ADOPTION OF HYDRAFORM - INTERLOCKING STABILIZED SOIL BLOCKS (ISSBs) BUILDING TECHNOLOGY AND ITS IMPACTS ON ENVIRONMENT IN NAKURU COUNTY

BY

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A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT FOR THE REQUIREMENTS OF DEGREE OF MASTER OF ARTS (ENVIRONMENTAL PLANNING AND MANAGEMENT) IN THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES, UNIVERSITY OF NAIROBI

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DECLARATION

This Research Project is my original work and has never been presented for a degree award in any other University.

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To my wife, son, parents and entire Sang'ori family for the unconditional and invaluable support during my study.

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

ABMTs:	Appropriate Building and Material Technologies
APHA:	American Public Health Association
CDF:	Constituency Development Fund
CRATerre-EAG:	The International Centre for Earth Construction-School of Architecture of Grenoble
CSEB:	Compressed Stabilized Earth Block
ERS-WEC:	Economic Recovery Strategy for Wealth and Employment Creation
GATE:	German Appropriate Technology Exchange
GoK:	Government of Kenya
HABRI:	Housing and Appropriate Building Research Institute
HDI:	Human Development Index
ITDG:	Integrated Technology Development Group
MDGs:	Millennium Development Goals
MOH:	Ministry of Housing
NACHU:	National Cooperative Housing Union
NCST:	National Council for Science and Technology
NEMA:	National Environmental Management Authority
PHO:	Provincial Housing Office
PI:	Plasticity Index
UNCHS:	United Nations Centre for Human Settlement
UNEP:	United Nations Environment Programme
UNESCO:	United Nations Education, Science and Cultural Organization

ABSTRACT

The world growing population poses major challenges to the efforts championed by various Governments' in facilitating access to affordable and adequate housing for their citizens and this is true in Kenya. For this reason, there has been need for cheap and appropriate technology to assist in alleviating the problem of inadequate housing and affordable construction cost. This study focused on the extent of Hydraform-ISSBs technology adoption and environmental impacts in Nakuru County. The specific issues addressed in this study included extent of use, factors affecting adoption, environmental impacts and mitigation measures. The overall objective of the study was to assess the impacts of Hydraform-ISSBs to the environment within Nakuru County. The general hypothesis was that Hydraform-ISSBs technology was an environmentally appropriate technology and therefore no adverse effects on the Nakuru County environment.

This study was carried out in Nakuru County from where the 35 Hydraform-ISSBs technology projects were included in the sample data. The 35 sites sampled were selected in such a way that the information sought on extent of use, factors affecting adoption, environmental impacts and mitigation measures could assist in solving the stated problem and meet the objectives of the study. To get the data required, a multi-stage sampling design was used where in the first place Constituency clusters were defined by the presence of the Hydraform-ISSBs technology projects sites. From the clusters list, six Constituencies were selected to reflect spatial representation in terms of soil, land use and type of application of the technology. The resulting data was then processed to create data code book which was used to create digital project database first in Microsoft Excel spreadsheet which was then exported into SPSS and saved as a data file. The data were then subjected to analysis procedures starting with descriptive frequency and crosstabulation procedures respectively to reveal the sample data distribution tendencies. From the descriptive results, the data were further subjected to inferential analysis to reveal differences in Hydraform-ISSBs technology use, adoption, environmental impacts and mitigation measures using the t-statistic at α 0.05 in all cases. The spatial data were also used to reveal the spatial spread of the projects sites as captured in field GPS recording.

The study revealed that there was gradual increase in Hydraform-ISSBs technology adoption but with slow uptake rate. Factors affecting adoption rate in the Nakuru County were found to include ease of construction with the blocks, savings in transport cost, existence of trained technicians and masons, low cost technology and good extension professional services. The environmental impacts were found to be mostly health related in terms of material preparation and block production processes, and natural resource depletion in terms of water use and agricultural land, which in all cases were found to be minimal. The study therefore concluded that the adoption of Hydraform-ISSBs technology was likely to be beneficial in improving access to and affordability of housing than being an environmental problem in Nakuru County. The study recommended that policy makers and implementers should take into account possible environmental impacts when promoting the adoption of Hydraform-ISSBs technology.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

The Hydraform-Interlocking Stabilized Soil Blocks (ISSBs) technology has been widely used in most parts of the World. For instance, various projects are found in India, USA, Turkey, South Africa, Botswana and Uganda among other Countries (Hydraform Building Systems, 2009). In Kenya, the technology was introduced in the year 2003 with formal launch of Appropriate Building Technology (ABT) Programme undertaken in 2006, an initiative that has since spread to most parts of the Country. The ABT Programme objectives included; lowering construction cost, improving quality of housing, enhancing speed of construction delivery, achieving environmentally friendly construction, and empowering community members to generate income and contribute to social inclusion among the youths and women who participate in Hydraform-ISSBs related activities.

The World growing population poses major challenges to the efforts being championed by various Governments in facilitating access to affordable and adequate housing for their citizens. In Kenya, population increase has been tremendous over the years with the 2009 Census results estimated at 38,610,097 (KNBS, 2009) Million people. The continued increase in population size has led to increased housing demand for the low, middle, and high-income groups in the society. Sessional Paper No. 3 of 2004 on National Housing Policy for Kenya indicates that annual demand for housing in urban areas is 150,000 units while 300,000 units need to be improved in the rural areas annually. The units produced annually, however, are a paltry 20,000-30,000 units which are not enough to meet the housing needs of urban dwellers (GoK, 2004). The Medium Term Plan (MTP) for the implementation of Vision 2030, however, provides that annual urban housing demand in Kenya has a projection of about 200,000 against a supply of about 50,000 housing units, thereby leaving a void of about 150,000 units. The population dynamics witnessed in the Country over time has prompted the introduction and adoption of Hyraform-ISSBs as an alternative affordable building material and technology to the more commonly used conventional methods in housing construction.

The steps in the implementation of Appropriate Building Technologies in Kenya with focus on soil stabilization have been a long process. Most of the work carried out by the Department of Housing in conjunction with Housing and Building Research Institute (HABRI) in 1980s and 1990s mainly involved production of stabilized soil blocks, which, despite their low output, still required mortar application during block laying at construction stages. Further research towards cost reduction saw the introduction of Interlocking Block making machine by Makiga Engineering Ltd in collaboration with Good Earth Trust organization (Uganda). The Makiga machines were however manual in nature and had a low output of between 400-600 block production capacity per day. In later developments, hydraulic (Hydraform) block manufacturing Machines were introduced for use in Kenya with marked output improvement and quality precision as the standard machine compaction pressure can be pre-determined / or pre-set and able to be adjusted appropriately. The technology has the potential of higher daily block output of up to 1500 blocks in the case of single chamber machine and 3000 blocks with double chamber machine model.

The application of the Hydraform-ISSBs technology relied heavily on the availability of local raw materials, key of which, being suitable soil and labour organization for ease of technology use and attainment of quality walling blocks. Promotion of Hydraform-ISSBs technology by the Government of Kenya has been supported by policy instruments and global concerns, especially in the realization of; local Agenda 21, Millennium Development Goal (Goal No. 7 on environmental sustainability), Kenya's vision 2030, and constitution of Kenya 2010. In essence, the new constitution under economic and social rights, provides that all citizens have a right to accessible and adequate housing, and reasonable standards of sanitation (GoK, Constitution of Kenya, Chapter 4, Article 43 (1) (b)).

The research findings demonstrated that environmental benefits accruing from adoption and use of Hydraform-ISSBs in housing development outweighed the negative impacts the technology could pose to the surrounding environment, thereby providing an indication that the technology could be considered as an environmentally appropriate technology.

1.2 Statement of the problem

The World increasing population has exerted pressure on the natural environment as humanity tries to exploit every available resource to improve livelihoods including meeting their housing demand. UN-Habitat (2009) observed that about 3 billion people lack decent housing globally with estimated 1 billion residing in developing Countries of Southern Asia, Eastern Asia, and Sub-Saharan Africa. To address the challenge posed by inadequate housing, Smith (2009) fronted the need to build about 35 Million new affordable homes annually. In trying to meet demand for housing over the time, conventional building materials such as stone, mud, bricks and timber walls have been widely used (Gooding and Thomas, 1995). The resultants environmental impacts of these conventional building materials are quite grave, for instance, timber house is no longer an alternative in Kenya or East Africa due to depletion resulting from uncontrolled harvesting of indigenous and commercial forests. Quarry stone extraction has resulted in huge excavations along the ridges of Kenya's Rift Valley and continental shelves with permanent scars being exposed in several areas. Burnt bricks require kilns to be fired for several hours ranging from 48-96 hours and above during the manufacturing process, which contributes to huge habitat destruction through the demand for firewood. All these conventional building materials are getting exhausted at a much faster rate and their accruing impacts contribute to global warming and aggravating the climate change situation.

The increased human population pressure on the conventional building materials have made them very expensive and unsustainable in future thus necessitating the need for an alternative cost effective building materials. It is out of this realization that Stabilised Soil Blocks as Appropriate Building Material and Technology programme (ABT) was developed and adopted by the Government of Kenya through the Ministry of Housing as a Low-Cost Housing Policy. The increased promotion of Hydraform-ISSBs technology and envisaged adoption by the Public in meeting their building and construction needs may result in mass block production and consumption of high amounts of soil in a short span compared to the manual/hand pressed machines. This could pose adverse impacts to the environment, thereby hindering realization of integrated sustainable housing provision and environmental development in Nakuru County. This could also affect the Country at large. Previous studies have however tended to concentrate on the production processes, structural suitability, and cost-effectiveness of the Stabilized Soil Blocks with little regard to the environmental impacts. Due to mass adoption of the technology with little information on environmental impacts, the study was therefore designed to provide information that related to the extent of Hydraform-ISSBs technology use, adoption factors and environmental impacts within Nakuru County.

1.3 Research Questions

The research study addressed the following questions:

1. What is the extent of use of Hydraform-ISSBs in Nakuru County

2. What are the main factors for consideration of use of Hydraform-ISSBs by the residents of Nakuru County?
3. What are the environmental impacts of use of Hydraform-ISSBs within Nakuru County?
4. What are the mitigation measures that can be adopted in the use of Hydraform-ISSBs to reduce environmental impacts?

1.4 Objectives of the Study

The overall objective of the study was to assess the impacts of Hydraform-ISSBs to the environment within Nakuru County. The specific objectives of the study were to;

1. Establish the extent of use of Hydraform-ISSBs in Nakuru County
2. Understand the main factors for consideration in the use of Hydraform-ISSBs by the residents of Nakuru County
3. Assess the environmental impacts of Hydraform-ISSBs technology adoption in Nakuru County
4. Recommend mitigation measures that can be adopted in the use of Hydraform-ISSBs to reduce environmental impacts and provide ways to upscale the technology use

These objectives were achieved through adequate validation of the corresponding formulated hypotheses.

1.5 Study Hypothesis

The general hypothesis of the study was that Hydraform-ISSBs technology was an environmentally appropriate technology that would easily be adopted by the Nakuru residents.

The research hypotheses formulated and validated by respondent data collected from the field were;

1. Hydraform-ISSBs technology has no adverse impact on the environment of Nakuru County.
2. There are specific factors affecting use of Hydraform-ISSBs technology in Nakuru County.

For hypotheses testing, significance tests were performed at α 0.05 in all cases.

1.6 Justification of the Study

The rapid increase in population sizes over time have created housing demand that far outstrip the supply in developing countries, a situation that is not different in the Kenyan context. As documented, Sessional Paper No. 3 of 2004 on Housing Policy indicates that the average annual urban Shelter demand is estimated at 150,000 units, but only an estimated annual average supply of 20,000-30,000 units are met, leading to a deficit averaging 120,000 units. In addition, an estimated 300,000 housing units requires improvement annually to cater for housing demand in the rural area. As earlier mentioned, housing provision strategies are supported by International and Local policy requirements namely; Local Agenda 21, the MDGs (Goal 7 No.11), Principles of Sustainable Development, The Constitution of Kenya 2010, Vision 2030 and Sessional Paper No. 3 on 2004 on National Housing Policy. Further, there is need to cement the divide in the society by enabling the low income members to realize their dreams of accessing excellent, affordable, adequate and quality housing in sustainable human settlements.

Attempts to address housing demand situation world over has been by use of conventional building materials. However, alternative technologies, which are mostly considered appropriate to local environments, have been introduced for use as building materials, more so, the introduction of Hydraform-ISSBs used by residents of Nakuru County with the Support of the Government of Kenya as low-cost building materials. Owing to the growing number of organizations using the technology within Nakuru County, there was need to establish the extent of usage, assess its environmental impacts, understand factors for adoption and recommend mitigation measures for likely associated negative impacts and ways to upscale technology use to policy implementers and professionals in the housing sector.

The study established important factors that could increase the technology adoption thus improving the housing and living standards of the low-income earners in the county. With efficient management of the technology adoption processes, the cost of buildings could greatly reduce. In such an event, private developers and financiers could find it profitable to develop more housing units for the middle and low-income earners. Based on the findings of this research project, future studies may be appropriate in establishing the viability of commercialization of the technology as well as its contribution to carbon emission curbs.

1.7 Operational definitions

Adequate Housing: Housing with adequate space, privacy, safety, lighting, ventilation, security of tenure, basic and social infrastructural services and free from environmental hazards.

Appropriate Technology (AT): This is a collective term for a broad range of technologies with proven developmental benefits. Some ATs are innovations, others rediscoveries. All address basic human needs and provide cost-effective and environmentally friendly solutions. They are viewed as affordable and simple to use and maintain. ATs are developed specifically to enable poor people to deal with their health and resource problems, and in essence constitute a basis for community empowerment leading to sustained self-sufficiency.

Block: A large type of brick not necessarily made of fired clay, but stabilized in some way, sometimes with central cores removed to reduce the weight

Brick: An object (usually of fired clay) used in construction, usually of rectangular shape, whose largest dimension does not exceed 300mm.

Building Code: A framework that guides the building and construction sector, and used by the approval authorities.

Cast-in-Situ: Cast in place; cast liquid in its permanent location, where it hardens as part of the building, as opposed to Pre-Cast.

Code 95: In 1995, Code 95 aiming at enabling Housing standards & procedures through reducing building costs, promoting innovative designs, encouraging use of local materials, and putting emphasis on performance rather than specific construction materials was introduced.

Compressed Earth Blocks (CEB): Construction blocks made from a mixture of soil and a stabilizing agent compressed by different types of manual or motor-driven press machines.

Compressive strength: This is measured by breaking cylindrical block specimens in a compression testing machine. It is calculated from the failure load divided by the cross-sectional area resisting the load and reported in units of pound-force per square inch (psi) in US Customary units or megapascals (Mpa) in SI units.

Coping: A cap of stone, brick or concrete for the top of a wall. It frequently projects beyond either or both faces of the wall, partly for protection from the weather, and partly for decoration

Durable Housing: Is generally defined as a "unit that is built on a non-hazardous location and has a structure permanent and adequate enough to protect its inhabitants from the extreme of climate conditions such as rain, heat, cold and humidity". (UN-Habitat, State of World Cities report, 2006/7)

Dwelling House: A single dwelling unit and any garage and other domestic outbuildings thereto, situated on its own site.

Dwelling Unit: A unit containing one or more habitable rooms and provided with adequate sanitary and cooking facilities.

Dwelling: A building or structure used regularly or intermittently for human habitation.

Earth Sheltering: Refers to the use of earth on the structure of a building and includes Earth berming, in-hill construction, and underground construction.

Fire resisting material: Brickwork, concrete, concrete work, wired glass or any other material approved as such by the planning & Building Authority.

Fire resisting wall: A wall constructed of fire resisting material carried vertically throughout the building from the lowest level of any basement or sub-basement bound by the wall, and continued 46cm above any portion (s) of the roof, the distance above the roof being measured at right angles to the surface of the roof covering

Foundation Wall: That portion of a wall between the foundation & the lowest floor above such foundation.

Foundation: That part of a construction immediately below the footings of a building which is in direct contact with and through which the weight of a building is transmitted to the ground, and includes piling works.

GATE: German Appropriate Technology Exchange, established in 1978 on behalf of the German Federal Ministry for Economic Cooperation (BMZ)-which is responsible for development cooperation with Third World Countries-and in consultation with the German Federal Ministry for Research and technology (BMFT).

Green Buildings: These are building practices and planning materials / or products that will result in the construction and renovation of buildings that are healthier for occupants; more energy-efficient; more resource efficient; healthier for global environment in long term; and more affordable to create, operate and maintain.

