dhaka (Sigit and Suharjo, 2007). Crop production has reduced from 70% - 80% in 3,000 acres affected by the emission of carbondioxide from the brick field. Pollination and formation of rice process in paddy are disturbed. As a result, the total rice production has decreased by 10% (Sigit and Suharjo, 2007).

The grass turns yellow after the acidity of the soil changes from the acid rain of sulphuric acid after reaction of sulphur dioxide and water vapour (Society for Environment and Human Development, 1998). The smoke and gases emitted from burning fuel produce volatile components having adverse effects on vegetables and fruits along river banks (Bilal, 2002). The gases mix in the air and spread then settle on the vegetation and crops closing stomata thus stopping photosynthesis reducing the farm yields (Ashrafal, 2006). Kilns emit high temperatures that damage ecosystems within brick making areas (Environmental Social Report for VSBK, 2005). Soil fertility decreases because of the soil forming organisms are destroyed with the high temperatures during burning of bricks (Hamid, 1994).

Studies carried out have shown that farm yields in Vihiga County have reduced due to various reasons. Walingo (2009b) found out that settlement as a land use as an activity has contributed to reduction of farming land. In addition, GoK (2008) relates decrease of farm yields to introduction of other activities especially animal keeping which reduces farming land to grazing fields. In other parts of the world research indicates that the burning activity has affected farm yields through the high temperatures that

shorten the graining period thus reducing yields in India (Sigit and Suharjo, 2007). This the reason why the study is necessary because there could be other causes of reduced farm yields in Vihiga County especially in the perspective of brick making activities.

2.5 The brick making activities and the Socio-economic Environment.

The increased soil erosion causes difficulties in settlement (Madulu, 2005). The pits created cause environmental hazards that may cause accidents (Padmalal *et al,* 2004). Localized landslides occur where excavations were done which is a threat to human life causing 5% to 10% of the accidents. Excavations are highly erodible areas in Siaya County and lead to massive erosion and land slide risks (Neyole and Oteng'i, 2007). There is need for research to widen our understanding on how brick making influences settlement. Most of the activities of brick making take place within the settlement sites creating hazardous brick fields which are part of human homesteads and farming land (Rahman, 2005). The brick fields left behind after some time are dangerous to human life and the animals kept.

Brick making causes profound changes on the surface and ground water sources of a given area (Padmalal *et al*, 2007). Most of the brick making activities are done along river banks of River Yala and River Nzoia in Butere and Mumias, where most brick makers preferred clay soil which retains lots of water is abundant (Kiddies and Cleghon, 1980). This is supported by a study conducted by Ashrafal (2006) who observed that brick making operated along river banks in Sudan. Brick making requires a lot of water, e.g. 1000 bricks require approximately 600 litres of water (Ashrafal, 2006). If the source is communal it may interfere with other users like domestic needs (Draaisma, 2009).

Vihiga County has various sources of water (GoK, 2008) as shown in Table 2 below. Majority of the population of Vihiga County get water from the springs. The residents in Vihiga County use water for domestic, industrial and brick making. The increase in uses of water in the county has resulted to competition of the resource forcing people to travel to about 1 kilometre to look for water (GoK, 2008). Other sources of water include water pan, ground water dug wells and rainwater.

Table 2: Numbers of water Sources in Vihiga County

SOURCE	NUMBERS OF WATER SOURCES
Permanent rivers	4
Wells	50
Springs	200
Boreholes	14
Dams	2
Reservoirs and wetlands	17

Source: Vihiga County Environment Action Plan (2008).

The wells and boreholes drilled experiences low levels and dirty water as evident in Vihiga County. This has skipped previous studies because most researchers concentrated on brick making activities along river banks like River Yala and Nzoia in Butere, Mumias areas and Sudan. The activity is carried out near water bodies due to the clay soils available that retain a lot of water, causing water pollution in Sudan, India, among others, (Environmental Social Report for VSBK, 2005). As discussed water is used for various purposes in Vihiga County. The study therefore is necessary to establish the contribution of brick making activity on the water sources in Vihiga County.

Generally the effects of brick making activities on forest cover has been covered but the use of tree plants on people's farms for brick making has been ignored. The effects of brick making activities on the biophysical environment has been well covered by the studies carried out and even measures recommended on how to fill the pits and valleys created on the earth's surface after extraction of soil for brick making. However, the effects of brick making activities on soil fertility and socio economic environment have been ignored.

2.6 Conceptual framework.

The study was based on the belief that the nature of human activity was controlled by the parameters of the physical world within its set, (Johnston, 1987). The physical environment is the control while the human behaviour is the response. In relation to

the study, the brick makers respond to the environment by making bricks. This is because; the physical environment provides the soil needed for brick making, water used for brick making is available and the wood fuel are all provided by the environment thus encouraging the brick making activity.

On the other hand, the belief that the humans could put an environment and select that which fits their cultural dispositions (Johnston, 1987). This applies in areas where brick makers are far from forests, water and required soil for making bricks. Wells and boreholes have been drilled to provide water and finally soils are carried from water sources and from communal land in areas with scarce soil or areas with unsuitable soils like the rocky areas of South Maragoli (GoK, 2004). Water and soils can be carried within 1 kilometer as indicated in an issue by (GoK, 2008).

The brick makers engage in brick making activities because of various reasons. From the reconnaissance study brick makers engage in brick making activities because of the increased unemployment, the brick making activities do not require a lot of capital and increased level of poverty. Recently, a study carried out by the GoK (2013) indicates that 62% of people in Vihiga County live below poverty line. The starting point of the framework is brick making activity which involves various processes like deforestation, soil mining, burning of bricks (CO_2 and high temperatures) and excess water use. The processes involved in brick making affect both biophysical and socio-economic environment. Deforestation and soil mining from the earth's surface leads to bare earth's surface leading to soil erosion. Continued extraction of soil limits settlement and agricultural land. Excess use of water reduces water levels and sometimes making the water dirty. The burning process produces CO_2 and high temperatures. The end result is negative effects on the environment on the biophysical and socio-economic environment which include: increase in gullies on the earth's surface, reduced water for other domestic purpose, reduced farm yields and congestion in settlement areas as shown in Figure 1.

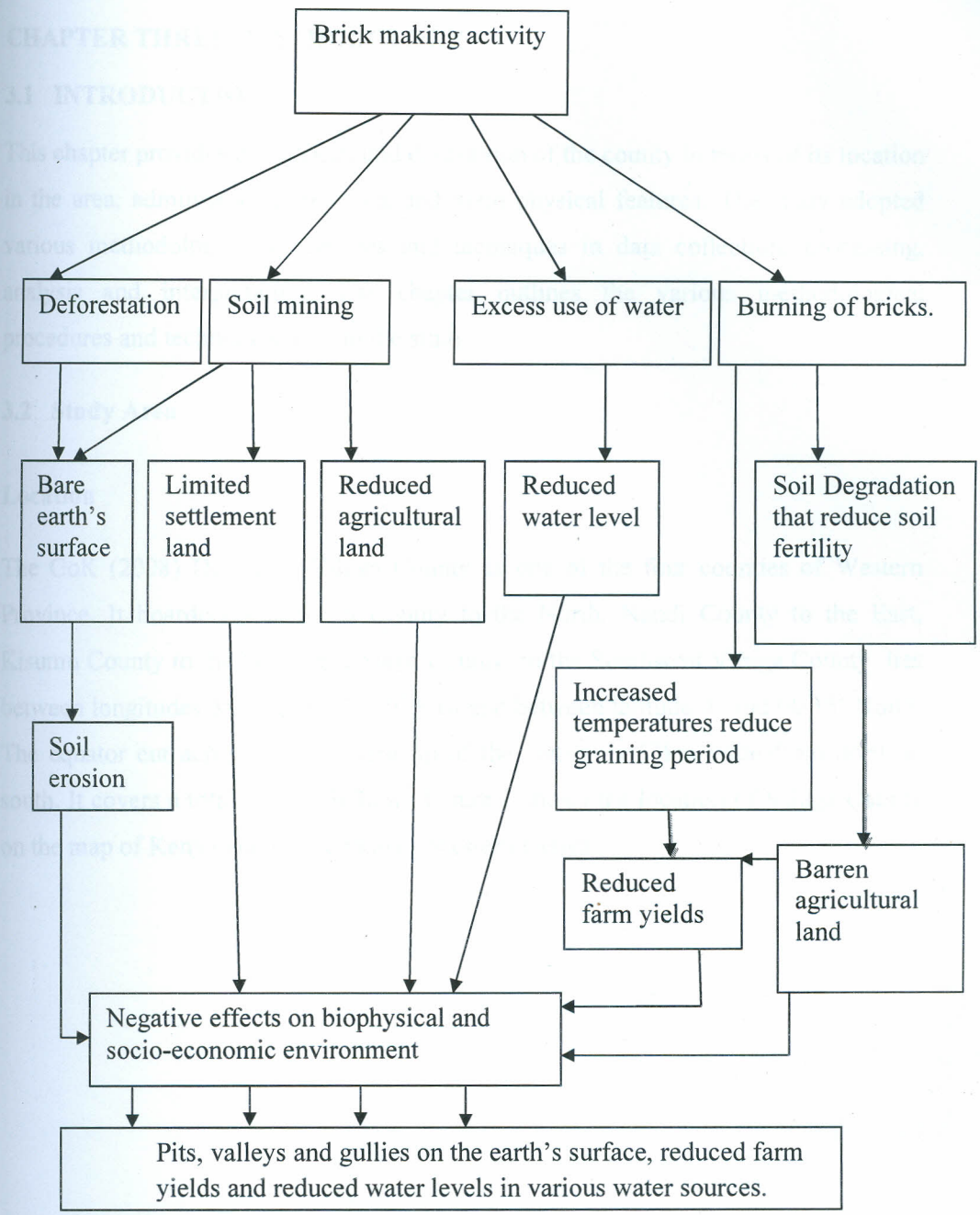

Figure 1: Conceptual framework

Source: Researcher, (2009)

CHAPTER THREE: METHODOLOGY

3.1 INTRODUCTION

This chapter provides the background description of the county in terms of its location in the area, administrative divisions and main physical features. The study adopted various methodological procedures and techniques in data collection, processing, analysis and interpretation. The chapter outlines the various methodological procedures and techniques used in the study.