Green Technologies These encompass materials, designs and other practices that are considered environmentally friendly in their application. In the built environment, the practices include installation of solar panels and wind energy, use of appropriate walling materials, low energy bulbs, buildings with natural lighting and ventilation, use of biogas, and water conserving sensitive taps among others.

Hydraform Block: An Interlocking Compressed Earth Block made of the Hydraform press.

Maisonette: Dwelling of more than one storey attached to other building (s).

Pascal (Pa): A unit of pressure equal to the pressure resulting from a force of one newton acting uniformly over an area of one square metre

Render: The sand / cement mix used to cover and protect walling

Skirting: A finishing board which covers the joint between the wall and the floor of a room.

Soil Plasticity: The numerical difference between the Liquid Limit and Plastic Limit is termed the Plasticity Index (PI).

Wall: A rampart of earth, stone or other materials constructed for defensive purposes. An enclosing structure composed of bricks, stones or similar materials laid in courses, each of the sides and vertical divisions of a building, an enclosing structure round a garden, yard, other property, also each of the portions between the angles of such a structure.

Weathering: The physical disintegration and chemical decomposition of earthy and rocky materials on exposure to atmospheric agents.

1.8 Scope and Limitation of the Study

The study focused on technology adoption, factors influencing decision in block usage and associated environmental impacts. Precisely, it was intended to investigate the relationship between Hydraform-ISSBs technology adoption and the resultant impacts on the environment. It was restricted to the six Constituencies of Nakuru County. From the six constituencies, a sample of 35 Hydraform-ISSBs projects implemented in the last three years (2008/2009-2010/2011) out of possible 50 projects were studied. It involved visits to material source (soil extraction sites), production & block yards, and construction sites as well as completed projects. The data collection was conducted through self-administering of questionnaires by the researcher, personal observations, transect measurement at soil burrows, GPS recordings and photography.

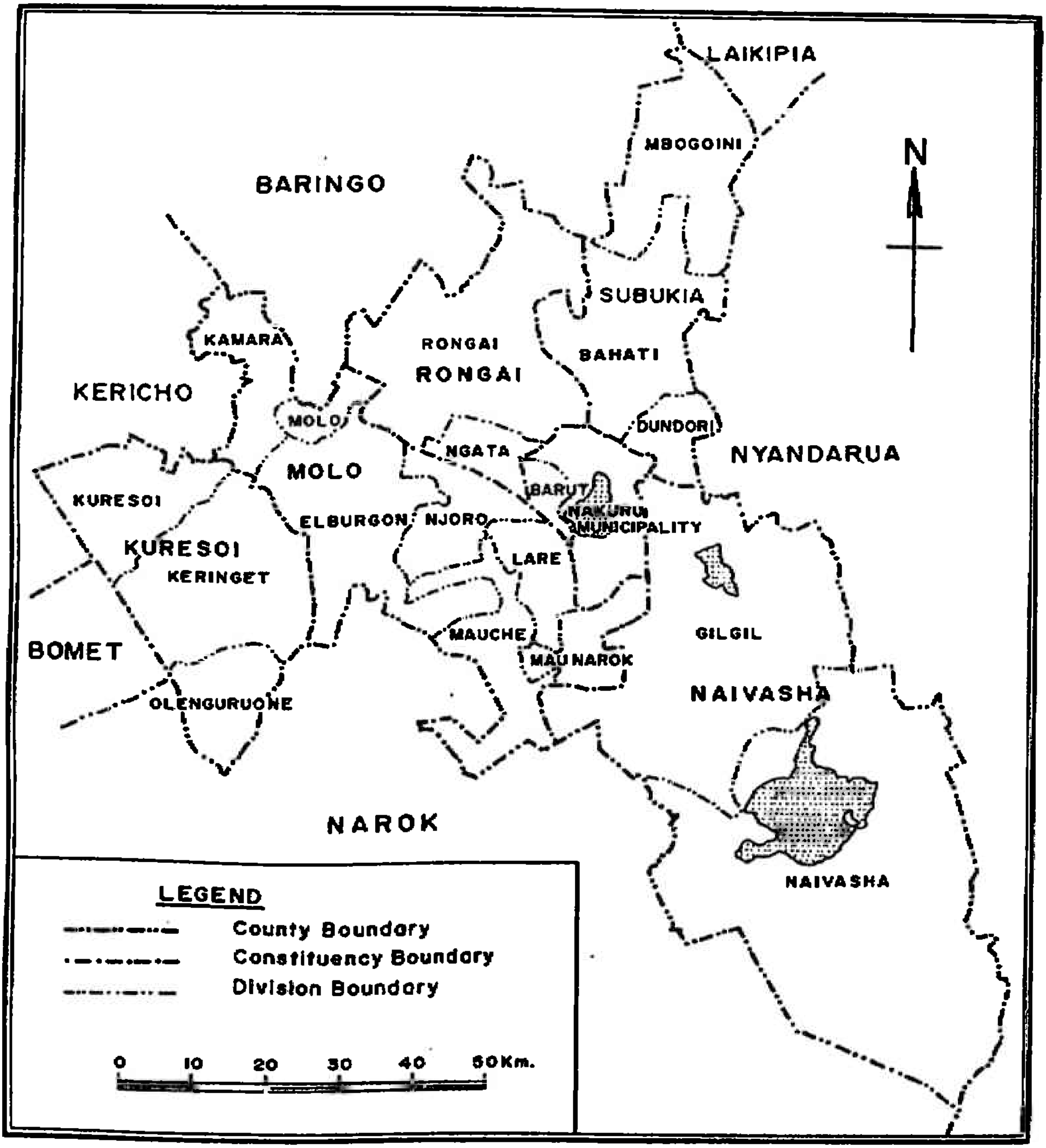
The study experienced some limitations notably; the vast study area could not be adequately covered due to Manpower, financial and time constraints. The technology was noted to have spread to most parts of the Country that exhibits different agro-ecological zones with varying soil types, adoption rates, and therefore, a wider study area and a larger sample size could have been more appropriate. The study was conducted between August-September 2011, and some of the projects in the sample were at their infant stages and not much of the environmental impacts could be noticed. Further, Cost-Benefit-Analysis in terms of Hydraform-ISSBs technology and poverty relationship were not adequately captured due to its broad nature, thus requiring an analysis of its own kind.

1.9 Study Area

1.9.1 Position and Size

Nakuru County is one of the 47 Counties created in Kenya in accordance with the new constitutional dispensation promulgated in August 2010. It borders eight other Counties namely, Kericho and Bomet to the West, Baringo and Laikipia to the North, Nyandarua to the East, Narok to the south West and Kajiado and Kiambu to the south.

Map 1.1 Political and Administrative Boundaries of Nakuru County



Source: Researcher, 2011

The County covers an area of 7,495.1 Sq Km and it lies within the Great Rift Valley between Longitude 35^0 28' and 35^0 36' East and Latitude 0^0 13' and 1^0 10' South. The County is composed of 6 Political Constituencies namely; Nakuru Town, Naivasha, Rongai, Molo, Subukia and Kuresoi. There are 19 administrative divisions namely; Elburgon, Mauche, Lare, Nakuru Municipality, Bahati, Njoro, Mbogoi-ini, Naivasha, Gilgil, Molo, Keringet, Rongai, Olenguruone, Kuresoi, Kamara, Dundori, Ngata, Mbaruk and Mau Narok. The boundaries of Political Constituencies and Administrative Divisions described above are provided in map 1.1.

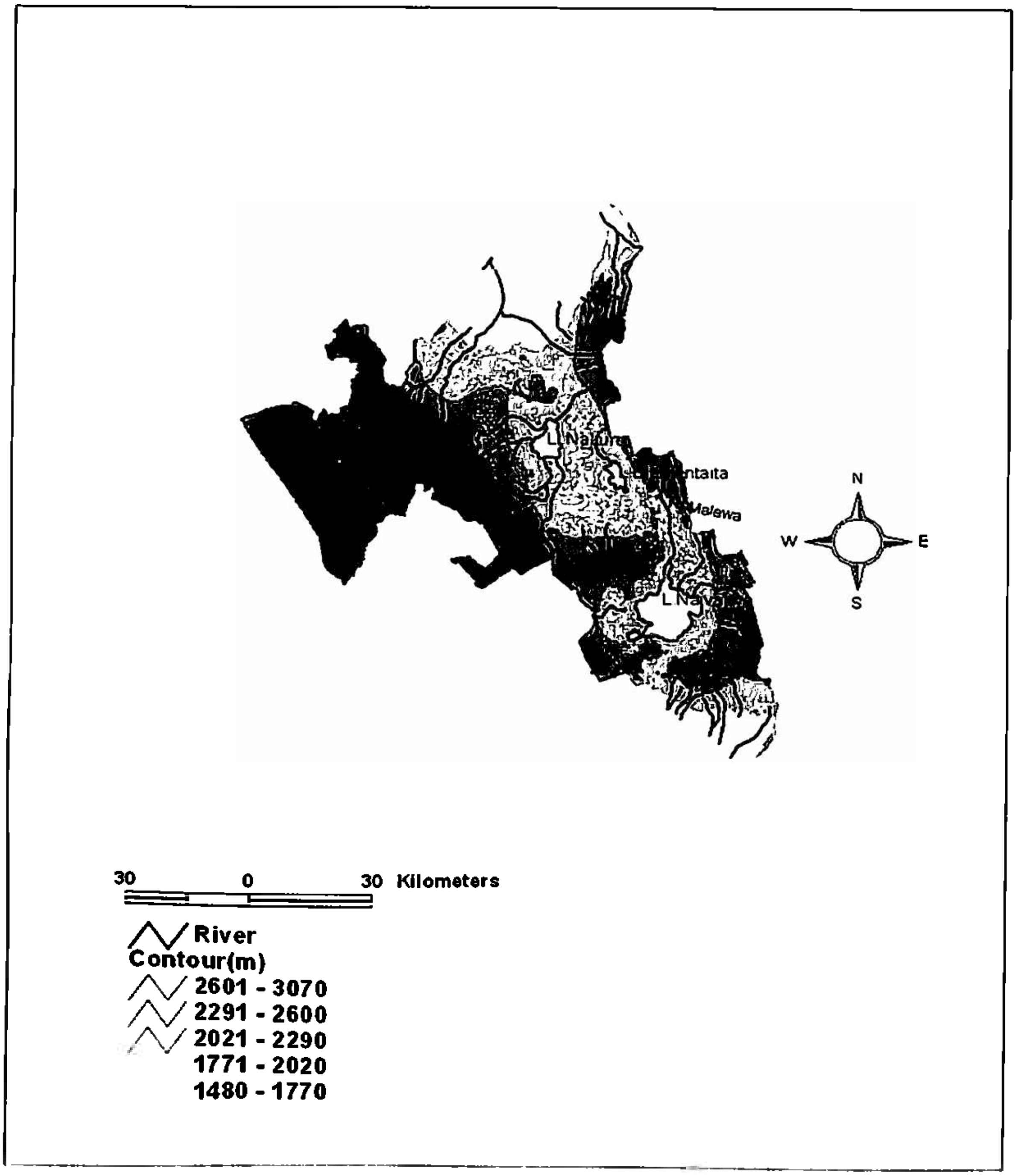
1.9.2 Relief and Drainage Patterns

Nakuru County is famous due to its rich topographic and relief features which involves long winding rift system and several drainage patterns. The notable features in Nakuru County include; the Mau Escarpment to the western and eastern sides, the Rift Valley Floor, Menengai Crater and various inland lakes (Naivasha, Elementaita and Nakuru) on the floor of the rift valley associated with the drainage for nearly all the permanent and seasonal rivers/streams in the County.

Rivers Malewa and Turasha drains into Lake Naivasha while River Njoro drains into Lake Nakuru, Subukia/Waseges into Lake Bogoria and Molo draining into Lake Baringo. Other rivers include; Kipsonoi, Amalo, Songon and Ndoinet, all draining into Lake Victoria.

The relief features and drainage systems of the County are significant in successful implementation of Hydraform-ISSBs projects as they contribute to the availability of local raw materials to facilitate the process with regard to soil type, water and transport needs for the exercise. Map 1.2 outlined the drainage patterns of the study area.

Map 1.2 Relief and Drainage Patterns of Nakuru County



Source: Researcher, 2011

1.9.3 Geology

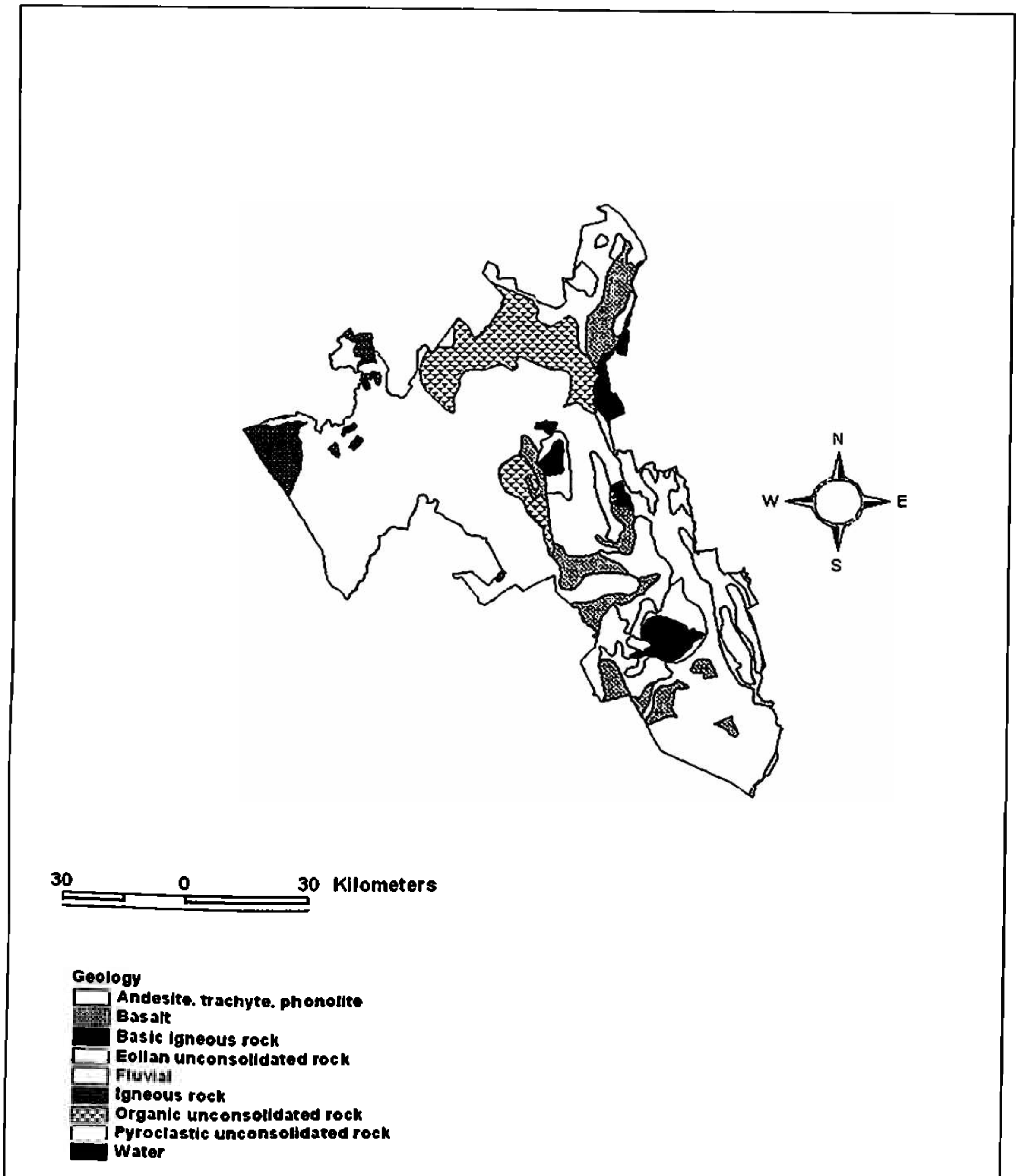
The County, for decades, has had its stake as the bedrock of volcanic activities within the Great Rift Valley system. The Western side was mainly covered by volcanic rocks, and lacustrine and fluviatile deposits, with key dominance around Molo area while the south eastern part (Naivasha) of Mau

Escarpment was characterized by occurrence of soft Volcanic Ashes and Turfs. It was however, observed that Rift Valley rocks, especially on its floor varied from under-saturated Tephrite to highly Acidic Rocks, example of which being Ryholites and Sodic Rhyolites.