3.2 Study Area

Location

The GoK (2008) Describes Vihiga County as one of the four counties of Western Province. It boarders Kakamega County to the North, Nandi County to the East, Kisumu County to the South and Siaya County to the Southwest. Vihiga County lies between longitudes 35^0 30' and 35^0 0' East and between latitude 0^0 and 00 15' North. The equator cut across the Southern tip of the county is 33km wide from north to south. It covers a total area of $563km^2$. Figure 2 shows the location of Vihiga County on the map of Kenya and on the map of Western Kenya.

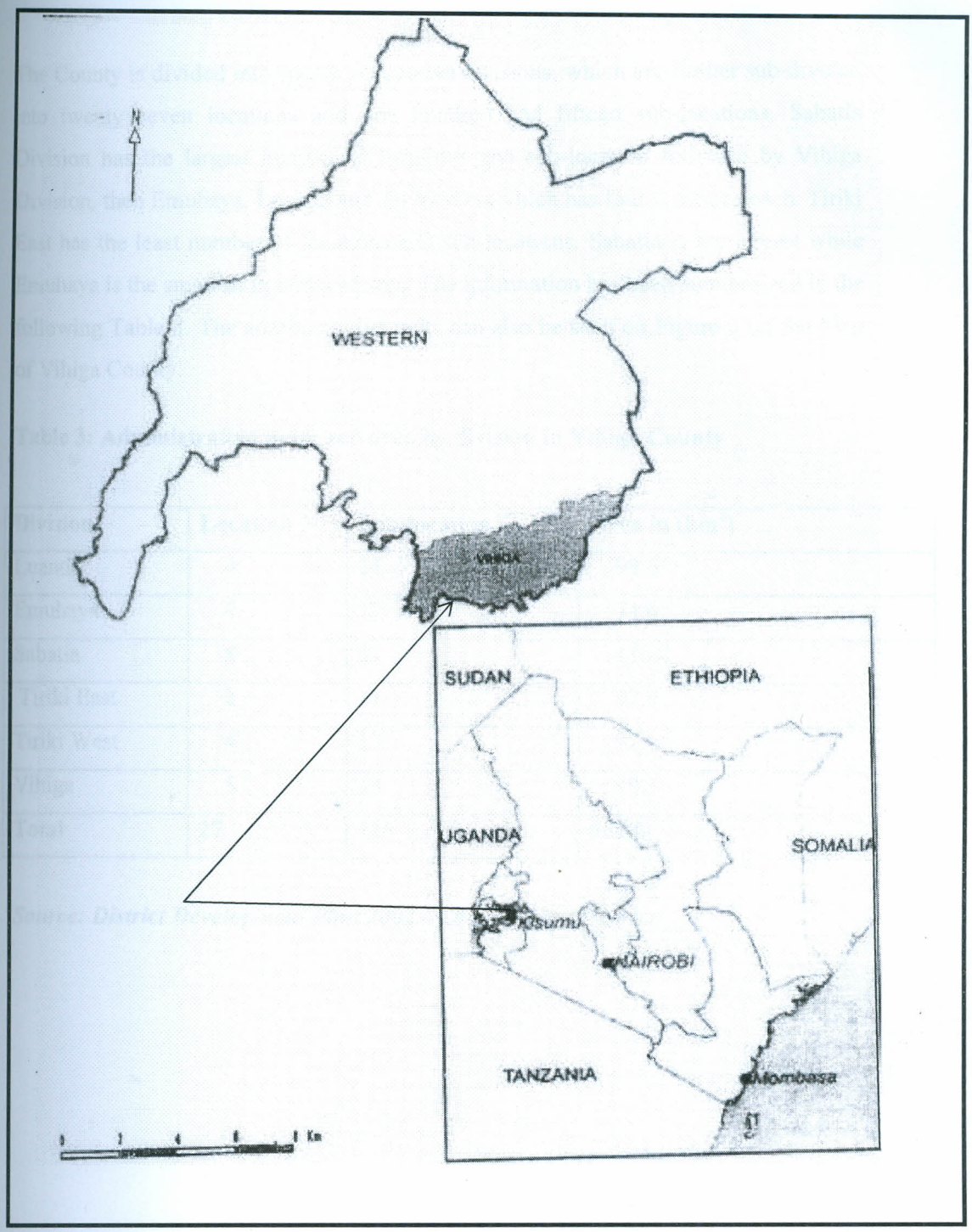

Figure 2: The location of Vihiga County on the map of Kenya

Source: Vihiga District Environment Action Plan (2009-2013)

The County is divided into six administrative divisions, which are further sub-divided into twenty seven locations and one hundred and fifteen sub-locations. Sabatia Division has the largest number of locations and sub-location followed by Vihiga Division, then Emuhaya, Luanda and Tiriki West which has four locations each. Tiriki East has the least number of locations and sub-locations. Sabatia is the largest while Emuhaya is the smallest in terms of area. The information has been summarized in the following Table 3. The administrative units can also be seen on Figure 3 on the Map of Vihiga County.

Table 3: Administrative units and area by division in Vihiga County

Division	Location	Sub-location	Area in (km^2)
Luanda	4	21	98.6
Emuhaya	4	17	74.6
Sabatia	8	31	110.4
Tiriki East	2	11	97.0
Tiriki West	4	17	92.1
Vihiga	5	18	90.3
Total	**27**	**115**	**563.0**

Source: District Development Plan 2002 – 2008 (Vihiga District)

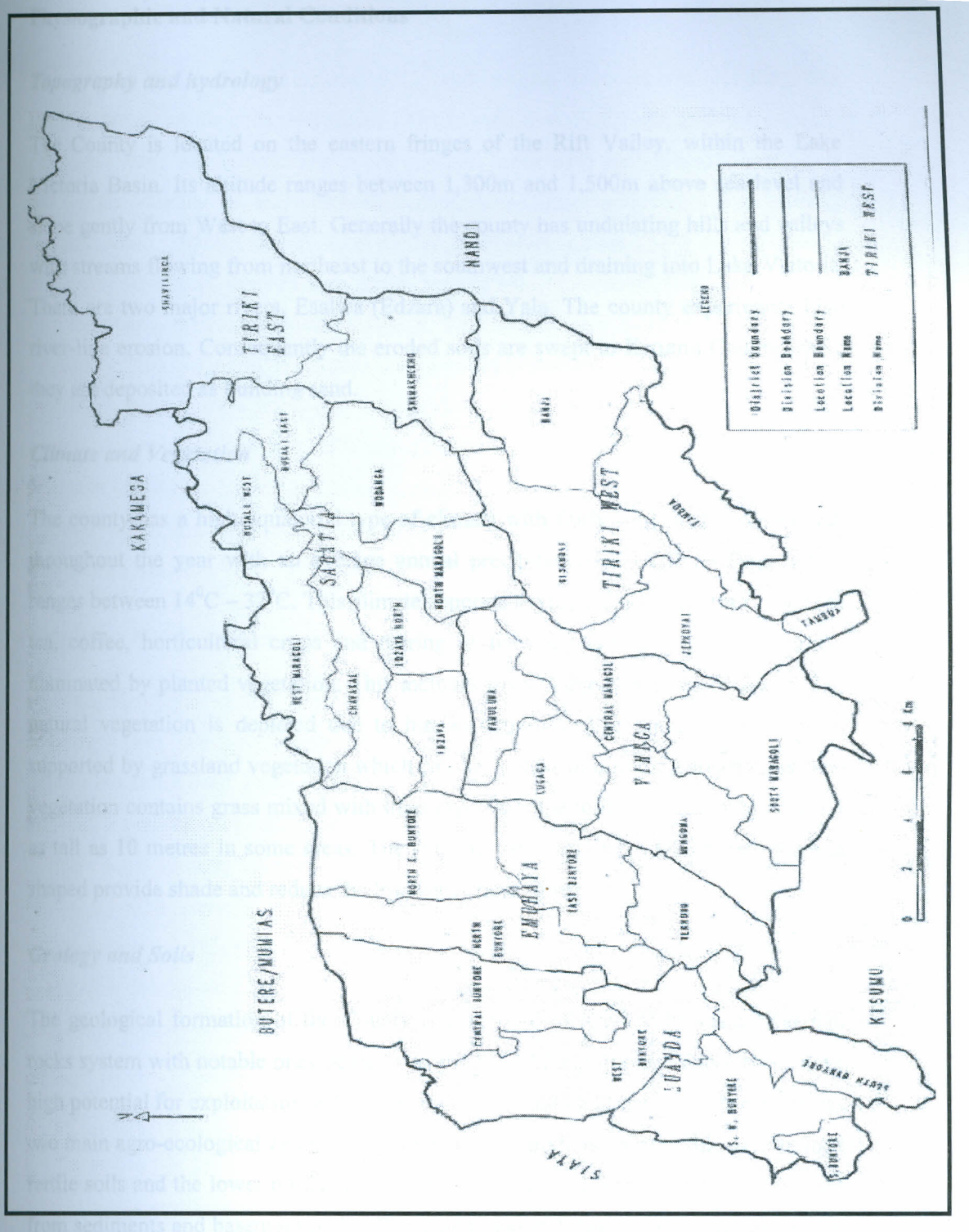

Figure 3: Vihiga District Adminstrative boundaries by division and location

Source: Vihiga District Development Plan (2002-2008)

Physiographic and Natural Conditions

Topography and hydrology

The County is located on the eastern fringes of the Rift Valley, within the Lake Victoria Basin. Its altitude ranges between 1,300m and 1,500m above sea level and slope gently from West to East. Generally the county has undulating hills and valleys with streams flowing from northeast to the southwest and draining into Lake Victoria. There are two major rivers, Esalwa (Edzara) and Yala. The county experiences high river-line erosion. Consequently the eroded soils are swept to Kisumu County where they are deposited as building sand.

Climate and Vegetation

The county has a high equatorial type of climate with fairly well distributed rainfall throughout the year with an average annual precipitation of 1900mm.Temperature ranges between $14^0C - 32^0C$. This climate supports a wide variety of crops such as tea, coffee, horticultural crops and rearing of livestock. Vihiga County is largely dominated by planted vegetation. This includes trees planted on peoples' farms. The natural vegetation is depleted due to human activities. The planted vegetation is supported by grassland vegetation which can be spotted in unsettled areas. Grassland vegetation contains grass mixed with trees especially the thorny acacias which grows as tall as 10 metres in some areas. The canopies of acacia trees which are umbrella shaped provide shade and reduce the loss water from farms.

Geology and Soils

The geological formation of the County is composed of Kavirondian and Nyanzian rocks system with notable ones being Nyang'ori and Maragoli hills. These rocks have high potential for exploitation as building material (stones and ballast).The district has two main agro-ecological zones which are the upper midland zones with well drained fertile soils and the lower midland zone has mainly the red loamy sand soils, derived from sediments and basement rocks. The soils found in Vihiga County are favourable for various crops like maize, beans among others and livestock. Soil is instead extracted for brick making.

Land use and Economic activities

The soils in Vihiga County determine the land use and the economic activities. The upper midland zones with well drained fertile soils that dictate the land use patterns and population distribution. The upper midland zones with well drained fertile soils has a high potential for crops like tea, coffee, maize, beans and covers most parts of Central Sabatia, Vihiga and Tiriki divisions. The lower midland zone has mainly the red loamy sand soils, derived from sediments and basement rocks. They support crops like sugarcane, maize, beans and sorghum. This zone covers most parts of Emuhaya Divisions, Tiriki east and West divisions have comparatively fewer densities because farming is done in those areas due to large farms. In addition, cattle farming are done on small scale in various parts of Vihiga County. Apart from farming other economic activities conducted in Vihiga County include quarrying and trading. There is plenty of quarrying in Emuhaya for murram. Trading involves food crops from the farms and the murram quarried.

Population distribution by density by division

In VihigaCounty, Sabatia Division has the highest population density of 1,179 persons per km^2. The flat land in Sabatia, Tiriki and Luanda is coupled with abundant rainfall has influenced dense settlement. The county has got the highest total fertility rate of 5.5 percent. Generally, the high concentration of population is witnessed even in rocky areas such as Maragoli hills and flat swampy parts of Luanda division. This has aggravated poverty levels, as land subdivision is rampant. This is further demonstrated in Table 4. Brick making is concentrated in Sabatia division of a population density of 1,179 per square kilometre followed by Luanda division of a population density of 1,035 per square kilometre.

Table 4: Population density distribution by division

Division	Area in (km^2)	Density/ km^2
Luanda	98.6	1,035
Emuhaya	74.6	1,025
Sabatia	110.4	1,179
Tiriki East	97.0	682
Tiriki West	92.1	915
Vihiga	90.3	1,015
Total	**563.0**	**978**

Source: Vihiga District Development Plan 2002 – 2008

3.3 Research Design

The research was a descriptive cross-sectional study. The research targeted both brick sites and brick makers (two levels). The brick sites were all observed to collect data. At this level, the study observed the brick site sizes, terrains, gullies and amount of soils created to form other physical feature. The second level involved getting individual brick makers around brick sites, at their homes while others could be found in market places sourcing for market for their bricks so as to fill in the questionnaire. Since the brick makers are many, the study used stratified sampling technique to get a sample population that was used to collect data using observation, interviews and the questionnaires.

3.4 Sources of Data

Sources of data for the study were based on both primary and secondary data so as to achieve the set objectives of the study. Primary data was mainly obtained from the following:

Observing brick sites: 50 bricks sites were observed to collect data.

Brick makers: Administering questionnaires to the sample population of 254 brick makers selected across the county.

Local Authority: The provincial administrators of Vihiga County (one District Officer one from each division, two Chiefs from each division, five Assistant Chiefs

from each division and ten village elders from each division) were interviewed to collect data.

KEFRI Maseno: Interviews with the head of the branch were done in the mornings before he left for field duties and evenings after field work. In addition, data was collected from the manual and books from the KEFRI offices on types of trees and forests in Vihiga County.

Questionnaires which comprised of both closed and open-ended questions were developed and provided to the brick makers and the local authority members to provide both qualitative and quantitative data which was used in the study. The study used Focused Group Discussion (FGD) with the brick makers who were grouped per brick site. From the reconnaissance study there were approximately 15 brick makers per brick site. The researcher picked 10 brick makers randomly to represent each division giving the researcher a total of 6 groups. Photographic techniques were applied at brick sites while key informant interviews were organised with the members of provincial administration to provide qualitative data to the study.

Relevant literature on vegetation and socio-economic activities was sought from both published and unpublished sources. They were obtained from relevant text books, journals, periodicals, academic reports and project reports. The documents were sourced from Maseno University and Kenyatta University Libraries, Kenya Forestry Research Institute (KEFRI), Vihiga County offices for the Vihiga Development Plan (2002-2008), Internet among others.

3.5 Study population and Sampling Procedure

The study used stratified sampling technique because each division was to be represented equally. There were six strata for the six divisions. Every brick maker in all the 50 brick sites was given equal chance of being part of the study in all divisions of Vihiga County. This was to enable the study to make observation, administer questionnaires and carry out interviews. The survey conducted during reconnaissance established that there were about 15 brick makers at every one brick site in Vihiga County giving 750 brick makers as the estimated study population.

The areas with high population contained the highest number of brick sites while those that have low population like Emuhaya and Tiriki East Divisions contain the lowest number of brick sites. From the study the brick sites are distributed as follows: in Luanda Division the 10 brick sites were observed in S.W Bunyore, Central Bunyore, South Bunyore, and West Bunyore. In Emuhaya Division the 6 brick sites were observed in North Bunyore, N.E Bunyore, East Bunyore and Wekhono. In Sabatia Division the 14 brick sites were observed in Chavakali, West Maragoli, Idzara, Idzara North, North Maragoli, Busali West and Busali East. In Tiriki East the 5 brick sites were observed in Shaviringa and Shamakhokho. In Tiriki West the 7 brick sites were observad in Jepkoyai, Gisambai, Banja and Tambua. Finally, in Vihiga the 8 brick sites were observed in Mungoma, South Maragoli, Central Maragoli and Lugaga. This information is further demonstrated in the table 5 below.

According to Fisher et al (1984) cited in Mugenda and Mugenda (1999), when a study population is greater than 10,000 its minimum sample size is 384 at 95% confidence level. For the study population less than 10,000 the sample size is calculated as follows:

$$n = \frac{384}{1+\frac{384}{N}}$$

Since N is 750 (estimated population), n is 254 (the required sample size).The sample strategy involved was the use of table of random numbers as a basis for sampling units from a population to get 4 brick makers from brick sites in Emuhaya, Tiriki East and Tiriki West Divisions. But in Sabatia division 6 brick makers, 5 brick makers from Luanda Division and 6 Vihiga Division. This approach gives a total of 254 brick makers. The study considered 15% female and 85% male so as to collect concrete data. The study considered gender because from the reconnaissance survey, women involved themselves with brick making activities. Sabatia, Luanda and Vihiga Divisions contributed more brick makers because they contained high population compared to Tiriki East, Tiriki West and Emuhaya. This information is further demonstrated in Table 5.

Table 5: Brick sites per Division

Division	Number of Brick sites per location	Number of brick makers by gender		Sample size per location
		Male	Female	
Luanda	10	42	8	50
Emuhaya	6	20	4	24
Sabatia	14	71	13	84
Tiriki East	5	17	3	20
Tiriki West	7	24	4	28
Vihiga	8	41	7	48
Total	**50**	**215**	**39**	**254**

Source: Reconnaissance, (2009)

3.6 Methods of Data Collection.

To obtain relevant data for the study, the following data collection methods were applied:

Structured Questionnaires

Structured questionnaires with both closed and open ended questions were the major research instrument utilized in the study at all levels to seek information about socio-economic characteristics of brick makers, and the effects of brick making on the environment (Appendix A). The target was the brick makers, some local authority members and few non brick makers to achieve the objectives. All the questions were administered with the help of field assistants to avoid mis-understandings

Key - informant interviews.

Purposive sampling technique was used to administer questionnaires on the key informants who were well-informed about brick making. Using Appendix B, informal interviews were carried out with the District officers, chiefs and village elders.

Observation and Photography

Direct observation of the brick making activities and events in the study area was undertaken so as to understand the effects of brick making. Photographs were taken to show some salient features relevant to the study, such as, pits and valleys caused, crops planted in pits and preparations of brick making processes.

Focus Group Discussion (FGD)

A total of 6 Focus Group Discussions (FGDs) of 10 brick makers who were picked randomly per brick site were held so as to assess effects of brick making on the environment. FGDs helped to capture more data for the study. The discussions captured the issues raised in questionnaires and interviews.

3.7 Data Analysis and Presentation

Both quantitative and qualitative methods of data analysis were employed to analyze the data. Quantitative data were analysed by using descriptive statistics which included percentages and means. Statistical cross-tabulation of various variables was undertaken to determine the effects of brick making on the environment. Qualitative data was analysed by grouping the arising issues into various categories relevant to the study. This was important because it helped the study to access important facts that were never captured during the administering of the questionnaire. Data was synthesized and put down in narratives in form of statistical tables, charts, photographs and percentages to show the effects of brick making on the environment as shown in chapters four and five.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 INRODUCTION

This chapter contains an analysis of the socio demographic characteristics of the study population. It further gives the results and discussion of the impact of brick making activities on the environment derived from the study population in Vihiga County basing on each objective.