Rock products found in the County included Diatomite deposits at Kariandusi, Manganese found along Gilgil-Nyahururu road to the North of the confluence of the Malewa and Oleolongo Rivers, Stone Quarries (Mau, Bahati, Menengai and Kedowa), Ballast Rock mined west of Gilgil town, Menengai slopes, Rhonda, Londiani, North west of lake Nakuru and near Larmudiac river with main rock types being Tracheitis and Phonolites. Further, Kaolin rock found at Eburu, was notably a light coloured Kaolimite rock clayed material which in its natural state could be used in the manufacture of Porcelain, Wall Tiles, Paper, Pefectory Ware, Rubber, Felt Pug for wire insulation among other uses. The Obsidian rock, mainly a natural glass with high thermal insulation characteristic gained through its porosity and stability was located in Longonot and Eburu. The geology and rock types described above were provided in map 1.3

The nature of the Geology within the landscape of Nakuru County was quite vital in the implementation of Hydraform-ISSBs technology in the region. In practice, residents were advantaged to make a choice from among the available options of building materials as could satisfy their choice of preference. In addition, availability of quarry dust resulting from ballast mining and preparation in various sites within Nakuru County, offered a perfect substitute to sand as a blending agent for soil during the production of Hydraform-ISSBs.

Map 1.3 Geology and Rock Types of Nakuru County



Source: Researcher, 2011

1.9.4 Soil Types

The County location was within an active volcanic zone along the Great Rift Valley with a winding stretch cutting across the Eastern African Region to the Southern African Region. The soil distribution within the County was found to be highly influenced by the extensive variations in Relief, Climate, Volcanic activities and underlying Rock types. The soils in the County comprised of three major types namely; Latosolic, Planosolic, and Alluvial and Lacustrine Deposits.

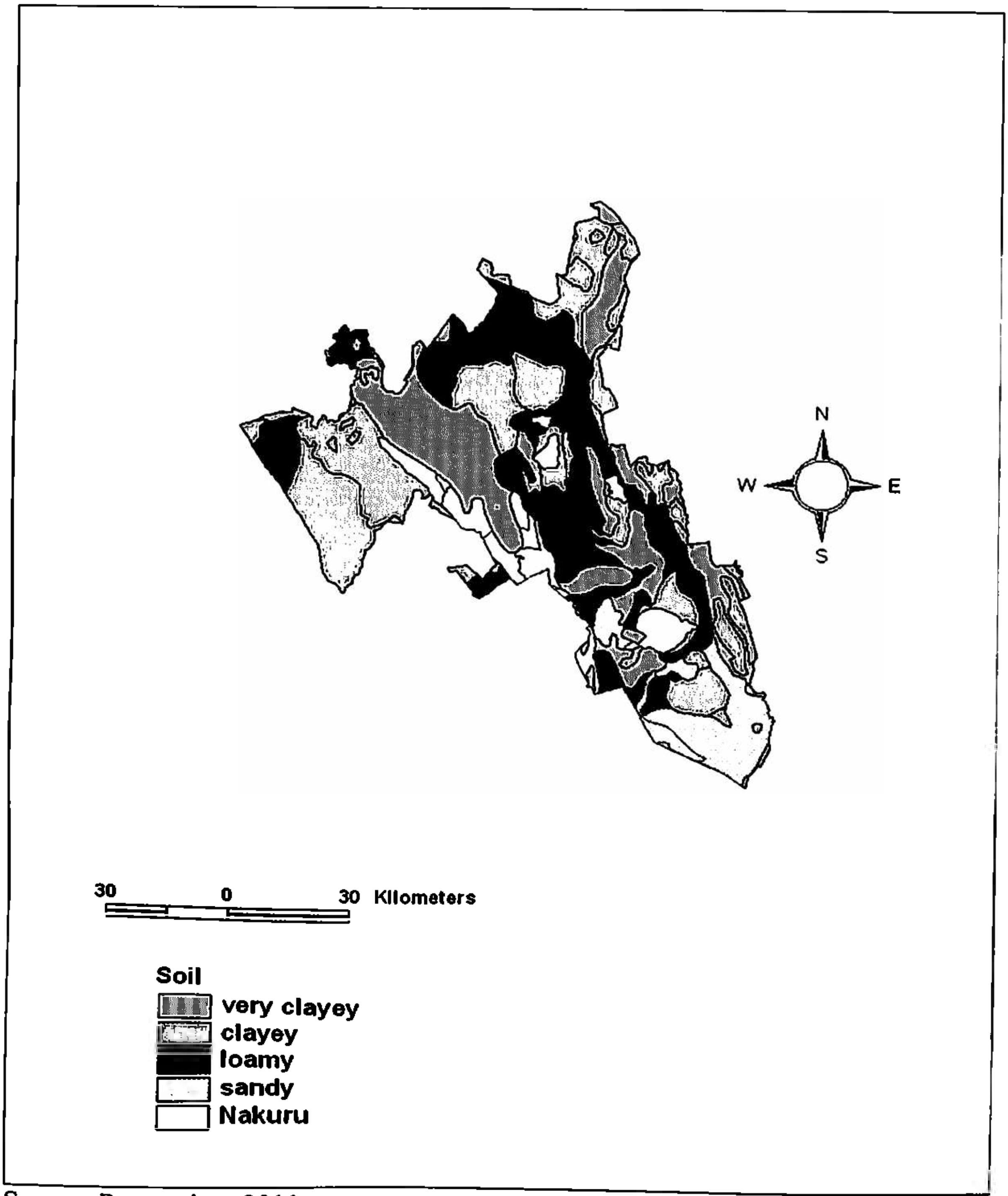
The Latosols were noted to be well drained red soils derived from volcanic and basement complex rocks, found around upper Subukia Valley and North Rift. They also existed in the form of imperfectly drained loams with dark brown sub-soils covering the highlands of Bahati, steep slopes of Njoro and Elementaita Hills, as well as Nakuru Municipality and Maai Mahiu area.

The Planosols were on the other hand, poorly drained dark brown clays with highly developed textured top soil. They also contained well-drained humic loams with dark brown sub-soils. These soils were widespread around Olenguruone, Molo, Rongai, parts of Bahati, Njoro and Kinangop Divisions.

The Alluvial and Lacustrine deposits however, were shallow soils developed from sediments of volcanic ashes and other sources and generally covered the Rift Valley bed between lakes Nakuru and Naivasha, Solai and Menengai Crater. The soil types in Nakuru County were given in map 1.4

The existence of the active volcanic activities mainly around Hell's Gate National Park (Ol Karia), Menengai Crater, Lake Bogoria National Park as well as the porosity of Soil around Nakuru town may increase the Vulnerability of built environment done with conventional materials. These may further increase the chances of occurrence of natural calamities like earth tremors and Earthquake related activities, which may be hazardous to the surrounding environment. However, these fears may be curbed by the introduction and adoption of Hydraform-ISSBs technology in Nakuru County and its hinterland since information source from the Hydraform Machines Manufacturers as per tests conducted indicated that the Hydraform-ISSBs structures were likely to resist earthquake occurrence. These make the region suitable for adoption and promotion of use of Hydraform-ISSBs in construction industry in the area as the said technology was found to be able to withstand earthquake of seismic 7.3 on Ritcher Scale measurement, (Hydraform manual, 2005). For such category of structures however, there must be structural reinforcements as would be advised by the technical personnel based on the recommendations provided by Hydraform Ltd.

Map 1.4 Soil Types of Nakuru County



Source: Researcher, 2011

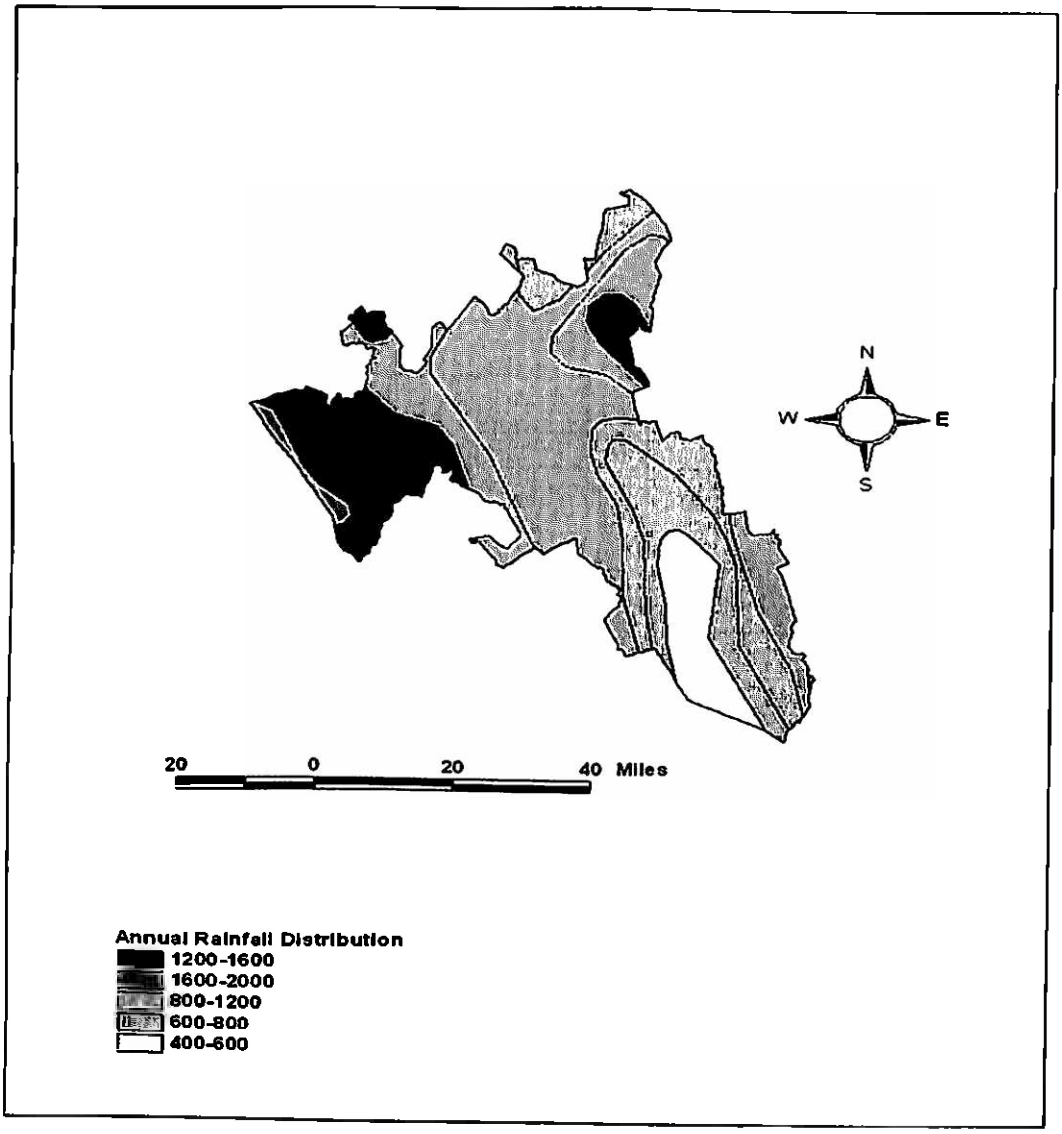
1.9.5 Rainfall Distribution

In the implementation of Hydraform-ISSBs projects, water was found to be a key ingredient that was necessary both at the production and curing stages of the blocks. The rainfall pattern for Nakuru County was quite dynamic and ranged between 400-2000mm per year.

In most circumstances, the rainfall situation was adequate to support various economic and environmental sustainability related activities. The water requirement for use in Hydraform-ISSBs related activities were fairly adequate in majority of technology use-sites. This supported successful promotion and adoption of the technology in the area.

Erratic rainfall situations and strong winds could however, be retrogressive as well as a hindrance to efficient production and preparation of Hyraform-ISSBs. The rainfall distribution for Nakuru County was contained in map 1.5

Map 1.5 Rainfall Distribution of Nakuru County



Source: Researcher, 2011

1.9.6 Administrative and Political Units

Nakuru County was divided into nineteen (19) administrative divisions, namely, Elburgon, Mauche, Lare, Nakuru Municipality, Bahati, Njoro, Mbogoi-ini, Naivasha, Gilgil, Molo, Keringet, Rongai, Olenguruone, Kuresoi, Kamara, Dundori, Ngata, Mbaruk and Mau Narok. Politically, the County comprised of 6 constituencies represented by members of parliament namely; Nakuru Town, Molo, Rongai, Subukia, Kuresoi and Naivasha which were provided in map 1.1. There were also four Local Authorities namely; Nakuru Municipality with 19 wards, Nakuru County Council with 33 wards, Naivasha Municipal Council with 12 wards and Molo Town Council with 8 wards. The promotion and adoption of Hydraform-ISSBs technology within the county required the corporation of the local administrators, approval authorities, opinion leaders and political goodwill.

In this regard, the Government has embraced working with established political structures in the promotion of the technology for adoption by the locals. The strategy involved the establishment of Constituency ABT Centres Countywide to offer training and skills development services to local constituents and act as research and development centres on appropriate, alternative building materials and new technologies among other initiatives.

1.9.7 Population Size and Density

Nakuru County had a total population of 1,603,325 people of which 804,582 were male while 798,743 were female according the 2009 census report. The County comprised of 409,836 households with a density of 214 per square kilometre.

The presence of Nakuru town within the Municipality made it have the highest density as major commercial and industrial activities were concentrated in the town area. The other area with high density was Njoro Division due to its high agricultural potential. On the other hand, Mbogo-ine, Naivasha and Gilgil Divisions were semi-arid with livestock as the main economic activity and characterized by low population densities while Keringet Division mainly had large farms formally occupied by white settlers with low population density.

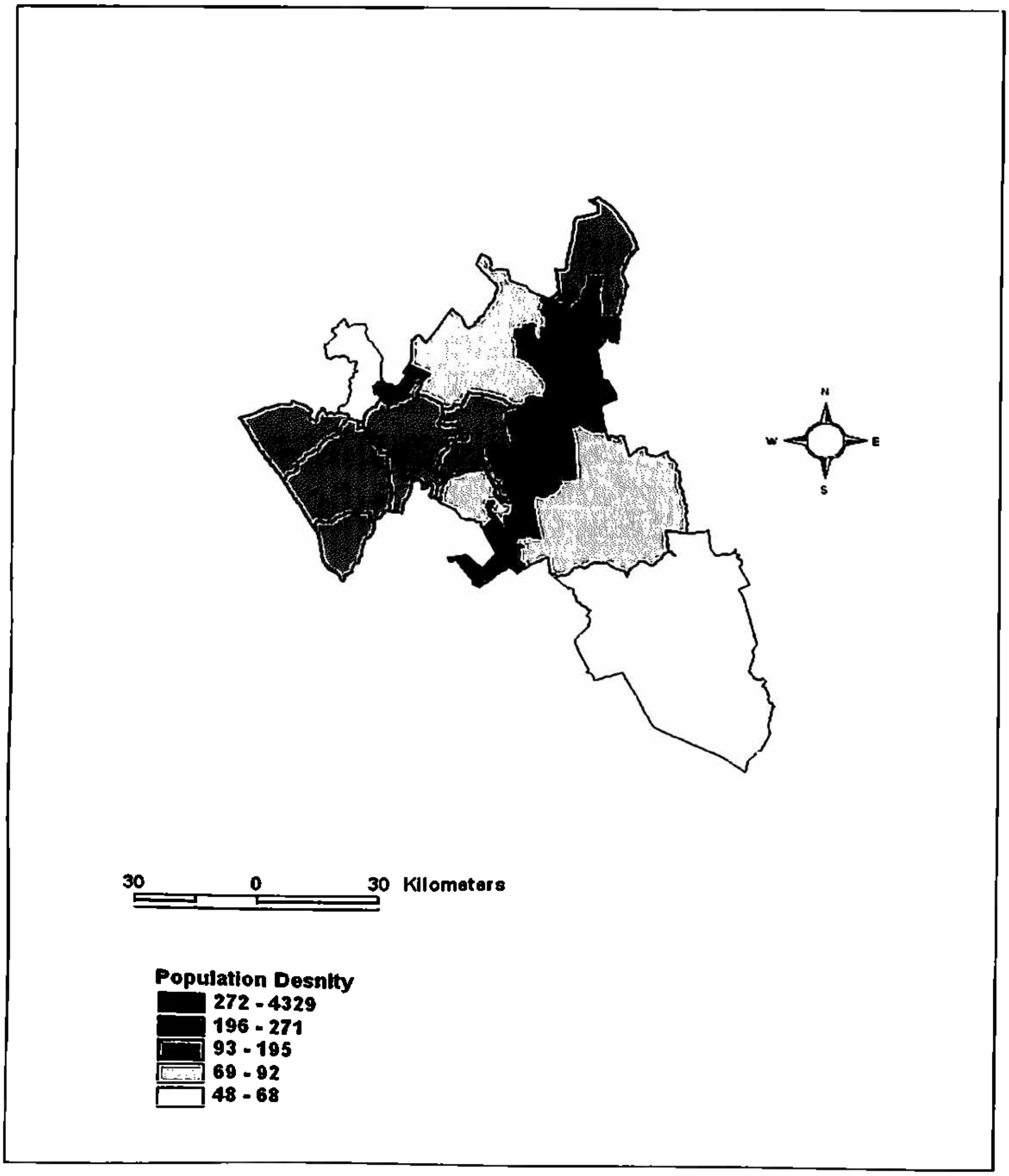
According to the development plan for Nakuru of 1997-2001, the population structure comprised of age 0-19 years 59%, 59 years + 4%, and about 37% formed the economically active population. The labour force (age 15-59) comprised of 51% male and the majority of these categories were unskilled hence required training and imparting of skills to make them exploit their full potential in their endeavours to earn a living and improve livelihoods.

The settlement patterns of most areas exhibited cosmopolitan settings with the inhabitants having originated from various ethnic communities from other parts of the Republic of Kenya. Most of the settlers of this area were quite industrious and innovative, hence did blend well with the introduction and adoption of the Hydraform-ISSBs technology in the area.

Further, the aftermath of the 2008 post-election mayhem resulted into additional household in Nakuru County from internally displaced persons (IDPs) who migrated from other parts of the Country. These IDPs mainly came from North Rift Region and western Kenya. Subsequently, their existence called for the development of strategies to address their immediate needs, more so, shelter provision.

For the realization of this desire, Hydraform-ISSBs technology with its on-site production use processes was made available so as to enable the attainment of cost-effective housing by these disadvantaged members of the society in a communal and participatory approach. The population density of Nakuru County was depicted in map 1.6

Map 1.6 Population Density of Nakuru County



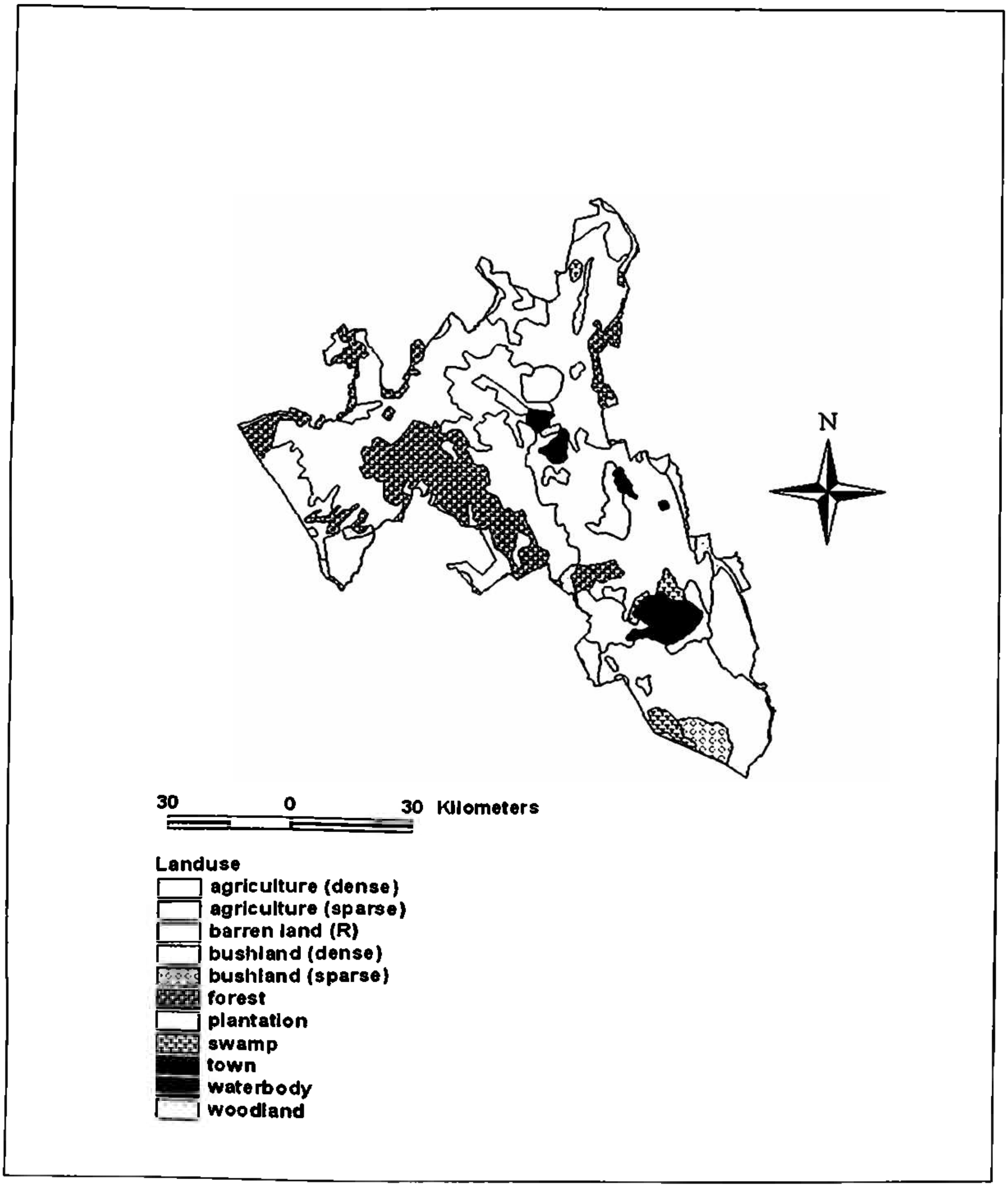
Source: Researcher, 2011

1.9.8 Land Use

The County was quite rich in biodiversity with dynamic land cover characteristics. It had a large area under forests covering Molo South and Olenguruone divisions, south east Molo, Siape, Mau Narok, Keringet, Bahati areas. The main forests found within the County included; Mau Escarpment, Bahati forest, Mau forest, Dundori forest, Aberdare ranges, Subukia range, and Eastern Mau forest.

Generally, Nakuru County exhibited large proportions of woodland, plantations, forest land, bushland, barren land, agricultural land as well as water bodies. The area was also covered by town development features. The general land cover and other land uses of the study area were contained in map 1.7. A good understanding of the land use was necessary in establishing the effects that mass introduction and adoption of Hydraform-ISSBs posed to the surrounding environment of Nakuru County.

Map 1.7 Land Use of Nakuru County



Source: Researcher, 2011

1.9.9 Human and Economic Activities

The County was well endowed with economic resources, which upon exploitation, provided good economic health. These included; small and large farm agricultural sectors, livestock production activities, fisheries management, forestry and agro-forestry, mining, textile industries, food processing, agricultural implements and animal feeds, saw mills and engineering works, other manufacturing industries and tourism activities. It was also a major producer of food, cash and horticultural crops with leading food crops being maize, wheat, beans, potatoes and various fruits and vegetables. The cash crops include; tea, coffee, pyrethrum, and flowers.

The main livestock kept within the County were dairy and beef cattle, goat and sheep, with milk, meat, hide and skin, wool and mutton as the main products. The main areas for livestock activities were noted to be concentrated in Naivasha, Molo, Rongai, Bahati and Njoro divisions. Fisheries activities were mainly carried out in Lake Naivasha while ponds, dams, and rivers contributed minimally to fishing in the area. The Government's fish farming promotional activities among the area residents have scaled up fish harvesting from artificially constructed ponds across the County. For instance, due to accelerated fish farming and increased harvests, a fish storage (coolant) plant was constructed at Subukia Township in the period of 2009/2010.

Other households depended directly or indirectly on income earnings from commercial, small-scale enterprise and "Jua-Kali" trade (informal) activities. The infrastructural provision especially the road linkages offering good communication network has a great impact on development of several parts of the county, more so, the elevation of most roads to bitumen standards. Furthermore, Nakuru Town being an intermediary urban centre connecting western Kenya to the capital city (Nairobi), boast of a modern dual carriage highway that easen transportation needs of the residents, tourists and traders, hence promoting robust economic growth of the town.

The existence of a robust population and availability of good infrastructure was necessary for successful promotion and adoption of Hydraform-ISSBs in any environment. It was further observed that the recipient population should possess positive attitude and adore favourable culture in order to blend well with the new technologies.

1.9.10 Settlement Patterns

Nakuru was one of the most populated County in Kenya and it comprised of about 409,836 households (Census, 2009), with Nakuru Town being one of the most densely populated Constituencies. The County was experiencing faster growth rate while provision of basic facilities stagnated hence their failure to adequately serve the population.

Other towns with faster population growth rate included; Molo, Bahati and Rongai, and were characterized by accelerated urban growth rate due to high economic potential. In addition, Gilgil and Naivasha towns, were sparsely populated, as they were marginal areas with most people found in urban areas.

It was further observed that, Nakuru County hosted poor people, who mainly resided in informal settlements and slums. In addition, there were displaced people due to the clashes of 1992, 1997 and recent post-election violence of the year 2008.

The diverse settlement patterns in the area were however, vital in the technology promotion, more so, by volunteering labour and inculcating positive attitude towards Hydraform-ISSBs technology adoption and use within Nakuru County.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter commenced with the review of studies done with regard to the genesis and use of Hydraform-ISSBs technology. It further looked at the factors that influenced the technology adoption and the environmental impacts associated with technology use. As a policy strategy, the Government of Kenya through the Ministry of Housing has adopted Appropriate Building Technologies as a Low-Cost Housing Policy. The increased promotion of Hydraform-ISSBs technology and envisaged adoption by the Public in meeting their building and construction needs may result in mass block production and consumption of high amounts of soil in a short span compared to the manual/hand pressed machines. This could pose negative impacts to the environment, thereby hindering realization of integrated sustainable housing and environmental development in Nakuru County and the Country at large. Previous studies have tended to concentrate on the production processes, structural suitability, and cost-effectiveness of the Stabilized Soil Blocks with little regard to the environmental impacts.

2.2 Background

The building and construction industry is considered a key player in sustainable development, with the potential to significantly impact on society and the environment (UN-HABITAT, 2009). According to Browne (2009), the earth has been the basic material for construction for thousands of years, from the simple moulded sun dried earth brick (Adobe) of 1950s, to the modern extruded clay fired bricks. In the findings of Buffington (2005), the use of earth (soil) has been significant throughout human history. For instance, many of the world's great feats of construction involved the use of mud and or dirt especially the Great Wall of China (246-209 BC) and Hannibal's watchtowers, built with compressed earth in Europe in 300 BC, which stood for more than 600 years.

It is understood that most of the buildings constructed using conventional building materials are unaffordable to a majority of the developing world's regions with no exception to the Kenyan population, thus necessitating the development and adoption of alternative, relatively cheap, decent and durable on site produced materials mainly in the form of Stabilized Soil Blocks (HABRI, 2003). However, the development and promotion of Stabilized Soil Blocks as they were, still proved costly for low cost housing provision due to their dependency on mortar masonry skills during construction phases

(UN-HABITAT/Adrian, 2009). This situation called for further research and development initiatives to find more accommodative low cost building technologies , hence the introduction of more Appropriate Technologies, specifically, Interlocking Stabilized Soil Blocks (ISSBs) which adopts dry stacking of blocks during wall construction. Appropriate Technologies refer to materials, methods, and / or practices that help protect the natural environment, take inspiration from the cultural values and practices in the area, make use of local resources, and contribute to local economic development (UN-HABITAT, 2009). It further details that Soil Stabilization is the application of additional supplements or forces to the soil in order to make it more water-proof and stronger while the interlocks increase the structural stability of the wall and reduce the amount of cement needed as mortar (UN-HABITAT, 2009). More recently, Good Earth Trust has been involved in the promotion and use of rammed Interlocking Stabilized Soil Blocks (ISSBs) especially in Uganda and some parts of Kenya in conjunction with Makiga Engineering Services Ltd, using manually operated ram (Browne, 2005).

The invention and introduction of Hydraulic block machine with greater compaction pressure and higher production capacity marked a great milestone in the promotion and adoption of ABTs both in global sphere as well as within the local context. The common form of the hydraulic machine is the Hydraform-ISSBs machine patented by Hydraform Company Ltd in South Africa. The capacities of Hydraform Machine production output are in the range of 1500-3000 blocks per day (Hydraform training manual, 2005). A Hydraform block is produced from a soil and cement mixture with soil type classified as a sandy-loam, with a clay proportion ranging from 15-35 per cent (Hydraform training manual, revised 2009). However, in mega construction projects and mass adoption of Hydraform-ISSBs, the impacts posed by massive extraction of raw materials (Soil and Sand) for block production remained widely unknown.

2.3 Low Cost Housing and Policy

Housing is regarded as a basic need that is recognized globally as a human right while in the hierarchy of human needs, shelter is considered third only to food and clothing, (GoK, 2010). In most developing countries, housing is inadequate and the housing backlog has been increasing rapidly, a situation that has been aggravated by the increase in population sizes in developing countries (Racodi, 1997). According to UN-HABITAT (2009), 3billion people lack decent housing globally out of which, an estimated 1billion people are mostly concentrated in the developing countries regions of Southern Asia, Eastern Asia and Sub-Saharan Africa. To this, there is need for building of about 35 million new affordable homes each year (Smith, 2009), a dream that may be cumbersome to achieve.

In Kenya, the population increase has been tremendous over the years with current population estimated at over 38.6Million (GoK, 2009). Sessional Paper No. 3 of 2004 on National Housing Policy for Kenya indicated that annual demand for housing in urban areas was 150,000 units while 300,000 units required improvement in the rural areas annually. However, paltry 20,000-30,000 housing units could be supplied annually to cater for the urban housing demand. The Kenya's population dynamics over the decades in each of the eight (8) Provinces was outlined in table 2.1

Table 2.1. Population Trends in Kenya by Province (1979-2009)

Name	Capital	A (km^2)	1979	1989	1999	2009
Central	Nyeri	13,176	2,345,833	3,116,703	3,724,159	4,383,743
Coast	Mombasa	83,603	1,342,794	1,829,191	2,487,264	3,325,307
Eastern	Embu	159,891	2,719,851	3,768,677	4,631,779	5,668,123
Nairobi	Nairobi	684	827,775	1,324,570	2,143,254	3,138,369
N.Eastern	Garissa	126,902	373787	371,391	962,143	2,310,757
Nyanza	Kisumu	16,162	2,643,956	3,507,162	4,392,196	5,442,711
Rift Valley	Nakuru	173,868	3,240,402	4,981,613	6,987,036	10,006,805
Western	Kakamega	8,360	1,832,663	2,544,329	3,358,776	4,334,282
Kenya	Nairobi	582,646	15,327,061	21,443,636	28,686,607	38,610,097

Source; Brinkhoff, 2010

According to Maasdorp & Humphreys (1975), the initiatives for public provision of mass low-cost housing always fell far below the actual demand. Thus, to meet the provision of affordable housing for the poor needed to be facilitated through the development of innovative strategies (Webb, 1983). Further, Kintingu (2009), observed that the adoption of appropriate, easy, fast and cost-effective mortarless ways in wall construction could save upto 50% in both wall construction cost and cement consumption respectively, thereby leading to 40% reduction in carbon emissions. This observation however, has its side of critique since the realization of savings and other benefits attributed to the adoption of mortarless construction strategies may not be automatically achieved and could as well depend on several factors emanating from the societal values and the management of the build-up process to the application of the technology.

2.4 The Society and Housing

The dwelling units and its neighbourhood are studied in terms of their potential to impinge upon the physical and mental health and upon the social and economic well-being of individuals, families, and communities. The evaluation of housing conditions, once a type of housing or location becomes imbued with symbolic overtones (either positive or negative), its consequences for the resident family can be much greater than any direct effects of the physical object itself. Further, Poor quality housing can affect the health of the family (Martin, 1967). Further, according to Morris and Winter (1978), the number of households and the number of available dwelling units are social facts, while the rule or standard that more than one family per dwelling unit is not acceptable is a cultural fact.