4.2 Socio demographic chacteristics of the study population

The study population of Vihiga County contained various respondents. It included individual brick makers from the six divisions. The study also derived information from various key informants who included village elders, assistant chiefs, chiefs, environmental officers, district officers and the District Commissioner. The discussion groups contained various people in different divisions. The study populations' analysis of the demographic characteristics includes the following:

Gender

The study found out that 85% of the sample sizes of the 254 brick makers were male while 15% were female. The study revealed from the questionnaires filled in appendix A and the group discussions in appendix C that the processes involved in brick making were heavy for the female gender. Brick making activity involve the following steps in Vihiga County. Firstly, mining of the soil using *jembes;* secondly, preparation of the soil by mixing with water and kneading to hold it together, thirdly the kneaded soil is moulded using brick moulders made from wood and few made from metal; fourthly, the bricks are dried on the sun but not directly because grass is used to cover the bricks; and finally, the bricks are arranged in kilns ready for burning using wood fuel. A lot of man power is required beginning from the first activity of breaking the ground to get the soil. In areas where water is scarce, long distances are covered by women because plenty of water is require for mixing the soil to get well kneaded soil paste. The kind of labour needed is not female friendly giving the reason why 85% of the brick makers being men. Table 6 shows the number and the percentage of male and female involved in brick making activities in Vihiga County.

Table 6: The number and percentage of male and female involved in brick making in Vihiga County

Gender	Number of brick makers	Percentage of brick makers
Male	216	85%
Female	38	15%
Total	**254**	**100%**

Source: Field data Vihiga County, 2009

The female gender involved were either widows continuing with their husbands' projects or those who owned projects because they are working elsewhere. In Wekhono area in Emuhaya Division, one of the brick site was owned by women. In Maragoli South and Shamakhokho, women assisted in arranging the bricks and drying. But in South Africa women are left for the brick making activities in totality because the men have migrated to the mines (GWA, 2006). They are involved in all the processses as from soil extraction, mixing the soil and water, kneading the soil, moulding into bricks, drying and finally burning the bricks. A study conducted by Buyinza and Bukenya (2009) found out that, in Uganda 86% brick makers are men. The women are involved only in minor activities like fetching water, cutting grass, selling wood and food to brick makers.

Level of education

The study found out that a bigger percentage of the brick makers were those who never went to school. From the sample size of 254, table 7 shows the number and percentages of various levels of education of brick makers in Vihiga County.

Table 7: The total number and percentage of the various levels of education of brick makers in Vihiga County

Level of education	Number of brick makers	Percentage of brick makers
None	102	40%
Primary	76	30%
O – level	38	15%
A – level	25	10%
Tertiary/college/university	13	5%
Total	**254**	**100%**

Source: Field data Vihiga County, 2009

Table 7 shows that brick making is dominated by individuals who never went to school and those who did primary level of education in Vihiga County. Those brick makers who are educated up to O- level and beyond believe brick making is for those who never went to school and those who reached primary level. The study found out that 40% of the 254 sample size brick makers never attempted to go to school or dropped out while 30% reached primary level. Through the interviews of appendix B the key informant revealed that lack of school fees contributed to the increased school dropouts. The increased number of school dropouts would increase brick making activities because they will offer cheap labour thus increasing the amounts of soil extracted, amounts of water used and the amounts of trees cut.

From the Focus Group Discussions, the brick makers revealed that they engaged in the activity to raise school fees for their children whom they did not want to be like them. In Mexico, the illiterates and those who dropped out of school at lower level engaged in brick making (Lowery and Octavio, 1996). Brick making was done with the help of NGOs training the brick makers unlike in Vihiga County. In their study Buyinza and Bukenya (2009) found out that in Mukono District in Uganda, high level of education increases a brick maker's ability to obtain, process information on wetland conservation. High level of education increases employment opportunity thus

less dependence on brick making. In Uganda 92% of brick makers attained formal education (Buyinza and Bukenya, 2009).

Age

The ages of between 18 to 40 years dominate the brick making activity in Vihiga County. Table 8 shows the number and percentages of different age-groups of brick makers in Vihiga County.

Table 8: The total number and percentage of different age-groups of brick makers in Vihiga County

Age-group	Number of brick makers	Percentage of brick makers
< 18	5	2%
18-30	102	40%
31-40	76	30%
41-50	38	15%
51-60	13	10%
60+	8	3%
Total	**254**	**100%**

Source: Field data Vihiga County, 2009

Table 8 indicates that the age group of 18-30 contains 40% of brick makers who are youth, who have energy for activities like soil extraction, mixing the soil with water, kneading the soil and arranging the bricks for burning are activities that are done continuously and repeatedly. All this activities require a lot of energy. Most of the brick sites in Luanda and Emuhaya Division were dominated by ages 18 to 30 years that made the highest number of bricks per year. The brick makers in Vihiga County always hit the mark of 100,000 bricks in a year per brick site. The interviews with the key informant revealed that Emuhaya and Luanda Divisions led in brick production. The presence of young energetic people causes extraction of more soil, consumption of more water and wood fuel. This is supported by the study in Uganda which found out that the age of 18-31 took 72% of the population while 53-60 ages own 8%

(Buyinza and Bukenya, 2009). The difference is big because brick making activities are vigorous thus require a lot of energy making them to suits the youth.

Occupational status

The study revealed that most of the brick makers in Vihiga County are unemployed. The study revealed that 90% of the 254 sample size depended solely on brick making to earn income. The employed were 10% which comprised of teachers, nurses and other civil servants. This group of people employed workers on their brick sites so as to make extra cash. The Focus Group Discussions revealed that the employed brick makers wanted more money because of the increased dependants. The study found out that the unemployed brick makers depended on brick making but also engaged in other activities in case ready market was not available for bricks. The study observed that, 50% of the unemployed practised subsistence farming or retail traders. The study established that 2% of of the unemployed tried other challenging economic activities like fish and poultry farming. Brick makers gave the reasons why other business ventures were not considered. The brick makers expressed that this activities were so involving especially considering the nature of poultry farming and fish farming, they would rather make bricks. This led to the increase in the amounts of soil extracted; water consumed, wood fuel extracted and high temperatures that affected graining period for crops as a result of burning bricks. Lack of secure sources of income pushes humans to engage in brick making (Buyinza and Bukenya, 2009). The study revealed that some brick makers made bricks to reduce building expenses to replace blocks due to high costs of cement.

Land ownership

Vihiga County is one of the overpopulated areas in Kenya. Due to overpopulation people here own few acres of land. Brick making is concentrated in areas where there is still space. This include: Sabatia, Tiriki East and Tiriki West divisions. The study found out through questionnaires administrations and the Focus Group Discussions that approximately the brick makers owned between a quarters of an acre to two acres. The land is small due to the traditional subdivision of inherited land (GoK, 2002). The study also found out that 5% of the 254 sample size (13 brick makers) owned land elsewhere specifically for farming which was acquired through purchasing. In Vihiga

County there were 50 brick sites observed during reconnaisance. As observed, 14 brick sites were in Sabatia Division. Sabatia was the division with the highest number of brick sites on peoples' land because of the high population in the division and the large area covered by the division. Large population and more space encouraged increased brick making activities.

Majority of the brick makers owned two acres of land and below. Table 9 shows the number and percentages of brick makers and their land ownership in acres in Vihiga County.

Table 9: The number and percentage of brick makers and their land ownership in acres in Vihiga County

Size of land	Number of brick makers	Percentage of brick makers
<0.25	64	25%
0.25-1.9	127	50%
2-5	38	15%
5.1 and above	25	10%
Total	**254**	**100%**

Source:Field data Vihiga County, 2009

Table 9 indicates that very few people own 2 acres of land and above. The study found out that in Luanda, Vihiga, and Emuhaya Divisions majority of the brick makers owned between 0.25 to 1.9 acres of land. Luanda, Emuhaya and Vihiga Divisions were the areas with the highest percentage of brick makers because they used communal land in addition to their land for soil extraction to be used for brick making. In another study conducted in Uganda areas of brick makers with between half an acre and two acres are the areas where brick making is concentrated (Buyinza and Bukenya, 2009). The people with fewer acres invade communal land and road reserve. This is supported by Neyole and Oteng'i (2007) in their study in Siaya, Bondo, Butere and Mumias who found out due to pressure on land, communal and road reserves are being encroached.

Marital status

Brick making earn families income. Table 10 shows the number and percentages of marital status of the brick makers in Vihiga County.

Table 10: The number and percentages of marital status of brick makers in Vihiga County

Marital status	Number of brick makers	Percentage of brick makers
Single	50	20%
Married	179	70%
Widowed	25	10%
Total	**254**	**100%**

Source: Field data Vihiga County, 2009

The study found out 70% of the brick makers was married. The brick makers confirmed that the families they owned required more income. Children required school fees, clothing, shelter and food. Married couples together with their children work around brick sites so as to earn more income. The brick makers revealed that they incorporated their children during weekends and holiday so as to make more bricks and cut down the costs. Table 10 indicates that people with families engage in brick making activities more than the widowed and the single.

Size of the brick making enterprise

The study found out that the sizes of the enterprises ranged between 200 square metres to 1 square kilometre. Figure 4 shows the percentages of workers and the size of the enterprises of brick makers in Vihiga County.