The issue of space norm is of great relevance in household and dwellings as it prescribe the amount of space a family should have and are dependent upon family size and composition. To this, the Committee on the Hygiene of Housing of the American Public Health Association (1950) published a set of recommended space standards for one-to six-member families. The APHA outlined ten activities that are generally performed within the dwelling unit. These includes; sleeping and dressing, personal cleanliness and sanitation, food preparation and preservation, serving food and dining, family recreation and self-improvement, extra-familial association, housekeeping activities, care of infants or the sick, circulation between various areas of the dwelling, operation of utilities. Table 2.2 shows the optimum floor space required for basic household activities according to the number of persons accommodated within that household.

Other researchers who have analyzed issues related to house and space norms included; Greenfield and Lewis (1969), Duncan & Newman, 1975, Goodman, 1974 all of Michigan University; Morris (1972) and Gladhart (1973). It was thus important to ascertain the favourable factors in the adoption and use of Hydraform-ISSBs that could enable Nakuru residents to realize their housing ownership dreams with recommended space standards.

Locally, urban middle-income housing comprises a minimum of three habitable rooms, kitchen, bathroom, and toilet for each household. Upper middle-income covers a minimum gross floor area of 120 M^2 while lower middle-income covers a minimum gross floor area of 80 M^2 (Housing Policy, 2004). Further, urban low-income housing comprises a minimum of two habitable rooms, cooking area and sanitary facilities, thereby covering a minimum gross floor area of 36 M^2 for each household. All the household categories should be provided with physical infrastructure and services conforming to the provisions of the building code (Housing Policy, 2004).

Table 2.2 Floor Space and House Occupancy

Household Activity	Number of persons					
	1	2	3	4	5	6
Sleeping and dressing	74	148	222	296	370	444
Personal cleanliness and sanitation	35	35	35	35	70	70
Food preparation and preservation	8	76	97	97	118	118
Food service and dining	53	70	91	105	119	141
Recreation and self-improvement	125	164	221	286	357	383
Extra-familial association	17	17	34	34	51	51
House keeping	48	91	110	127	146	149
Care of the infant or the ill	-	124	124	124	124	124
Circulation	20	20	35	35	45	45
Operation of utilities	-	20	20	20	20	20
	400	750	1000	1150	1400	1550

Source: American Public Health Association (1950)

2.5 Housing and Environment

According to research findings by National Housing Forum, UK (1997), the way in which housing is located, built and maintained has a profound impact on the environment. The adoption of designs which; minimize use of non-renewable materials, re-cycled materials or materials which use less energy to manufacture was paramount in achieving healthy housing-environment interaction. In this regard, the adoption of Hydraform-ISSBs could help in attaining housing-environment best practice and interactions within Nakuru County. According to Kintingu (2009), poverty factor among the Developing Country's inhabitants plays a role in housing-environment relationship. He provided insights into past studies indicating that more than 50% of African people alone live below the poverty line with more than 80% of the population living in rural areas possessing poor shelter (Kintingu, 2009). The low per capita levels could therefore make people to resort to use of environmentally destructive materials and unsustainable technologies in shelter provision strategies. It was therefore important to note that, the existence of various social groups in society could bring divergent ways in which the

Hydraform-ISSBs could be applied with eventual resultant varying degree of impacts to the environment.

2.6 Informal Settlement and Human Development

Cities have been associated with human development (Teune, 1998), and the HDI, developed in 1990 by the United Nations Development Programme (UNDP, 1990), as a comparative framework for the Country case studies. This was done by ranking each country from lowest to highest based on 'longevity', knowledge and decent living standards (UNDP, 1991).

According to UNDP (1991) report, a decent living standard could be measured by multiples of the poverty level in which, 'the higher the income relative to the poverty level, the more sharply the diminishing returns affect the contribution of income to human development. This Index varied from a high of 0.993 for Japan to a low of 0.048 for Sierra Leone (UNDP, 1991) for 160 Countries. In essence, Human Development was a process of enlarging people's choices such as; living a long and healthy life, to be educated and to access resources needed for decent standards of living (UNDP, 1990). It was thus vital to establish the role these characteristics play in the adoption and use of Hydraform-ISSBs technology within Nakuru County.

2.7 Housing in Kenya

Housing is an integral part in environmental control and this has been a key motivating factor for the country in an effort to provide adequate shelter for all people, both in the urban and the rural areas (Busaka, 1986). The primary aim of government policy on housing is to facilitate Kenyans to access excellent, affordable, adequate and quality housing in sustainable human settlements (GoK, 2007).

According to Ghai and Lisk (1979), about 70% of the urban population were not able to afford a complete self-contained house even if it was one roomed, and further to this, 25% of the urban population could not be able to even afford a serviced plot. Kenya's population grew from 8.64 million in 1962 to 15.3 million in 1979, an average annual growth rate of 3.5%, having risen to 3.9% in 1979. The World development report forecasted an annual growth rate of 4.1% for Kenya's population between the years 1980 to 2000 (World Bank; 1982). The overall Kenyan population according to Census (2009) result was estimated at over 38.6 million people. Sessional paper No.5 (1966/1967) set out the strategies by which Kenya could achieve her housing objectives within the framework of social and economic development with major housing schemes initiated at the time being; mortgage; tenantpurchase and owner-builder schemes; site-and-service schemes; upgrading of existing units; and rental housing. Housing is thus pertinent in the efforts made towards the realization of Vision 2030, MDGs (Goal No.7 on ensuring environmental sustainability), as well as meeting the constitutional requirement as housing provision is no longer a privilege but a right anchored in Law (Constitution of Kenya, 2010). The regulatory reforms being spearheaded by the Government and the participation of the Kenyan people has created an opportunity for research and development on Appropriate Building Materials and Technologies that could help accelerate the housing provision to Kenyans, a situation that has found adoption and use of Hydraform-ISSBs ideal.

2.8 Hydraform Technology and Building Laws

Hydraform-ISSBs technology complies with the South African National Building Regulations, satisfying the requirements for structural performance, rainwater penetration, fire protection, thermal performance and durability, and is nationally approved for use under certificate № 96/237 (Hydraform manual, 2005). In Kenya, the standards supporting the implementation of Hydraform-ISSBs technology operations are guided by the requirements pertaining to Soil-Cement Blocks production (KS02-1070), approved in 1992 as a quality control measure (Gooding, 1995).

The application of building controls in Kenya followed the development of urban areas, with the earliest attempts to introduce legislation related to building or planning in colonial Kenya being traced to around 1900 when surveyors started planning camps and townships along the Kenya-Uganda railway, then under construction (Agevi, 1987). However, the first by-laws for building development and control in Kenya were introduced by the colonial Government in 1926 and were applied to the then Nairobi Town Council (GoK, 2009). The by-laws were later replaced by the Nairobi City Council By-laws that incorporated town planning and zoning (Building) in 1948. The current building code dates back to 1967 and mainly found to be a replica of the British building Regulations of 1948. This code is material based and has several outdated and inappropriate provisions that are susceptible to multiple interpretations, (Kimani and Musungu, 2010). Various planning initiatives which included: the 1926 Mombasa Municipal Council Plan; 1948 Nairobi Master Plan; Swynerton Plan of 1955; and Mombasa Municipal Council Master Plan of 1962 were institutionalized through the 1931 Town and Country Ordinance, (Kimani and Musungu, 2010).

Further to this, in 1995, a set of new building regulations commonly referred to as Code 95 were developed through a Government/Private sector initiative (Kimani and Musungu, 2010). This was meant to promote housing standards and procedures aimed at reducing building costs through use of innovative designs and local materials. However, no significant success was realized through this initiative due to failure by most of the local authorities to adopt these new adaptive by-laws. Positive developments would be realised, more so as soon as the draft Housing Bill, 2011 is enacted into law. The draft Housing Bill, 2011 advocates for enhancement of research and development as well as promotion and adoption of Appropriate Building Materials and Technologies in specific localities.

2.9 Traditional Building Materials Common in Developing Countries

According to Gooding & Thomas (1995), traditional building materials common in Developing Countries are considered to fall into four broad groups namely; unstabilised soil, fired brick, wood and stone. Unstabilised soil construction is widespread in rural areas but at the same time, generally viewed as undesirable being the bottom rung of the materials ladder. This view was pronounced in South Africa, Kenya and Zimbabwe, (Gooding & Thomas, 1995). Financial institutions normally adhere to standards and building codes in a way that limits access to affordability schemes for the working poor (UN-HABITAT, 2006). Further, a French organization, CRATerre was noted to have been involved in the promotion of improved architecture to extend the life of unstabilized soil structures, however despite the existence of some admirable demonstration houses, unstabilised soil remained firmly fixed in the minds of Developing Countries residents' as being rated second and the overwhelming demand in all of the countries surveyed was for "something better than soil" (Gooding & Thomas, 1995). The significant feature was that most of the materials were detrimental to the environment, a situation that necessitated seeking of alternative building technologies, a key contributing factor in the promotion and adoption of Hydraform-ISSBs in Kenya.

2.10 Appropriate Building Technologies

According to Syagga (1993), research into and development of appropriate building materials that are climatically adaptable, socially acceptable and relatively cheaper to produce is one of the ways in which provision of more housing at prices that are affordable to the majority of those in need can be realized. The cost of materials constitutes 60-70% of the total cost of housing. The main reasons considered for their limited use included; very little data on material occurrence disseminated, ignorance by most Kenyans on the use of materials in housing and construction industry, little exchange of practical information on how to mine, develop, process and utilize the materials, lack of an adequate housing policy especially in the rural areas which has hindered availability of incentives for seeking out local raw materials for housing and construction, and inadequate prototype demonstrations conducted to popularize the materials.

Table 2.3 Some Materials and Technologies currently under use in the Country

Technology	**Material/Solution**	**Available from**
Hydraform machine	Interlocking stabilized soil blocks for walling	South Africa (SA) and Turkey
Manual block press	Interlocking stabilized soil blocks for walling	Kenya
Rammed earth	Walling	Kenya
Newbuild Construction Technology	Cost-effective foundation, floor & ring beam	Kenya
Tevi roofing tile vibrator	Micro-concrete roofing tiles	Ecuador
Battery roofing tile vibrator	Micro-concrete roofing tiles	Kenya
Machine-cut quarrying	Smooth stones for walling	Kenya
Zinc/aluminium/silicon (ZAS)	Rust-resistant sheets	Kenya
Aluminium	Rust-free sheets	Kenya
Light gauge steel	Walling frames & roofing trusses	Kenya/SA
Structural Insulated Panels (SIP)	Cement fibre/polyurethane walling panels	Kenya/India
Prefabricated concrete panels	Walling	Kenya
Recycled plastics	Posts	Kenya
Powermax cement	Soil stabilization	Kenya

Source: GoK, 2011

In the stabilization process, soils that do not possess the desired characteristics for a particular construction could be improved by adding one or more stabilizers. According to UN-habitat (1988), stabilizer (s) fulfilled one (or at the most two) of the following functions; increase the comprehensive strength and impact resistance of the soil construction, and reduce its tendency to swell and shrink, by binding the particles of soil together; reduce or completely exclude water absorption (causing swelling, shrinking and abrasion) by sealing all voids and pores, and covering the clay particles with a watering proofing film; reduce cracking by imparting flexibility which allows the soil to expand and contract to some extent; and reduce excessive expansion and contraction by reinforcing the soil with fibrous material. The stabilization process was not an exact science and it was up to the builder to make trial blocks with various kinds and amounts of stabilizers for testing (UN-HABITAT, 1988).

2.10.1 Green Building

According to Hydraform Building System (2009), the Hydraform-ISSBs technology was regarded as eco-friendly building systems with low embodied energy and were cost-effective, labour-intensive, fast to use, and equally ideal for both remote rural areas and high-density urban areas. The current global strategy is to encourage all actors in the field of environmental conservation and protection to promote application of green initiatives, more so within the built environment. The recent action in this field has been spearheaded by UN-HABITAT, which has pioneered an Ultra modern building complex in Gigiri, Nairobi that remarkably integrated the green building concept, as launched in the year 2011. In most instances, individuals, institutions and real estate developers have been using green built practices and products imported from developed and developing countries albeit in small scale applications. The practices include; installing of Solar panels and Wind energy generating devices for lighting and heating system, use of special low energy bulbs for lighting, adopting of housing designs utilizing natural lighting and ventilation, biogas for cooking and heating system, and water conserving sensitive taps. The materials were composed of renewable, rather than non-renewable resources and characterized by; re-usable and recycling content; zero or low levels of harmful air emissions; zero or low toxicity; sustainable harvested materials; and high recyclables, durability, longevity and local production.

According to Jeong (2011), the industrial revolution brought mankind an unprecedented level of material wealth along with population convergence to urban areas, but at the same time, these has caused mankind many other new challenges notably; natural resource depletion, creation of new and toxic organic chemicals, and indiscriminate overexploitation of the environment. In overall, the impacts of green building on the ecosystem, especially, the use of less energy, water, space, and materials should be very minimal during transportation, point of production as well as the construction point. Above all, the practices should not pose health risk on workers during construction period and occupation period of the house developed using these buildings. It was on the above considerations and requirements that Hydraform-ISSBs adoption was considered for assessment on its impacts to the environment.

2.10.2 Block Making Machines

According to HABRI (2003), there has been a number of Block making machines in use in Kenya namely; CINVA-Ram Press, BREPAK Press, and more recently, the Hydraform Machine. The CINVA-Ram Press was one of the earliest machines for making Stabilised Soil Blocks (SSBs) which was developed in the 1950s (UN-HABITAT, 2009). It was capable of exerting pressure of upto $10KgN/M^2$ (Kintingu, 2009). The Building Research Establishment (BRE) in the UK developed the BREPAK Press Machine in the late 1970s. Due to the hydraulic mechanism it incorporated, the BREPAK could exert high amount of pressure (almost five times the pressure of CINVA-Ram), and therefore the quality of stabilized blocks produced was quite high (Agevi, 1986). The report by HRDU (1987), indicated that these machines had been known to produce between 200-250 soil blocks per day, with a group of 5 labourers, while on construction process, one mason and a labourer could lay upto 150 blocks per day (i.e. 4.7 square metres). The blocks were measuring 290mm X 140mm X 125mm and weighed approximately 8kg (Donde, 1994). The introduction of Hydraform-ISSBs machines into the market brought with it a lot of dynamism since it was capable of achieving mass production of blocks with single chamber machine having a daily maximum production of 1500 blocks and a double chamber machine having a capacity of 3000 blocks per day. The standard Hydraform blocks weighed between 8-12kgs.

The market price of Hydraform Machine was valued at about USD 31,000 at Hydraform Company sales department in South Africa (Hydraform Ltd, 2009). This cost was noted to be beyond the reach of most residents with intent to use the technology due to the prevailing high poverty situation that has characterised most residents in the study area. The Kenyan Government has therefore undertaken the responsibility of acquiring the machines from South Africa and distributing them to the Provincial and Constituency Appropriate Building Technology (ABT) Centres Countrywide. This has been aimed at enabling more citizens to access the machines free of charge or at affordable cost in their respectively constituency ABT Centres. This development was anticipated to generate interest among players in the construction industry, especially in Nakuru County.

2.10.3 Stabilized Soil Blocks Regime

Soil as a resource, was considered widely available and in some parts of the world, especially in remote areas, it is the only material available (Adam & Agib, 2001). In building and construction, it was observed that the most significant part of the physical structure was the walling constituents, which comprised about 60% (Agevi, 1999), and thus vital to concentrate work on low-cost walling. By understanding the characteristics of soil, use of earth could be promoted as an ecological on-site building material (Adam & Agib, 2001). Various types of soils are suitable for use as building materials and to improve their quality, there was need to identify the characteristics of the soil and suitability for use in building construction. It further became apparent that, besides the addition and removal of certain constituents, soil suitability tests must be carried out (Kerali, 2001), as this would help the users to determine mix proportions for the production of desired quality blocks. Soil Stabilization process was a necessary undertaking to help achieve a lasting structure from local soil, as the local material properties determine the appropriate stabilization method (Montgomery, 1998). According Houben & Guillaud (1994), stabilization techniques could be broken down into three categories namely; mechanical stabilization; physical stabilization; and chemical stabilization. This happens either by creating a matrix, which binds or coats the grains or by a physic-chemical reaction between the grains and the additive materials (Gooding & Thomas, 1995). The main categories of binders used for earth construction were Portland cement, lime, bitumen, natural fibres and chemical solutions such as silicates (Houben & Guillaud, 1994).