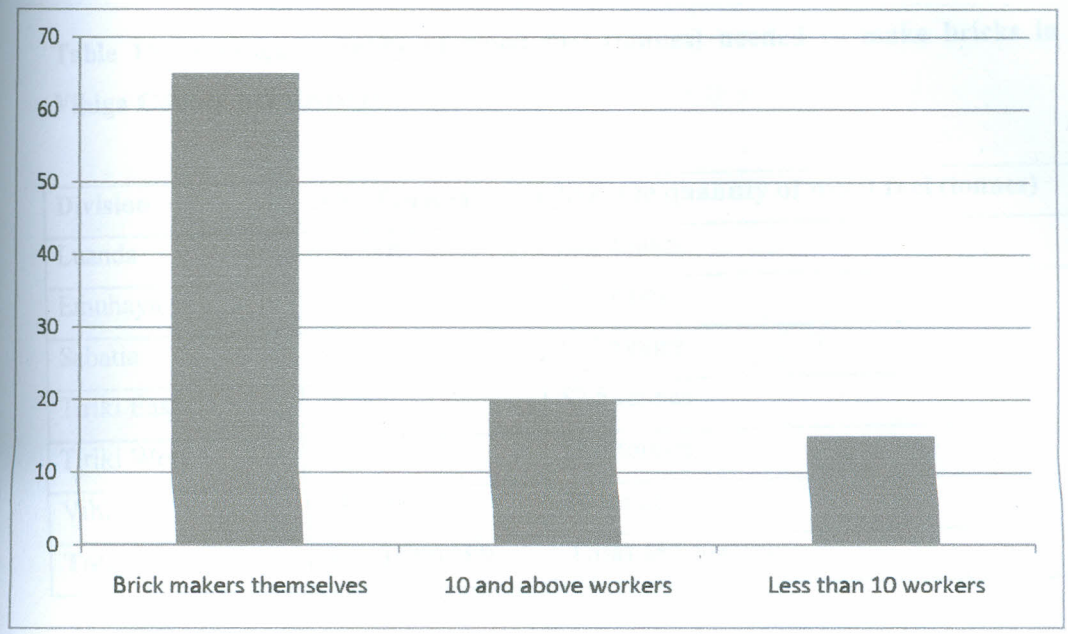

Figure 4: The percentages of the workers and the size of the enterprises in Vihiga County, 2009

The brick makers revealed that the bigger the enterprise the more the number of the workers. Figure 4 shows that 65% of the brick makers from the sample size of 254 works by themselves in the enterprise, 15% of the brick makers from the sample size of 254 employed ten workers and more while 20% of the brick makers from the sample size of 254 employed below ten workers on their enterprise. From the observation on brick sites and the interviews with the brick makers, the bigger the enterprise the more the soil extracted, the more the wood fuel consumed, the more the water consumed and the less time spent in the farms.

4.3 Effects of brick making activities on forest cover in Vihiga County

Table 11 below shows the quantity of wood fuel in tonnes needed by one brick maker in a year. In a single year a single brick maker makes an average of 10,000 bricks that consume on average 7 tonnes of wood fuel. Table 11 shows on average in a single round the total number of bricks made in each division. Each brick site was owned by approximately 15 brick makers who made at least 1,000 bricks each in a single round. In a year they could make 6 rounds.

Table 11: Average quantity of wood fuel (tonnes) needed to make bricks in Vihiga County per division

Division	No. of bricks	Average quantity of wood fuel (tonnes)
Luanda	150,000	105 tonnes
Emuhaya	30,000	21 tonnes
Sabatia	210,000	147 tonnes
Tiriki East	75,000	52.5 tonnes
Tiriki West	105,000	73.5 tonnes
Vihiga	120,000	84 tonnes
Total	**Total 690,000**	**Total 483 tonnes**

Source: Field data Vihiga County, 2009

A study conducted by Howard (1986) found out that 100,000 bricks required 70 tonnes of wood fuel. The 70 tonnes is translated to about 2 mature trees 1½ ft basal diameter (Howard, 1986). The 750 active brick makers in the county require 7 tonnes per year for the 10,000 bricks made in a year. The 483 tonnes required in Vihiga County just in a single round requires about 20 mature trees 1½ ft basal diameter. This leads to a loss of many smaller trees because the mature trees are very scarce in Vihiga County. This is because trees are also used for building, timber, production and firewood. GoK (2008) indicates that trees in Vihiga County serve as woodfuel for brick burning, timber and firewood for cooking. Table 11 shows approximately the total number of bricks made in Vihiga County in a single round and the approximated number of tonnes required. The study revealed that most of the brick makers measured their wood fuel using the lorries that carries the wood fuel. To be sure of the wood fuel they specified the to a 7 tonne lorry.

A study carried out in Sudan (Ashrafal, 2006) found out that the total number of woodfuel used per year amount to 52,500 tonnes simply because the total number of brick makers differ in four states of Nothern Sudan and Vihiga County. Sudan had over 10,000 brick makers. The types of kilns used also determined the amount of wood fuel used (Neyole and Oteng'i, 2007). The study in Vihiga County revealed that 99% of the 254 brick makers (sample size) used the rectangular kilns. The more the

bricks the more the wood fuel used because many bricks are arranged horizontally unlike square kilns where vertical and horizontal arrangements are equal.

The wood fuel used comprises of various parts of a tree in Vihiga County. Plate 1 shows the use of wood fuel for firing the bricks.

Plate 1: Use of wood fuel for burning bricks in Vihiga County

Source: field data (Jepkoyai Division) Vihiga, 2009

Plate 1 shows the use of wood fuel in burning of the bricks. The trees are used for burning/firing the bricks. The brick makers make use of the whole tree from the branches to the roots. The wood fuel is consumed highly because of the crude construction of kilns (Neyole and Oteng'i, 2007). Most of the brick makers prefer to use indigenous trees since they are considered to have high calorific value compared to exotic ones when used as wood fuel (KEFRI, 1990). The indigenous species have high calorific value and thus less fuel utilised, (Maundu and Tengnas, 2005). The indigenous trees are very scarce as revealed by the study. The study revealed that 25% of the sampled brick makers (254) were able to get indigenous tree species while 75% of the sampled brick makers used the exotic tree species. The indigenous species used in Western Kenya include; black wattle, elgon teak, '*omuterere*' among others, (Noad and Bimie, 1990). The study found out that '*omuterere*' and black wattle were mainly used because they were available throughout Vihiga County. The study found out that apart from brick making, carpentry industry also preferred indigenous tree species thus increasing the rate of consumption. The brick makers revealed that the

indigenous species are very expensive. The reasons were; their demand is high, their seedlings are hardly found and they take longer to mature thus forcing the majority to use exotic. This can be compared to a study conducted in Busia, Siaya and Butere Mumias found out that brick makers in these areas prefer the indigenous trees (Neyole and Oteng'i, 2007).

Plate 2 shows some of the tree plantation observed in Vihiga County. The tree plants are on a brick maker's farm in Majengo.

Plate 2: Tree plants in Vihiga County

Source: Field data (Majengo) Vihiga County, 2009

Plate 2 shows some of the trees plantation observed in Majengo, Vihiga County. From the study, wood fuel is becoming very expensive because wood is used for other purposes thus high demand therefore 80% use wood fuel from farms either their own or buy from neighbours. The study revealed that because of high costs, 90% of the brick makers use the entire tree, that is; trunk, twigs, branches, stamps and roots. Only 10% reserve other parts for cooking. Mkoka, (2003) found out that forests in Malawi are disappearing because of various activities like clearing the forests for woodfuel for brick making and other activities like charcoal burning and wood gathering. Wood is required for construction of houses, carpentry and wood fuel for cooking as found out from the research. The study found out that the majority of the inhabitants in Vihiga can comfortably afford wood fuel for cooking. It is becoming difficult for brick makers to afford wood fuel because it is becoming more expensive, thus some have resorted to planting their own trees. This is supported by a feature of UNDP, (2008)

conservation projects which encourage community engagement in forest protection and ecosystems conservation.

Table 12 shows the number of brick makers and their sources of wood fuel in percentages. From the sample population of 254 brick makers 203 brick makers used the trees on their farms, 43 brick makers went to other counties especially Kakamega Forest and parts of Nandi Forests. The remaining 8 brick makers revealed that use wood fuel from the forests within the county.

Table 12: Sources of wood fuel for making bricks with the number of the brick makers and percentages in Vihiga County

Source	Number of brick makers	Percentage of the brick makers
Forests within the county	8	3%
Forests from neighbouring county	43	17%
Farms	203	80%
Total	**254**	**100%**

Source: Field data Vihiga County, 2009

The natural forests in Vihiga County, Maragoli and Ebusiekwe were all depleted due to wood logging and wood fuel as revealed by the key informant interview in Emuhaya and Vihiga Divisions. The study also found out that in the 1990s, 60% of the sample population depended on forests for wood and wood fuel. Currently 10% of Vihiga County has traces of natural vegetation as 90% is covered by manmade vegetation (GoK, 2008). The county has one manmade forest (Kibiri), covering 41.61 square kilometres, 409 square kilometre arable land and 154 square kilometre non-arable land (GoK, 2002). This can be compared to the study done by Ashrafal (2006) confirmed that, the Savanna woodlands surrounding Khartoum have shrunk. The study in Vihiga County found out that 3% of the brick makers use wood fuel from Kibiri forest,17% from Kakamega and Nandi forests and the majority 80% use wood fuel from the farms either their own or buy from neighbouring farms. The study revealed that the forests and vegetation on peoples' farms do not only provide wood

fuel for brick making but also provide fire wood, charcoal and timber for carpentry. These activities contribute to the depletion of the vegetation cover in Vihiga County. GoK, (2008) confirms that wood fuel for brick making, charcoal burning and timber harvesting contribute to the destruction of vegetation cover. But the study established that brick making activities has increased the use of wood fuel compared to other uses because brick makers could access other sources of cooking energy like gas, sawdust and maize cobs. In Africa, brick production is the major consumer of wood fuel from the forests (Mkoka, 2003). Mkoka (2003) confirms that in Malawi, forest cover on Ndivande and Michiru mountains has disappeared due to brick making, charcoal burning and wood gathering. The study also found out that trees on people's farms are being depleted at a high rate as 80% of the brick maker forcing them to cut down immature trees. The continued cutting of trees and depletion of forests leave the land bare exposing it to erosion. Removal of vegetation cause more flow of water on the surface thus eroding the top soil, (Archer, 1987).

4.4 Effects of soil Extraction for bricks on environment in Vihiga County

Extraction of soil for brick making in Vihiga County causes damage on the earth's surface as shown on plate 3 & 4 taken in Jepkoyai Division and South Maragoli Division.