According to Al-Jadid (2004), some of those characteristics were important for the developing countries more than others, but other characteristics were important to the advanced and Western Countries and some of the characteristics are important to all Countries. The choice for utilization of earth blocks were as summarized in table 2.3

Table 2.4 Characteristics of Earth Blocks

Advantages of building with Interlocking Stabilised Soil Blocks	**Degree of importance to the countries**					
	Developing			**Developed Countries**		
	High	**Mid.**	**Less**	**High**	**Mid.**	**Less**
The low cost and availability	*			*		
Limited pollution and depletion of environmental resources.			*	*		
Ease of construction with earth material.	*					*
Reduced unemployment of unskilled labour.		*				*
Variation in constructions techniques and methods.		*			*	
Savings in transport cost.	*				*	
Saving in energy consumption.	*			*		
Engineering characteristics of earth material.		*			*	
Easing recycled of earth products.			*		*	

Source: Modified from Al-Jadid, 2004

2.11 History of Interlocking Stabilized Soil Blocks

The history of interlocking blocks started in early 1900s with the construction of toys for children (Kintingu, 2009). From this source, "An Interlocking Brick construction for toys (Automatic Binding Brick) was first developed in Denmark in 1949, and in 1951 the "Automatic Binding Brick" was renamed as "Lego Mursten" "Lego Brick" in English", first produced commercially in 1958" (Kintingu, 2009). In 1958 version of interlocking bricks with stubby cylinders and matching studs moulded into the surface allowed the Lego bricks to be firmly attached to one another. In 1967 a simplified version called "Duplo" bricks was launched (this was the latest version available in variety of sizes, shapes and colours that formed the basis for mortarless technology using interlocking bricks/blocks). Since 1970s the interlocking mortarless bricks/blocks for house construction, made from sand-cement, stabilized soil and burnt/baked soil, have been pioneered in Africa, with Hydraform-ISSBs machine as engine driven being dominant. The invention of Hydraform Machine, so called due to its application of the hydraulic system, was preceded by the introduction of first engine-driven machine by The Mountain Institute, China in the late 1980s (Buffington/London, 2005).

2.12 Role of Government of Kenya in the Promotion of Hydraform-ISSBs to Kenyans

According to Terry (1986), the cost of building materials and labour accounts for 82% of the total cost of a conventional housing unit in Kenya, an indication that total cost of housing can be decreased significantly by decreasing the cost of building materials and labour. In the 1984/88 National Development Plan, the Government of Kenya formulated several housing policies and objectives among them being; formulation and adoption of realistic and performance oriented building standards, especially in the area of low-cost housing; to promote self-help in housing construction both in urban and rural areas so as to increase housing stock at a reduced construction cost; and to intensify research on and use of local building materials and construction technologies. According to GoK (2007), the Ministry in Charge of Housing, aimed to establish Constituency Appropriate Building Technology Centres Countrywide for training and dissemination of information on Hydraform-ISSBs and other available forms of Appropriate Building Technologies.

2.13 Production of ISSBs/Hydraform Blocks

According to Hydraform Manual (2005), the production of ISSBs/Hydraform standard blocks encompassed five (5) key interrelated activities namely; Soil Selection and Suitability Test; Local Labour organization; Material preparation and block/production yard setting; Material batching, mixing and block press/compaction process (Hydraform Machine operation); and Block curing process. These processes were illustrated in the plates; 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, and 2.7

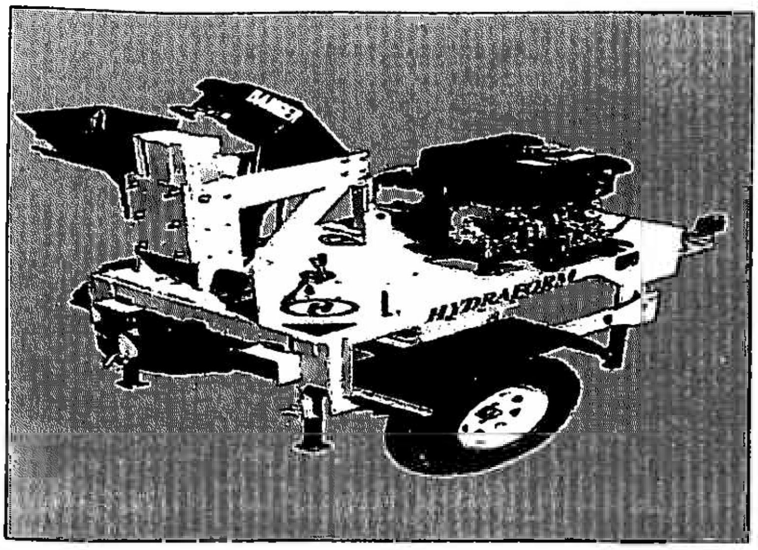


Plate 2.1 Hydraform Machine/Hydraform Manual, 2005


Plate 2.2 Soil Samples


Plate 2.3 Soil Excavation


Plate 2.4 Mix Preparation


Plate 2.5 Block Production

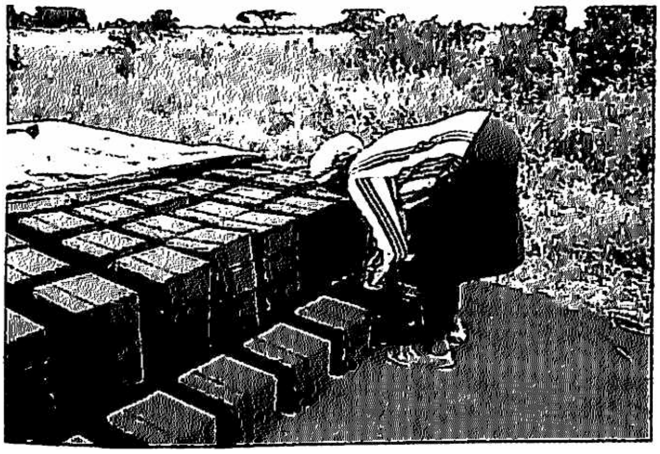


Plate 2.6 Block Stacking


Plate 2.7 Block Curing

The best soil for production of quality Hydraform-ISSBs was classified as Sandy-Loam soil. The soil should contain more sand than clay and silt (fines). If the results of the suitability test found high clay content, then soil should be blended with sand. Blocks could also be produced with higher clay and silt contents, but there was need to determine the plasticity index for suitability (Hydraform, 2009).

Table 2.5 Summary of grading and plasticity required for quality ISSBs production.

Soil Range	% by mass passing the 0.075mm sieve (silt and clay fraction)		Plasticity Index (maximum)	Estimated block strength (after curing)
	Minimum	Maximum		
A	10%	35%	15	4 MPa (using soil range A)
B	10%	25%	10	7 MPa (using soil range B)

Source: *Hydraform, 2009*

The Hydraform instruction manual highlighted a number of ways of performing soil suitability tests namely; Visual test, wash test, jar test and shrinkage test (Hydraform, 2005). These tests may however, not determine with 100% precision the suitability of soil.

Table 2.6 Soil classification

SOIL CLASSIFICATION	PARTICLE SIZE
Gravel	>2.0mm
Sand	0.06 – 2.0mm
Silt	0.006 – 0.002mm
Clay	<0.002mm

Source: *HABRI, 2003*

The soil test was noted to allow for mixture proportions to be adequately worked out in terms of the Soil: Cement : Sand quantities and applied in the block production process. The mixture ratios however, would differ from one soil type to the other. The soil type would also influence the colour, strength and quantity of blending materials to be used. For soils of high clay content, more sand proportion or any other alternative coarse materials would be added and vice versa. The cement proportion in mixture could be apportioned either at 5% or at 8% with 5% cement mix yielding blocks of about 4 Mpa in the compressive strength and 8% cement mix noted to produce blocks of about 7 Mpa in strength. In one of the Hydraform-ISSBs production sites visited during the study, the mix ratios for Cement : Sand : Soil were 1 : 4 : 7, that implied, One Wheelbarrow Portion of Cement : Four Wheelbarrow portions of Sand : Seven Wheelbarrow Portions of Soil. Each mixture comprising these proportions yielded an average of 60 blocks. There would however, be variations on the mix proportions of materials depending on the soil type available for use. In practice, the 8% cement mixture should yield an average of 45 blocks and exhibit high compressive strength of about 7Mpa.

2.14 Summary of Literature Review

Literature review for this study provided fundamental insights into the genesis and use of Hydraform-ISSBs technology from the global, regional, national, and local perspectives.

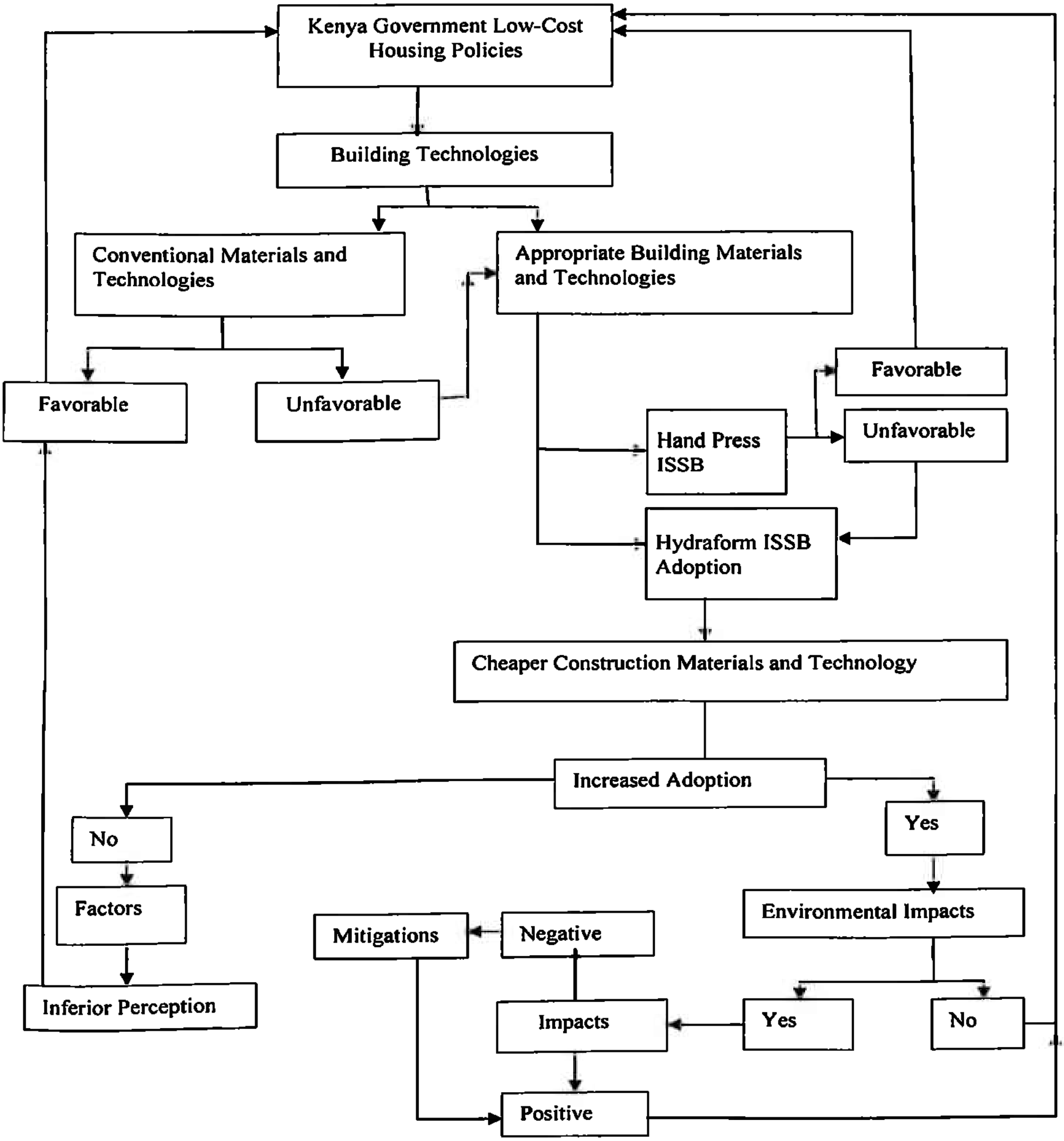
The analysis of previous studies by various researchers revealed very little information on the aspect of impacts the Hydraform-ISSBs technology posed to the surrounding environment, and this therefore formed the gap that this particular study thrived to address. From the existing literatures, it emerged that past studies have concretely provided clear contributions of the technology in poverty alleviations among various adopters. Further, gender roles in technology promotion and use in terms of who the main adopters (whether Men or Women) are has not been adequately documented. The study focused on; factors considered key in influencing decisions made by potential technology users, the negative environment impacts, as well as technology use benefits. For the negative impacts, the study sought to establish the mitigation strategies from the technology use whose implementation would ensure sustainable use of the technology.

2.15 Decision-Flow Diagram

The variables relationship analysis in the use of the technology and resultant environmental impacts commenced with the low cost housing policy support, factors for adoption and eventually, the impacts of the technology use in the environment of Nakuru County. Based on the literature review results, the case study put forward by the researcher was widely thought about after examination and evaluation of previous studies on use of Stabilized Soil Blocks in which Hydraform-ISSBs was a subset. This thought was augmented by the researcher's passion for work in the promotion of ISSBs to the residents of Nakuru County as a Government employee.

The Decision-Flow Analysis for this study provided clear illustrations on underlying variable relationships as depicted in diagram 2.1. It also outlined the terminologies used in the study, key among were; independent, dependent and intermediate variables.

Figure 2.1 Decision-Flow Diagram



Source: Researcher, 2011

The decision to use Hydraform-ISSBs technology by residence of Nakuru County interlinked to policy framework, adoption factors and resultant impacts. The emerging variables in focus were dependent and independent depicted by; adoption factors and technology impacts respectively.

2.15.1 Independent Variables

From the Decision-Flow Diagram, the independent variables in focus were the factors for Hydraform-ISSBs adoption and use in the study area. It demonstrated that environmental impacts could only be felt upon adoption and use of the technology necessitated by favourable factors since block production practically involved direct interaction with the physical environment through soil excavation and other raw materials sourcing, especially sand/quarry dust for blending of soil and cement for stabilization. The factors considered for Hydraform-ISSBs technology adoption were provided in table 4.8

2.15.2 Dependent Variables

The identifiable dependent variables in this study were the environmental impacts (both negative and positive). Positive impacts to the environment in this study referred to economic use benefits of the technology. The flow analysis depicted that the emergence of these impacts were a direct result of favourable factors leading to increased adoption and use of Hydraform-ISSBs technology within the study area. The negative impacts could be traced to technology implementation phases notably; raw material sourcing, mix preparation, machine operation and block curing, and construction stage. The negative impacts and benefits of Hydraform-ISSBs technology use were provided in tables 4.10 and 4.12 respectively. It was noted that, the study projects were either individual or community projects and the minimization of negative environmental impacts as well as maximization of benefits that could accrue from the technology use, could be influenced by efficient management processes applied.

2.15.3 Intermediate Variables

The influence of policy framework in the Hydraform-ISSBs technology adoption and resultant impacts could not be underestimated. The policy formulation and implementation therefore played an intermediary role in this study. It was also observable that however much the technology could be affordable; some people due to some other reasons were hesitant to adopt the technology thereby hindering impact analysis process.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Introduction

This chapter outlines the study process, which described how the entire research was done. It described the research subject and the study area. It further stated the research problem, guiding questions and the study objectives. The hypotheses were then formulated with the broad hypothesis focusing on whether Hydraform-ISSBs was an environmentally appropriate technology. This was followed by literature review with intent to acquire in-depth grasp of the subject matter and identify existing gap in the field of study. According to Hydraform Manual (2009), use of Interlocking Stabilized Soil Blocks was considered environmentally friendly, thereby implying appropriateness of the technology to the environment of Nakuru County. There however, existed little information on the impacts of the technology on the environment in relation to current promotional activities. This then necessitated a study on the extent of Hydraform-ISSBs technology use in relation to environment and factors influencing adoption of the technology within Nakuru County. Concisely, the chapter described the study design, types of data used and their sources, data collection process, and data processing and analysis procedures used during the study.

3.2 Study Design

The study used both qualitative and quantitative methods to collect secondary and primary data from clustered projects. It further probed to gain deeper understanding for purposes of answering the research questions and adequately address the research objectives. The study was specifically intended to investigate the relationship between Hydraform-ISSBs technology adoption and the resultant impacts on the environment. This was to enable the researcher to investigate whether Hydraform-ISSBs concept is an environmentally appropriate technology. The deduction on the appropriateness of the technology was demonstrated by the results of the levels of negative impacts the technology could pose to the environment and the support for benefits associated with the technology use. In conducting the study, Stratified random sampling procedure was used on urban-rural divide of projects implemented. In addition, sample size elements selection was done through project categorization into individual-community projects. The study involved relevant documents analysis, examining data types and sources, defining data collection procedure, outlining fieldwork activities, data collection and analysis, and data processing procedures. The study assumed that the survey design used provided a representative sample of the entire population adopting the technology.

3.3 Types of Data and Sources

The study used both Primary and Secondary data in an attempt to solve the stated problem and address the objectives. The primary data used in this study were sourced from the field on Hydraform-ISSBs adoption in terms of extent of use, factors for adoption and impacts within Nakuru County. It involved use of structured and open-ended questionnaires, interviews, field observations at project sites, Photography, field measurement, and projects sites GPS recordings. This was enabled through deployment of various field data collection tools. The Secondary data used during the study were sourced from Ministry of Housing (Provincial Housing Office-Nakuru) on project owners and locations, training procedures and number of Hydraform-ISSBs Machines in use within the study area. It involved review of training request application list as documented in order to sort out applicants from Nakuru County and generate sample frame. There were also instances of additional information beef-up from multiple sources at the Ministry's Headquarters in Nairobi. In addition, other secondary information pertaining to use of hydraform-ISSBs were obtained from relevant Libraries with information on previous research project reports with relevance to the study.

3.4 Data Collection

3.4.1 Sampling Design

The sample for this study was drawn from the target population using purposive sampling technique (Kothari, 1985). This technique was used because the researcher was interested in the projects that had been implemented and thus had direct interaction with the environment, more so, with regard to raw material sourcing (soil excavation). The study therefore focused on both individuals and community owned projects implemented using Hydraform-ISSBs technology in Nakuru County.

The individual projects were mainly related to household use projects while community projects encompassed projects undertaken in individual or collective capacities, but beneficial to area residents. For instance, community projects ranged from educational, spiritual, recreational facilities, rehabilitation and other public amenities. A list of all projects depicting category by ownership that had used the Hydraform-ISSBs technology in Nakuru County constituted the sampling frame as provided in table 3.1.

Table 3.1: Sample Frame (Sourced from Provincial Housing Office, Nakuru, 2011)

S/NO	PROJECT NAME	OWNERSHIP	CONSTITUENCY
1.	Muungana Wa WanaVijiji/Shikamoo SHG	Community	Nakuru Town
2.	United Methodist Mission School	Community	Subukia
3.	St. Marks Njoro Teachers Training College	Community	Molo
4.	Nakuru Appropriate Building Technology Centre	Community	Nakuru town
5.	Naheco Sacco society Ltd	Community	Nakuru Town
6.	PCEA-Nakuru West	Community	Nakuru Town
7.	Esther Wanjiru	Individual	Subukia
8.	Lt-Col Josiah Kimosop	Individual	Rongai
9.	Ruth Bosco	Individual	Rongai
10.	Philip Sitienei	Individual	Molo
11.	Dorothy Mbaya	Individual	Rongai
12.	Gilgil Good Shepherd Academy	Community	Naivasha
13.	Eunice Wanja	Individual	Subukia
14.	Hedman Gitonga	Individual	Rongai
15.	George Nyaga	Individual	Nakuru Town
16.	Elma Barnett Children's Centre	Community	Rongai
17.	John Mbatia	Individual	Molo
18.	Ayub Kiplagat	Individual	Rongai
19.	Mary Wanjiru Danson	Individual	Nakuru Town
20.	CTS Schools	Community	Rongai
21.	Grace Korir	Individual	Rongai
22.	Charles Muthee	Individual	Rongai
23.	Mustard sch	Community	Nakuru Town
24.	Mary Mburu	Individual	Nakuru Town
25.	Onesmus Kibe	Individual	Rongai
26.	Gichana Samuel	Individual	Rongai
27.	Musa Cheberege	Individual	Rongai
28.	Grace mount Sch	Community	Molo
29.	Deliverence Church njoro	Community	Molo
30.	Malewa Trust	Community	Naivasha
31.	Nakuru Prisons	Community	Nakuru Town
32.	Lucy Njeri	Individual	Nakuru town
33.	K-Rep Dev. Agency/Makao Mashinani	Community	Nakuru town
34.	Samuel Murigi Waweru	Individual	Nakuru Town
35.	Municipal Council of Nakuru	Community	Nakuru Town
36.	Moses Irungu	Individual	Rongai
37.	David Kiptoo	Individual	Molo
38.	Teret Sec	Community	Molo
39.	Amos Kibet Cherono	Individual	Rongai
40.	Rev. Samson Owenga	Individual	Nakuru Town
41.	Joan Nyongesa	Individual	Nakuru Town
42.	Lily S. Amoche	Individual	Rongai
43.	Christopher Tarus	Individual	Rongai
44.	Hellen Ngunje	Individual	Naivasha
45.	Sun and Shield School	Community	Rongai
46.	Irene Mwangi	Individual	Nakuru Town
47.	AIC Kabarnet	Community	Rongai
48.	Merica Hotel	Community	Nakuru Town
49.	Regent Prolink Ltd	Community	Nakuru Town
50.	Bomo Hardware and Construction Services	Community	Rongai

Source: Researcher, 2011

The sampling frame was then subdivided into clusters based on Constituency boundaries in the County. The clustering of projects along Political Constituencies' was informed by the fact that the Hydraform-ISSBs technology promotional processes by the Government through the Ministry in charge of Housing were being conducted in line with existing political geographies in the area. Further, the Government long-term development blue print (Vision 2030) provides for progressive establishment of Appropriate Building Materials and Technology Centres in all the Political Constituencies in Kenya by the year 2030 as a flagship project. Clusters were identified followed by stratification based on rural-urban divide. This provided a platform for difference measure in terms of adoption factors and negative environmental impacts and value of benefits. This process yielded a sample size of 35 projects which were subjected to the study. The resulting sample size was distributed within the clusters using a proportional ratio to the target population, that is, by use of proportional sample size formula (n).

3.3.2 Sample Size Distribution

The sample frame had 50 projects from which a sample of 35 projects was drawn, and these were distributed proportionately by ownership types (individual or community). The sample size elements of 35 projects based on cluster representation was arrived at using the proportional sample size formula;

$$f = \frac{n}{N}$$

Where; f = Ratio of Proportion

n = Sample Size

N = Target Population

Source: *Nachmias (1996:189)*

More often, proportional stratified sampling is used to assure a more representative sample than might be expected under simple random or systematic sampling (Blalock, 1960). This view was similarly propagated by Buchanan (2009) that in trying to know the fraction/proportion of individuals in a population who have certain desirable qualities, data from a sample is used to estimate the proportionate representation. This concept was important in the distribution of elements from various strata sampled for this study.

The distribution of target population and sample size elements within the clusters were summarized in table 3.2

Table 3.2: Summary of Target Population and Sample Size Elements by Clusters

S/No.	Constituency Clusters	Stratification by Ownership		Cluster projects Sizes	Sample Size
		Individual	Community		
1.	Nakuru Town	7	11	18	13
2.	Naivasha	2	2	4	2
3.	Subukia	2	1	3	2
4.	Rongai	14	4	18	13
5.	Molo	3	4	7	5
6.	Kuresoi	-	-	-	-
Total				50	35

Source: Researcher, 2011

The sample elements were then arrived at purposively by taking into account the proportional strength of the project categories by ownership (individual/community) in various clusters through referencing / or snowballing techniques. For individual project elements, household heads were interviewed while head of institutions in the case of community projects in the study sample were interviewed.

3.3.3 Data Collection

Data collection was conducted using questionnaires, interviews, field observations, field measurements, project location positioning / GPS recordings, and photography.

3.3.3.1 Data collection Equipment

The equipments for data collection used in this study included:

3.3.3.1.1 Questionnaire

The field questionnaire was a principal tool for this study. The questionnaire content covered both structured and open-ended questions. The questionnaires were adequately administered during the visits to the project sites with 100 per cent response rate attained from both individual and community project categories. By self-administering the questionnaires, the researcher managed to get probable information from the respondents. The descriptive data obtained from the respondents as captured by the questionnaire variables were used to run the frequencies and generate inferential statistics.

3.3.3.1.2 Digital Cameras for photography work

The Digital Camera was effectively used to capture still pictures of sampled projects, existing burrows, production process, burrow measurements activity, and respondents' interview sessions. The information obtained was vital in order to corroborate evidence of fieldwork, show the practicability of Hydraform-ISSBs adoption and the nature of resulting burrows from technology use that could affect the environment.

3.3.3.1.3 Tape Measure

The Tape Measure was used to take measurement of burrow dimensions (Length, Width and Depth) in metres. This was used to calculate the volume with equivalent soil amount estimates as excavated for block production. Determination of amount of soil was vital as it sought to establish if there were differences in amount of soil used by the two projects (Individual and Community) categories. The burrow volume computed from raw data collected from the field was provided in Appendix A.

3.3.3.1.4 GPS

Geographic Positioning system equipment was applied to determine project locations with precision. The data on project site positions were captured in Universal Transverse Mercator (UTM) with the aim of mapping the projects and linking crucial variables to be located in the map. The projects location co-ordinates were provided in Appendix A.

3.3.3.1.5 Data Sheet for recording measurements from extraction pits and soil type

The data sheet was developed and used to capture measurements relating to project location positioning and burrow dimensions.

3.3.3.2 Data Collection Procedure

The procedure for data collection was as outlined;

- Step 1: Prepared questionnaires and transect measurements data sheets
- Step 2: Extracted Sample Frame from the PHO-Nakuru's ABT training application list
- Step 3: Computed sample size by purposively taking 70 per cent of the target population.
- Step 4: Generated sample elements list proportionately

- Step 5: Enquired Telephone contacts for sample elements from the Provincial Housing Office
- Step 6: Booked appointments with project owners by calling through mobile phone contacts
- Step 7: Visited sampled projects in the field.

3.3.3.3 Fieldwork Activities

The activities performed during the field study involved; interaction with respondents in order to create awareness about the study, understand its objectives and internalize the questionnaire contents. The researcher further recorded Geo-spatial reference points, filled questionnaire responses as captured from respondents, identified burrow location where burrows existed and recorded dimension measurements using Tape Measure. For projects where burrows were non-existent, Length and Width measurements were taking while the depth estimates were provided by the respondents. Interview skills were used to probe the respondent for certainty and adequacy of the responses given. In addition, projects and burrow appearance observation and photography were done.

3.4 Data Processing and Analysis

3.4.1 Data Processing

Field data were subjected to data processing techniques before analysis commenced as outlined in the steps below;

- Serialization of questionnaires for traceability
- Data quality and integrity was checked through verification to ensure that outliers were identified and corrected.
- Developed a book code in SPSS (version 18) platform to enable easy entry of data and avoid entry of invalid data.
- Converted Universal Transverse Mercator (UTM) coordinates (metres) to Geographic coordinates (Degrees) using UTM/Co-ordinates Converter
- Data Entry of both the survey data and geospatial data
- Data cleaning through frequency tests
- Reduction of qualitative data through classification and decoding
- Reducing the 10 likert scale data to 5 likert scale data for factors of importance on Hydraform-ISSBs technology adoption.
- Performed variable computation analysis to calculate burrow volume using Excel Platform

- Geospatial data was exported to Excel to transform it into a compatible format, dbf (dBaseIV) for mapping software (ArcView)
- Selected variables for frequency runs for descriptive analysis of data.

3.4.2 Data Analysis

The sample data were analysed using descriptive statistical techniques to show the distribution tendencies in the variables. The distribution tendencies indicated aggregations and dispersions in the sample data for accurate descriptions with regard to the study problems. In descriptive statistical technique, frequency analysis was used to show the number of occurrences in order to determine the distribution mode or modal class while graphical technique was used to show proportion of occurrence as a measure of variable roles in a specific event. The platform for data processing and analysis was SPSS (Version 18). Crosstabulation technique was used both as a descriptive tool and a measure of association or difference. In frequency analysis, all the variables in the sample data that related to Hydraform-ISSBs use, adoption and impacts were entered in the frequencies analysis model. The results of frequency analysis were tabulated and graphically represented (Bar Charts and Pie-Charts). The tabulation were useful in determining the mode or modal class for each variable that was necessary as a measure of extent of use, factor of adoption and impact in the context of Hydraform-ISSBs in Nakuru County. The frequency results were strictly tendency measures and therefore for description of sample data only. To get indepth conditions of the variables described by frequency analysis, the study used crossstabulation technique as measure of cell-to-cell differences or associations thus differences or associations between variables in the sample data.

3.4.2.1 Crosstabulation of Variables of Interest

The technique was performed on selected variables of the study in order to show association tendencies exhibited by the variables and thus necessitated drawing of deductions that addressed the research objectives. It was used to determine how the use of Hydraform-ISSBs as alternative building material was distributed among various Age groups and the period of residence of respondents within the study area. Further crosstabulations were performed on project categories (individual and community) against burrow volumes as well as on projects location (town and rural areas) against the burrow volumes. Based on the respondent data, choice of variables crosstabulation was found necessary to show preference of Hydraform-ISSBs use among different ages and period of residence. It also offered a chance to show how burrow sizes and volumes varied in terms of project categories (individual/community) and location (rural/urban) divide. The frequencies and crosstabulation outputs were then exported to excel platform and formatted for drawing of charts and report writing.

3.4.2.2 Spatial Analysis

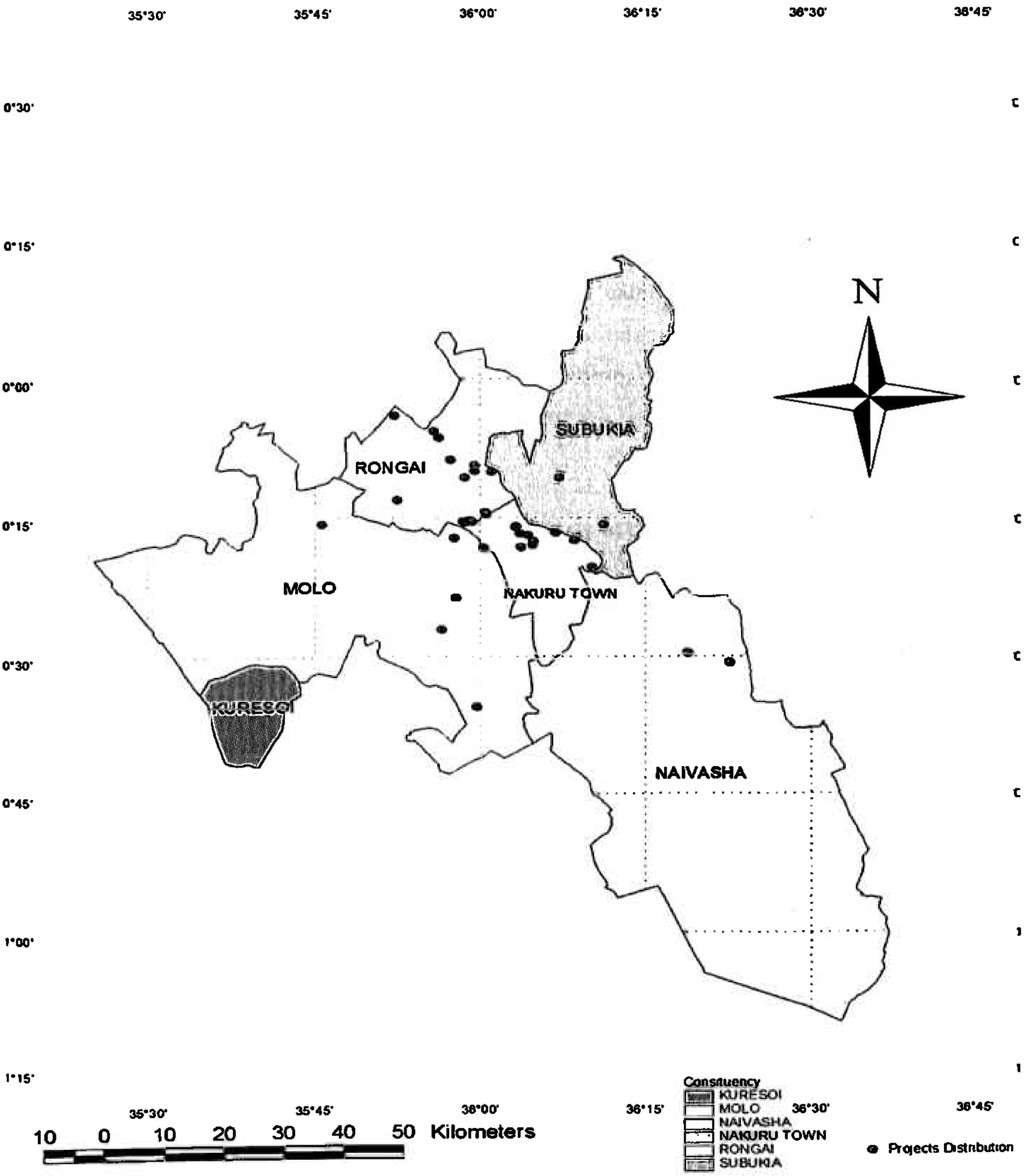
The study used spatial analysis to show the varied levels of impacts that could result between individual and community Hydraform-ISSBs technology adopters. This was done by examining the burrow volumes of the two project categories and their spread within Nakuru County. The resulting statistical estimates were applied in projects spatial distribution and corresponding analysis to show spatial variations and patterns in various locations within the County. This was vital in making projections on the desirability of the use of Hydraform-ISSBs technology with respect to project ownership (individual/community) and location (rural/urban).