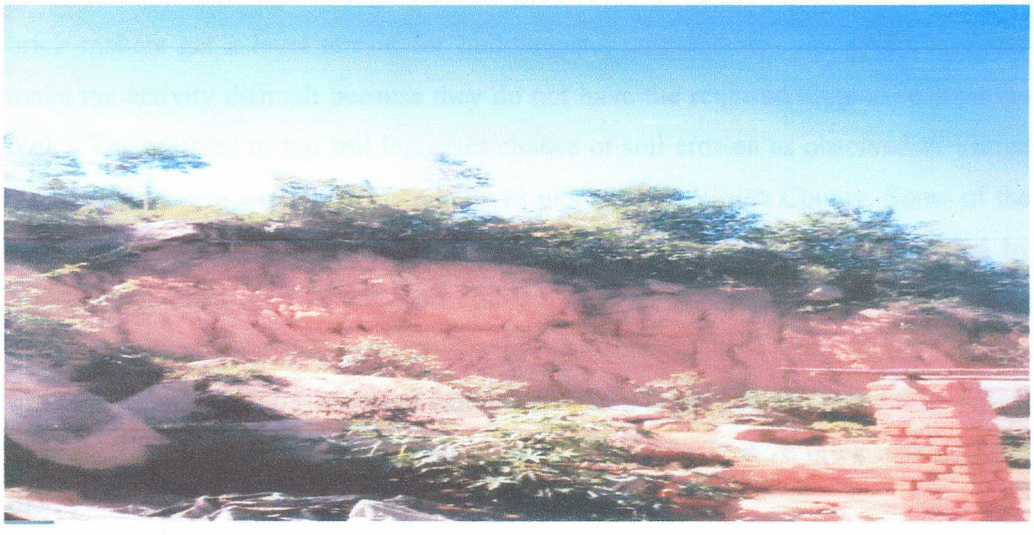

Plate 3: A valley in Vihiga County

Source: Field data (Jepkoyai division) Vihiga County, 2009

Plate 4: Pits on farms as a result of brick making in Vihiga County

Source: Field data (South Maragoli division) Vihiga County, 2009

The study established the presence of gullies and valleys as in plate 3 and 4. The extraction of soil from the earth's surface causes gullies and valleys. Vihiga County has undulating hills and valleys (GOK, 2002). Digging out of the soil complicates the situation, but the brick makers especially in Vihiga and Emuhaya Divisions (Maragoli South, Maragoli Central, Bunyore North and Wekhono) which contain a ragged terrain. The study found out that in the hilly and rugged areas like Vihiga and Luanda Divisions brick making was highly encouraged because the extraction of soil helps the brick makers get a level terrain for building and construction. The rocks available make the activity difficult because they do not have the required tools to remove the rocks. The removal of top soil increases chance of soil erosion as observed in Vihiga County. Excessive extraction of soil leaves pits all over Vihiga County. Some of the gullies have been refilled by planting crops in them, while others were filled by broken bricks and the rest left with nothing. The study revealed that 50% of some parts of Vihiga Division and Tiriki west contained valleys and gullies. This is supported by GoK (2008) revealed that brick making cause gully formations in Vihiga County. The study found out that out of the 254 brick makers 76 brick makers filled their gullies with crops as shown in Plate 5 and 6.

Table 13 shows the percentages of the brick makers and the areas they extract their soil for brick making. Brick makers used soil various sources as shown in Table 13. From a sample population of 254 a total of 124 (49%) extracted soil from communal

land, 124 (40%) extracted from their own land, 20 (8%) extracted near water bodies and 8(3%) imported soil as far as 1 kilometre from the brick sites.

Table 13: Sources of soil for brick making with the number of brick makers and their percentages in Vihiga County

Source	Number of brick makers	Percentage of brick makers
Communal land	124	49%
Private land	102	40%
Near water bodies	20	8%
Importing	8	3%
Total	**254**	**100%**

Source: Field data Vihiga County, 2009

Table 13 shows the sources of soil used for brick making. The table shows 49% of the brick makers use communal land for the activities. These are areas along the road reserve (1 - 5 metres) and other public areas. The study established that 40% use their private land. The soil around water bodies is preferred but it is scarce thus only 8% of the brick makers could access near water bodies. Being near water bodies, the brick makers use all kinds of containers to draw water. River Yala and River Idzara water is made dirty more in parts of the rivers dominated by brick makers. In Boyani, there is a spring which has been dominated by brick makers. The study also found out 3% of the brick makers imported soil from banks of rivers and near swampy areas, (the same is done for soil for smearing the house) and communal land. This was observed in the group that owned less than a third of an acre of land.

Plate 5: Sugarcane and nappier grass grown in valley as a result of brick making in Vihiga County

Source: Field data (Jepkoyai location) Vihiga County, 2009

Plate 6: Banana plantation grown in pits as a result of brick making in Vihiga County

Source: Field data (Maragoli South) Vihiga County, 2009.

In Emuhaya and Luanda Divisions the study revealed that the gullies and valleys were filled with broken bricks. A bigger population did neither planting the crops nor filling the gullies with the broken bricks. The study found out that 60% of the 254 brick makers (sample size population) had left their brick sites with neither broken bricks nor crops posing as a health hazard. In a study carried out in Uganda, Buyinza and Bukenya (2009) confirms that there are pits left after extraction of soil for bricks

making. But in Uganda he found out pits are turned into fish ponds thus reducing accidents by 50%. Walingo, (2009) found out brick making activity contributing to the activities that affect the environment. Because the activities are taking place on the land in Vihiga and especially farming land, the quantity of the soil decreases leaving behind valleys, gullies and pits which have increased soil erosion. In Vihiga10% of human accidents are due to gullies created due to extraction of soil. Animal accidents that occur in Vihiga county 50% of them are due to falling of animals in pits of which half of them are pits and gullies created after extraction of soil for brick making.

Accidents in Vihiga County have been witnessed in Jepkoyai, Maragoli south and Maragoli north. A village elder in Jepkoyai confirmed that he records at least 2 cases of people injured and 8 cases of livestock in one month. In Bangladesh, Rahman (2005), found out that brick making activities leaves behind hazardous environment. In Chad, Omoyen (2006) found out that pits and trenches left behind cause so many accidents to humans and animals as it is Vihiga County where 25% of livestock accidents is as a result of the pits due to extraction of soil for brick making. Padmalal et al (2004), confirms indeed pits and valley cause environmental hazards that cause accidents. In other areas like Siaya County, localized landslides occur where excavations were done. This has led to massive erosion and landslides risks (Neyole and Oteng'i, 2007).

The study found out thst the gullies and pits created lowers the aesthetic beauty of the land in Vihiga County. The interview conducted with a village elder in Jepkoyai revealed that the passengers who used to alight around Boyani on Kakamega-Kisumu Highway to view the scenic vistas has reduced by 50%. In addition the brick makers complained that there is increase in mosquitos during dry seasons. The confirmed that the pits that were filled with water harboured mosquitos. This finding is supported by the study conducted by researchers from the Department of Tropical Medicine at Tulane University in the US city of New Orleans in collaboration with their colleagues from the Kenya-based International Centre of Insect Physiology and Ecology, showed that brick-making generated dry season habitats for malaria vectors in western Kenya (IRIN AFRICA, 2004).IRIN AFRICA, (2004) study further revealed that most abundant habitat type containing Anopheles larvae was brick-

making pits. Indoor spray catches found that houses close to brick-making sites had malaria vectors, whereas those next to swamps did not (IRIN AFRICA, 2004).

4.5 Effects of burning bricks on soil fertility in Vihiga County.

Plate 7 shows some of the crops grown in central Maragoli Division. Farming is conducted at the same time with brick making.

Plate 7: Crops grown on farms in Vihiga County

Source: Field data (Central Maragoli division) Vihiga County, 2009

Plate 7 shows some of the crops grown in Vihiga County. The research found out that Vihiga has a favourable climate and good soils that support farming (GOK, 2002). The county can sustain tea, bananas, coffee, maize, beans, and sugarcane among others. The study established that 45% of the sample size of 254 brick makers used well drained soils for brick making, 45% of the 254 brick makers sampled used loamy soils and 10% of the sample population used clay soil. The soils in Vihiga can produce good and high yields if used well. Residents of Vihiga Couty own very small farms thus do not produce a lot of yields.

Plate 8 shows brick making on agricultural land. When the burning activity is carried out on the agricultural land, it affects crops directly because of the high temperatures during burning.

Plate 8: Brick making on agricultural land in Vihiga County

Source: Field data (Majengo) Vihiga County 2009.

Table 14 shows the comparison of crop yields in Vihiga County between 2005 to 2009 when the study was carried out.

Table 14: Comparison of crop yields of maize, beans and sorghum from farming from 2005 to 2009 in Vihiga County in bags.

Year	Maize (No. of bags) 90kgs	Beans (No. of bags) 90kgs	Sorghum (No. of bags) 90kgs
2009	5	0.5	1
2008	9	2	3
2007	10	3	4
2006	15	3	5
2005	18	5	7

Source: Vihiga District Development Plan 2002 – 2008

Plate 8 shows brick making taking place on agricultural land. As revealed by the study, 49% of the 254 brick makers use communal land while 40% of the 254 brick makers use their own land where brick making takes place at the same areas farming takes place. Table 7 shows crop yields have been decreasing since 2005. The study found out that during the burning process which takes place on farms with crops, the burning activity increases the temperatures suitable for crops thus reducing the graining period for the crops. This reduced yields in areas where brick making take

place on farming land. The organisms necessary for soil formation took off to other areas thus reducing soil formation processes. The areas dominated by brick sites had no single anthill. This is supported by a study carried out in the USA. The study revealed that at 50 degrees centigrade soil microbes begin to experience mortality (Swezy and Agee, 1991). Furthermore in Bangladesh a study found out that the burning of bricks affects soil microorganisms, reduce soil fertility and reduce soil microbial contribution (Khan, 2007). In Sabatia and Vihiga Divisions, some crops appeared to be yellowish in colour. Scientifically there could be other reasons for the yellowing of the crops. Kenneth (2005) explains that plants differ in their temperatures for their life cycle for example rice requires 15 degrees centigrade to 20degrees centigrade. High temperatures therefore reduce the growth duration. At 25degrees centigrade there will be declining yield because of the shorter grain filling duration thus failure to produce filled grains. This is why Sigrid and Suharjo, (2007) and Shouichi(1981) found out that increased temperatures in rice fields in India has reduced production by 10% because pollination period is reduced. Ashrafal, (2006) found out that gases from the burning brick kilns were mixed in the air and they fell on vegetation and crops closing stomata thus stopping photosynthesis reducing farm yields.

Plate 9 shows a brick kiln arranged ready for burning. The kilns are arranged rectangularly in Vihiga County by the brick makers.

Plate 9: Kiln brick ready for burning in Vihiga County

Source: Field data (Wekhono division) Vihiga County 2009

Plate 9 shows the arrangement of bricks in a Kiln ready for burning. During burning carbondioxide is produced and the high temperatures produced reduces growth period of the crops grown. In all the farms that combined brick making and farming, the study found out that25% of the crops on farms are yellow in colour. Ashrafal, (2006) found out that increased carbondioxide in the atmosphere mixes with air which when it fall on the crops the stomata closes stopping photosynthesis. The barrow animals and insects run away from high temperature thus reducing soil making process. The rectangular Kilns consume a lot of woodfuel that produce a lot of carbondioxide is released in the atmosphere. In Mexico circular and square Kilns were introduced to reduce the use of wood fuel thus less emissions in the atmosphere (Lowery & Octavio, 1995). In China and India, VSBK project aimed at reducing wood fuel use, thus reduced carbondioxide emission (VSBK Report, 2005) UNDP and Global Environment Faculty introduced energy efficient smokeless brick making technology to curb carbondioxide. Hybrid Huffman Kiln developed in Germany was efficient, eco-friendly and cost-effective. This Kiln had the ability to completely burn most of the fuel that is mixed into the bricks during firing and thereby drastically reduce energy use and production costs. It also dries the bricks by directing hot air into the tunnel from annular Kiln which blocks carbondioxide emission, (UNDP 2008). After the burning activity, after the removal of the bricks from the Kilns the remaining ash is used by the brick makers in Maragoli South as manure in their farms.

4.6 The effects of brick making activities on the socio-economic environment.

Table 15 revealed the majority of brick makers stay in mud houses whereas they make bricks which are used to construct permanent houses. Table 15 shows the number and the percentages of the type house owned by the brick makers in Vihiga County.

Table 15: Types of houses owned by brick makers and the percentages in Vihiga County

Type of house	Number of brick makers	Percentage of brick makers
Semi-permanent	76	30%
Permanent	13	5%
Mud houses	165	65%
Total	**254**	**100%**

Source: Field data Vihiga County, 2009

Table 13 shows the percentages of the type of houses owned by the brick makers. The study found out that 65% of the 254 brick makers sampled stay in mud houses whereas they make the bricks used to construct permanent houses. The study found out that 35% of the 254 brick makers sampled stay in semi-permanent houses while 5% of the sample population stay in permanent houses. The study revealed that most of the houses were weak and even where the constructions took place was not safe. The brick maker explained that construction of houses requires other building materials which are expensive. The revealed that 65% of the sample population used mud and iron sheets while 30% of the sample population used mud and iron sheets but cemented their houses. Some parts of north, south and central Maragoli are too hilly and rocky making construction of houses difficult (GOK 2002). This is supported by Madulu (2005), who found out that availability of gullies and pits increases soil erosion and difficulties in settlement.

Plate 10 shows family members (Men, women and children) working. They are arranging the bricks ready for sale and transportation in Jepkoyai Division.

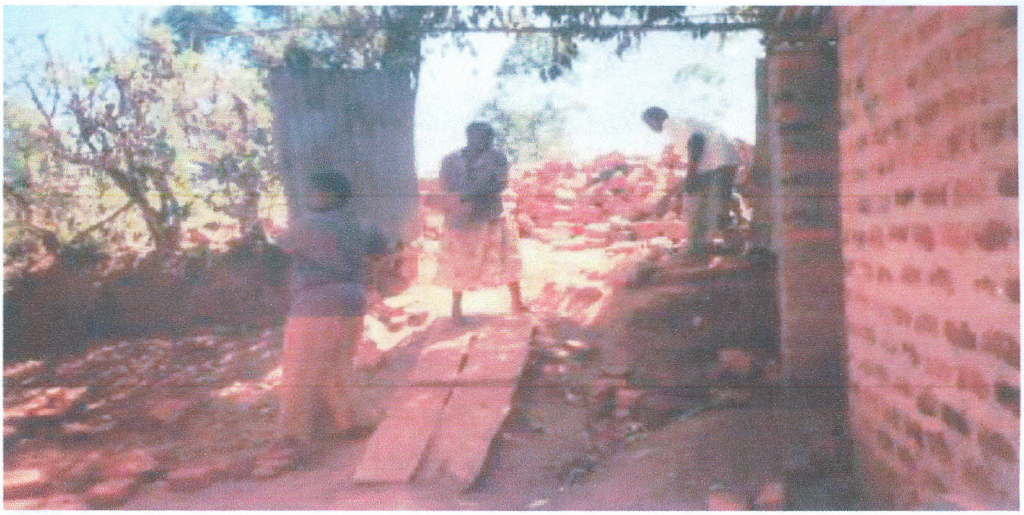

Plate 10: Family members working on bricks.

Source: Field data (Jepkoyai Division) Vihiga County 2009.

The study found out that the brick making processes involved men, women and children. This was observed across the county. In Luanda division there was one brick site in Wekhono which was owned by a woman. In Jepkoyai and Shamakhokho divisions women assisted in fetching water. Children assisted on weekends and holidaysbecause they were not attending school. In a study carried out in Siaya, Neyole and Otengi (2007) found out that brick making was purely male dominated but women assisted in minor chores of fetching water. But in Vihiga county women have taken charge in that in Wekhono they owned a brick site. In plate 10, women can also be seen assisting in arranging bricks ready for site.

The study found out that most of the brick works are concentrated in areas of between 1 metre to 5 metres near roads. This was to enable easy transportation or cut down costs as shown below on plate 11.

Plate 11: Bricks along road reserve ready for transportation.

Source: Field data (Boyani Village, Kakamega- Kisumu Highway) Vihiga County 2009.

The study found out those brick makers preferred road reserves as shown on plate 11 bricks around the road reserves ready for transportation around Boyani on Kakamega-Kisumu highway. The result go hand in hand with the study conducted in the Lake Victoria Basin counties which revealed that most of the brick makers preferred road reserves for easy transportation (Neyole and Otengi, 2007). Crops yields have been decreasing as revealed by the study as shown on table 16 farm yields have been decreasing per acre since 2005 to 2009 when the study was conducted in Vihiga County.

Table 16: Comparison of the number of people and the percentages involved in brick making and farming from 2005 to 2009 in Vihiga County

Year	Maize (No. of bags) 90kgs	Beans (No. of bags) 90kgs	Sorghum (No. of bags) 90kgs	No. of bricks	% of People	
					Brick making	Farming
2009	5	1	1	100,000	75%	25%
2008	9	2	3	60,000	64%	36%
2007	10	3	4	55,000	55%	45%
2006	15	3	5	24,000	40%	60%
2005	18	5	7	10,000	22%	88%

Source: Field data Vihiga County 2009.

Table 16 shows the cause and effects of the decreasing farm yields. The study discovered that since 2005 the number of brick makers has been increasing from 22% to 75% in 2009 and farming decreasing from 88% to 25% in 2009. The main reason of the decrease of the yields was; the time dedicated on farms was reduced to once a week to even not going at all or delegating. The lack of care for the crops led to decreased yields of 18 sacks of maize in 2005 to 5 sacks in 2009 of maize. The study found out that 2% of the sample population of the brick makers in Vihiga Division did not plant at all the entire year.

The brick makers keep livestock with a few mixing livestock and poultry, livestock and fishing, livestock and bee farming among others (GoK, 2002). The study found out that in 2005, 70% of the 254 brick makers were consuming their own milk but as at 2009, only 25% of the 254 brick makers were consuming their own milk. Poultry, fishing and bee farming is being practiced by 10% of the 254 brick makers. The study revealed that the earnings from brick making amounted to between Kshs. 300, 000- Kshs. 350,000 per year, compared to farming which earned brick makers between kshs. 70,000 to Kshs 120,000 per year per acre when he planted maize, beans, sorghum and had dairy cattle. The earnings could go as low as Kshs. 50,000 when the farmer only planted maize and beans.

The study found out that the brick maker settled for brick making activity because the expenses were less compared to the expenses on livestock, poultry, fish farming and bee keeping. The study revealed that 10% of the sample population engaged in other income generating activities such as poultry, fish farming and bee farming. The 90% of the sample population revealed that they tried at one point but decided concentrate on brick making. Engaging in these activities enabled brick makers to compare other economic activities and brick making. The found out that poultry farming, livestock farming, crop farming, fish farming and bee keeping required close monitoring and more capital compared to brick making.

Table 17 shows the average quantity of water used by one brick maker in a year in Vihiga County. Large amounts of water are consumed yearly.

Table 17: Average quantity of water needed to make the number of bricks in litres in Vihiga County

No. of bricks	Average quantity (litres)
2,000	1,200
3,000	1,800
5,000	3,000
20,000	12,000
30,000	18,000
40,000	24,0000
Total 100,000	**60,000**

Source: Field data Vihiga County 2009.

A single brick maker in Vihiga can make 100,000 bricks on average in a year which requires 60,000 litres of water as shown in Table 17. Brick making causes visible changes on the surface and ground water sources of a given area (Padmalal et al, 2004). The study found out that wells and boreholes (Esirulo and Shamakhokho among others) and Rivers (Yala and Idzara) arethe major sources of water to brick makers as shown in Table 17. The study revealed that a borehole in in Esirulo was to given two to three days to fill. Elsewhere dirty water was observed especially along Rivers Yala and Idzara as revealed by the study. The containers used are dirty with mud especially the 8% of the 254 brick makers who make bricks near water bodies as shown in Table 18. Water is required during the mixing of the paste of soil to make bricks and during drying one has to sprinkle on the bricks. The study found out that brick making consumed a lot of water as other activities like industrial and domestic purposes. The study revealed that some of the brick sites are situated near water bodies and those far, women and children are used to fetch water as far as 1 kilometre. This supported by Buyinza and Bukenya(2009), who found out brick making is situated in wetland areas and areas far from water sources brick makers use women and children to fetch water. This is also supported by Keddie and Cleghon (1980) who found out that preferred areas for brick making is around river banks. Ashrafal (2006) found in Sudan that brick making operated along banks of rivers like El Gash and Adbara. The study found out that brick making requires plenty of water, like 1000

bricks require 600 litres of water. This is supported by Draaisma(2009), who found out that huge volumes of water are needed for brick making which interferes with the other communal users of water like domestic and industrial purposes.

Brick makers used water from various sources as table 18 shows the sources of water used for brick making. It shows the percentages and number of various sources of water used for brick making in Vihiga County.

Table 18: Sources of water for brick makers and the percentages in Vihiga County

Source	**Number of brick makers**	**Percentage of brick makers**
Wells and Boreholes	102	40%
Springs	64	25%
Harvested	50	20%
Rivers	25	10%
Others	12	5%
Total	**254**	**100%**

Source: Field data Vihiga County, 2009.

Brick making requires plenty of water during mixing of the soil as shown on Table 18. This causes competition of water use in various water points. Table 18 shows various sources of water for brick making. The study revealed that 40% of the 254 brick makers use water from wells and boreholes, 25% of the 254 brick makers use water from springs, and 20% of the 254brick makers use harvested water 10% of the sample population use water from rivers and 5% from other sources. Increased brick making activities cause scarcity of water for domestic purposes. Table 18, shows on average the amount of water used by a single brick maker in a year in Vihiga County. The study revealed that, in Esurulo (in Luanda Division) and Shamakhokho (Tiriki East) contained brick sites that depended on boreholes. In Boyani (Vihiga Division) brick makers use water from a spring. In Chavakali town brick makers use harvested water. River Yala especially in Luanda Division and river Idzara in Tiriki East

Division brick makers use water from the rivers making the water dirty causing conflict with non-brick makers.

The study found out that brick makers sold 1 brick at Kshs. 5. A single brick maker produced 100,000 bricks per year. Expenses included; labour per day Kshs 100 and for bricks to be completed it would take around 30 days. One required a minimum of 5 workers, who would make 10,000 bricks in a period of one month. Therefore labour for 100,000 bricks would be:
(100 x 30 x 5) x 10 times
Kshs. 150,000

The revealed that for brick makers who use wood fuel from their farms only spent on labour therefore a net of Ksh. 350,000 was realized. But for those who purchased trees for wood fuel spent 1 mature tree which goes for between Kshs. 1000 to kshs. 1,500. In a year, one brick maker uses 20 mature trees costing Kshs. 30,000. Transport of the wood fuel depending on the distance roughly spent Kshs. 10,000. The total expenses amount to kshs. 200,000, giving this brick maker a net of kshs 300,000. In farming, 1 acre of land produced 20 bags of maize and 10 bags of beans on the high side. The study found out that 80% of the 254 brick makers practiced subsistence and the 20% of the 254 brick makers who farmed for income earned up to Kshs 70,000. The study found out that 90% of the 254 brick makers preferred brick making so as to earn more and faster. They also revealed that brick making was increasing due to increased demand for construction material.

This is supported by a study by Abila *et al* (2006). They found out that the population around Lake Kanyaboli 28% get Kshs. 2100 mean monthly from brick making which brings to an end to other economic activities. For example maize takes 3 – 4 months to mature in which one will have earned Kshs. 8,400 in the 4 months. In Mexico no knowledge is required for brick making, it consumes more time compared to other activities (Lowery and Octavio, 1995). The study found out that brick makers work in brick sites more than their farms. This is supported by Kristjanso *et al*, (2004) in his study that people in Western Kenya engage in brick making to earn income, making it to be popular thus people forgetting other economic activities. This is also supported by Walingo (2009a) who found out that brick making is one of the increasing land use activities overtaking other activities.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter contains the summary of findings, conclusions and recommendations, and the areas for further research.

5.2 Summary

The first specific objective sought to determine the effects of burning of bricks on the forest cover on the environment in Vihiga County. The findings reveal that there is destruction of forest cover and trees on farms due to increased brick making activities. About 3% of the 254 brick makers depend on the Kibiri man made forest, 17% of the 254 brick makers extend to the neighbouring forests of Kakamega and Nandi as 80% of the 254 brick makers use trees from their farms for wood fuel. In addition, the results show that there are other activities that contribute to the loss of forest cover which include timber logging, firewood gathering and charcoal burning.

The second specific objective was to determine the effects of extraction of soil for brick making on environment. The study reveals that brick making caused damage on the earth surface. It caused valleys, gullies and pits which posed as an environmental hazard to human life. The findings revealed that 5% to 10% of the human accidents are due to the pits and valleys that resulted from extraction of soil for brick making as explained by brick makers during the discussions and interviews. The brick makers interviewed explained how the valleys trigger landslides and rock falls because Vihiga County is rocky. The results show that increased excavations caused low farm yields as farming land was reduced. Furthermore, the pits and gullies caused 25% of accidents of cattle kept in homes as revealed by the village elders who recorded at least five accidents of animals in a month. In addition, the results show that some of the brick makers are trying so much to rehabilitate and refill the damages caused on the earth surface with crops like bananas and nappier grass.

The third specific objective was to establish whether burning of bricks affects soil fertility in Vihiga County. The results reveal that the farm yields have been decreasing as a result of reduced number of people on farms and less attention to crops. In 2005 only 22% of the brick makers involved in the brick making activity. In 2009 the percentage went up to 75%. The brick makers gave the brick making a priority to

farming. The study reveal that the land is not enough because of further family divisions of land as a result of inheritance. The results show that some crops especially the farms near brick sites were yellowish in colour and stunted in growth.

The fourth specific objective was to evaluate the effects of brick making activity on socio-economic environment. The results reveal that the pits, gullies and the valleys inconvenienced building and construction of settlement structures. It was confirmed from the discussion held by the brick makers that most of them lived in mud houses because the costs of other construction materials were very expensive. The results show that about 90% of the brick makers had no savings which could help or used as capital for other opportunities because the earning mostly came in bits causing them not to have bank accounts. In addition, the results reveal that because of less land people had invaded road reserve, water bodies and communal land so as to extract soil for brick making. Finally, the results show that 40% of the 254 brick makers used well and boreholes for water during brick making. Both the brick makers and non-brick makers interviewed confirmed that wells and boreholes near brick sites were dirty during kneading of the soil process for brick making.

5.3 Conclusion

Brick making destroys forest cover and trees on peoples' farms. Increased brick making activities would further destroy the forest cover and the trees on farms if not controlled or stopped. Most of the brick makers can not relate soil erosion and destruction of forest cover because majority of the brick makers and even non brick makers did not understand the importance of trees and forest cover in their environment. Lack of this knowledge causes increase of these activities that further destroys the forest cover and trees. The other activities include: brick making, timber logging, fire wood gathering and charcoal burning. This activities contribute to the destruction the forests and trees on farms at a high rate.

Extraction of soil for brick making creates pits and gullies which increases both human and animal accidents. In addition, soil erosion is increased as a result of the gullies and valleys thus reducing soil fertility. Reduced soil fertility decreases crop yields. The extraction of soil for brick making will continue to create more the pits, valleys and gullies which increases the number of accidents if not controlled. In

addition, crop yields will keep on decreasing due to increased soil infertility resulting from soil erosion due to increased valleys and gullies.

The burning activity causes increased temperatures and carbon dioxide. Increased carbon dioxide reduced seed formation thus affecting the yields. In addition, the high temperatures reduced maturity duration of crops near brick sites thus causing low yields during harvesting. Furthermore, increased temperatures kills the living organisms some which are vital for soil formation thus reducing soil fertility. Increased burning activity of the bricks will cause further decrease in the farm yields due to increased temperatures and carbon dioxide which affects crops growth.

The extraction of soil process has affected farming as an economic activity because of invading the agricultural land and less time spent on farms by the brick makers. In addition, settlement areas are reduced due to pits, gullies and creation of more brick sites. The use of water for brick making decreases water levels from various sources of water. Especially, during dry season competition for water uses increases making residents to travel long distances looking for water.

5.4 Recommendations

Brick makers should be made aware of importance of conservation of the environment like tree planting and providing tree seedling which may improve the forest cover in Vihiga County. The provincial administration together with environmental officers in Vihiga County should regulate the tree cutting in the county and even put mechanisms like tree planting and providing tree seedling which may improve the forest cover.

Since the main source of energy for brick making is wood fuel which depletes forest cover, alternative sources of energy for burning bricks should be sought for example use of sawdust, rice husks and even dry cow dung. In addition fuel efficient technologies like proper kilns like circular or square kilns to be used by brick makers in Vihiga County.

The extraction of soil from communal land and river banks should be regulated so that the number of pits and gullies are reduced. Communal land and river banks be

gazetted, the provincial administration and environmental officers in Vihiga County to put measures to govern the activity.

The brick makers should be educated on importance of conserving soil to restore fertility. The provincial administration, the environmental officers and agricultural officers in Vihiga County should be active and teach farmers new ways of farming to improve the yields. Finally brick making activity should be made on large scale to reduce the small scale production on people's farms.

5.5 Areas for further research

The study established that the forest cover in Vihiga County is used for various activities. Research should be carried out assess other causes of forest cover destruction.

The study revealed that there is competition for water use between the brick makers and non-brick makers. Therefore, it is necessary that studies to be carried out to establish other causes of decreasing water levels in various sources of water in Vihiga County.

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