This was further demonstrated through projects spatial mapping arrived at scientifically using the following procedure;

- Sourcing for the right dataset (Map of Kenya showing administrative boundaries)
- Extracted map of Nakuru by use of geoprocessing analysis
- Demarcating Constituency boundaries to map the clusters through geoprocessing
- Overlaying the geospatial data by use of longitude and latitudes
- Converted overlaid geospatial data into shape files
- Developed layout for presentation
- Export the layout into an image format, e.g JPEG image

The output map depicting the spatial project area and spread was given in map 3.1

Map 3.1 Project Areas by constituency



Source: Researcher, 2011

3.4.2.3 Student's t-statistic Analysis

Student's t-test being a parametric test was used to determine the significance of the difference between groups of data measured on an interval scale (Mugenda and Mugenda, 1999). It was also used to determine the significance of correlation coefficient between variables under study. An independent-samples t-test procedure was used to compare means for two groups of cases notably individual and community projects. The variables used to perform the t-test within these groups were on factors for Hydraform-ISSBs technology adoption and the adverse environmental impacts associated with the technology use. The t-test was performed at interval confidence level of 95 per cent and α 0.05 with 33 degrees of freedom (df).

For statistical interpretation, a t-value showing a significant value of ≤ 0.05 was found to be significant indicating that any difference in responses were due to the treatment (or lack of treatment) and not to other factors. The significance difference that arouse from treatment implied existence (or non-existence) of perceptions shaped by either availability of the resources and level of adverse impacts of the technology use.

In situation where t-value was significant, there existed a big variation in the mean. Further, the Levene's test for equality of variances was used to show the variability within the group and across the group. It was significant (≤ 0.05) whenever variance across the group was high, thereby enabling us to use the lower t-values in the output of SPSS table for independent t-test. But it was insignificant if the variance across the group was low hence necessitating use of upper t-values.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter described respondent bio-data in terms of; projects locations, Project categories, respondents' educational levels, age of respondents, respondents' occupation, period of residence, housing materials in use. It aimed at providing insights into Hydraform-ISSBs technology extent of use, adoption factors, negative environmental impacts, technology use benefits, Mitigation strategies, reasons for use preference, consideration of the technology as environmentally appropriate, application/uses of soil burrows, and ways of up-scaling technology adoption. The results and discussions presented regarding the above areas of concerns were aimed at addressing the objectives of the study.

4.2 Hydraform-ISSBs Technology Extent of Use in Nakuru County

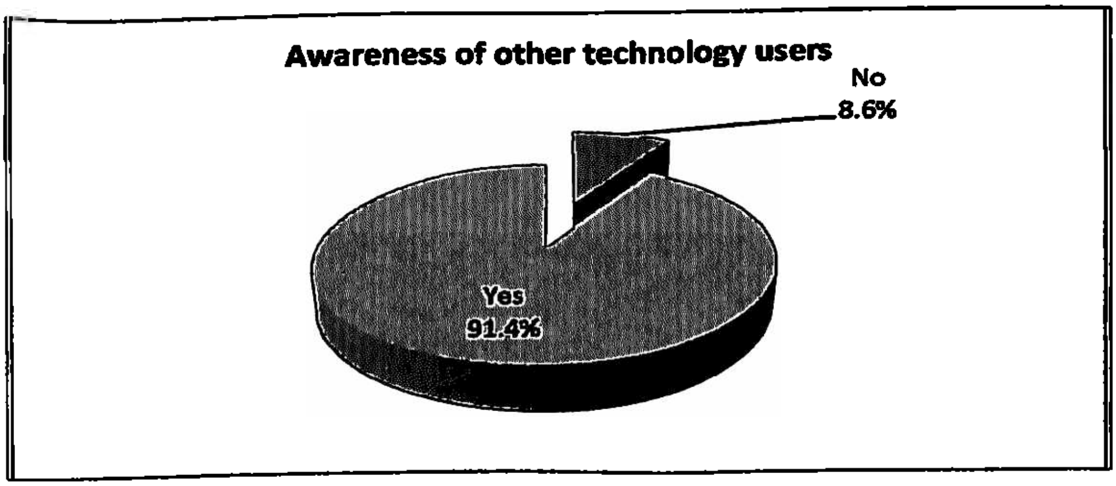
This was one of the objectives that the study sought to address. It established the genesis of Hydraform-ISSBs and extent of use in shelter provision within Nakuru County. The information established through interrogation of both the primary and secondary data sources during the study showed that Stabilised Soil Blocks (SSBs) were introduced in Kenya as early as 1982 by Housing and Building Research Institute (HABRI) formerly known as Housing and Research Development Unit (HRDU) as Compressed Earth Blocks (CEBs) using Manual Block Presses, notably, the Action Pak/CINVA-Ram block presses (GoK, 2011). The technology found wider adoption with the manufacture of the block presses (Manual Action Pak) locally, more so, via the initiatives undertaken by Makiga Engineering Services, Undugu Society, and Western College (WECO) among others. Between 1982 and 2003, the Ministry in charge of Housing worked in conjunction with HABRI to disseminate the technology and with the dissolution of HABRI in 2003, the Ministry embarked on this task alone. By this time, Makiga Engineering had just introduced Interlocking and Curved Stabilised Soil Blocks in the year 2001 produced by Manual/Hand Pressed Machines.

In August 2003, a Kenyan delegation visited Namuwongo Police Projects as well as Mbale and Jinja Community Housing Projects in Uganda, with a view to acquaint themselves with the operations of Hydraform-ISSBs Machine for the manufacture of SSBs. Further, the promotion of Rammed Stabilised

Soil Blocks had earlier been depicted in the work of Browne (2005) as he demonstrated their use between Good Earth Trust/UK and Makiga Engineering Ltd in Uganda and some parts of Kenya. Upon return, the team recommended that the SSBs equipment was appropriate, especially for Prison, Police and other public as well as community Housing Projects. This was so because with efficient and innovative management of the Hydraform-ISSBs technology use processes, more so, in community participation and labour volunteer approach coupled with availability of revolving housing fund at affordable interest rate for low income earners in the society, affordable housing was deemed a reality. By December 2003, the Ministry of Housing purchased the first Hydraform M7 Block making Machine from Multi-Line Industrial Supplies for use. So far, about 15 Hydraform-ISSBs Machines were available for use by the public in Nakuru and 177 Machines distributed across the Country.

Despite this progress, the study revealed low knowledge of the technology use in the research area and the respondents' consideration of Hydraform-ISSBs to be among the several options of building materials available in the area did not help matters much. To address this issue, the research question sought to know if the respondents were aware of other people who had adopted and used the technology in the surrounding environment apart from their own projects. The findings revealed that 91.4 per cent of the respondents affirmed awareness of other people in the neighbourhoods who had used the technology as depicted in chart 4.1. This concurred with Buffington (2005) assertion that earth building had been significant throughout human history. It further confirmed the assertions by Browne (2005) on earlier promotion of rammed earth blocks between Good Earth Trust/Uganda and Makiga Engineering Ltd in Uganda and some parts of Kenya.

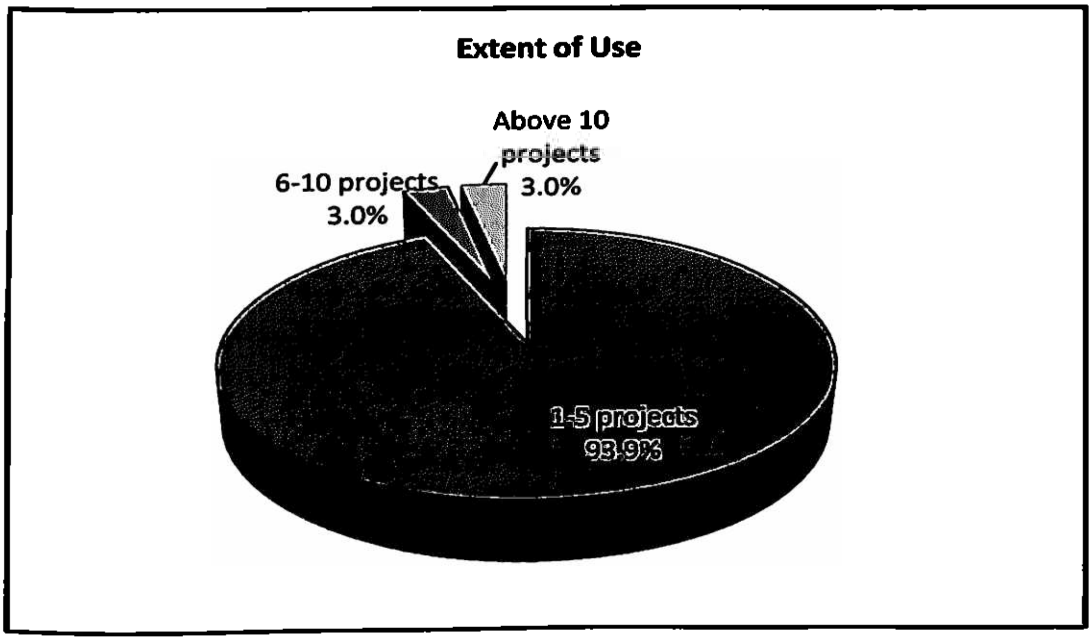
Figure 4.1 Awareness levels of other Technology Users Among Respondents



Source: Fieldwork, 2011

A part from this general awareness of other technology users within the surrounding, subsequent enquiry of the actual number of projects in the vicinity supported the point that the level of adoption of the technology was generally still low in the area. To validate this, three categories were concieved depending on the number of projects each respondent could confirm knowledge of having been undertaken in their neighbourhoods. The result of this was demonstrated in chart 4.2

Figure 4.2 Extent of Hydraform-ISSBs Technology Use



Source: Field data, 2011

As depicted in the Chart above, the respondents who indicated knowledge of 1-5 projects formed the majority at 93.9 per cent, while those who confirmed knowledge of 6-10 projects as well as above 10 projects were merely represented by 3 per cent respectively. The Census result of 2009 indicated that Nakuru County comprised of about 409,836 households. These number of households were noted to be many and ordinarily one would expect building materials with wide usage to be proportionately reflected by the number of households that have adopted them in various construction projects, a situation that was lacking in this particular research findings.

Other results demonstrating extent of Hydraform-ISSBs uses were depicted by projects distribution in terms of; physical location, category by ownership, educational levels, age cohorts, occupations, period of residence, and frequency of wall materials use in the area. These were further discussed below;

4.2.1 Projects Constituency Location

The study area comprised of six (6) political Constituencies that formed the focal points of Hydraform-ISSBs technology promotion and trainings. The focus on projects distribution by Constituencies was informed by the Government Policy of introducing the projects through the Political Constituencies in the area, a task achieved through the establishment of Constituency Appropriate Building Technology Centres as provided for in the Vision 2030. This also encompass capacity building of local populace through trainings on material preparation, block production and wall construction processes. From the respondent data, the projects distribution by Constituency was as provided in table 4.1. It was however, observed that there were no Hydraform-ISSBs accomplished projects in kuresoi Constituency at the time of the study.

Table 4.1 Projects distribution by Constituency

Constituency	Frequency	Percent
Nakuru Town	13	37.1
Naivasha	2	5.7
Subukia	2	5.7
Rongai	13	37.1
Molo	5	14.3
Total	35	100.0

Source: Fieldwork, 2011

The study revealed that Hydraform-ISSBs technology adoption rates were high in Nakuru Town and Rongai Constituencies' of Nakuru County respectively. High rate of technology adoption in Nakuru Town Constituency could be attributed to close proximity to the Provincial Housing Office from where the information on the technology use and Machine administration procedures are sought. On the other hand, increased use of the technology in Rongai Constituency could be atributed to the initiatives by the local Members of Parliament both in Rongai and neighbouring Mogotio Constituencies', as well as the environment influence due to the cluster proximity to Nakuru Town where both administration of the Hydraform Machines and more adopters were found. In addition, the two Local Members of Parliament from the Constituencies mentioned above have personnally used the technology in various construction projects, more so, school development projects. They have also advocated for use of Hydraform-ISSBs technology in various community projects in their respective Constituencies. The distance that prospective technology users were located relative to the point of technology acess may have hindered the rate of adoption in Nakuru County. For instance, increasing distances resulted in increased operation costs of moving/towing the machine to the clients on-site location and the training personnel(s) who may be paid subsistence allowance depending on the distance/location of the training site. The challenge relating to distance client Versus Hydraform Machine administration office was being addressed by accelerating the establishment of Constituency Appropriate Building Technology Centres across the County.

4.2.2 Projects Categories

The study sought to find out the Hydraform-ISSBs projects distribution based on category of users notably; individual and community projects. The proportion of users between these two categories were as shown in table 4.2

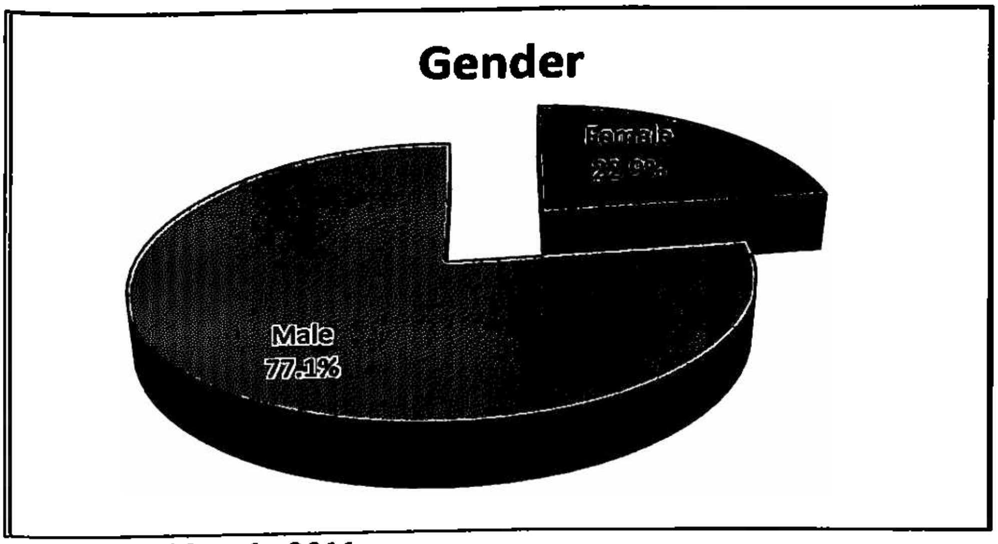
Table 4.2 Projects Categories

Project Category	Frequency	Percent
Community	17	48.6
Individual	18	51.4
Total	35	100.0

Sources: Fieldwork, 2011

The distribution of projects along gender lines revealed that more males had adopted the technology compared to their female counterparts. This was in the proportion of 77.1 per cent for males and 22.9 per cent for females as depicted in chart 4.3

Graph 4.3 Respondents Gender



Source: Fieldwork, 2011

4.2.3 Respondents Education Levels

The research study sought to find out the respondent educational levels in order to show how educational background has helped in the adoption rate of Hydraform-ISSBs technology. From the respondent data, post-secondary education respondents showed high rate of adoption of the technology represented by 82.9 per cent as compared to high school education level respondents which was 17.9 per cent as shown in table 4.3.

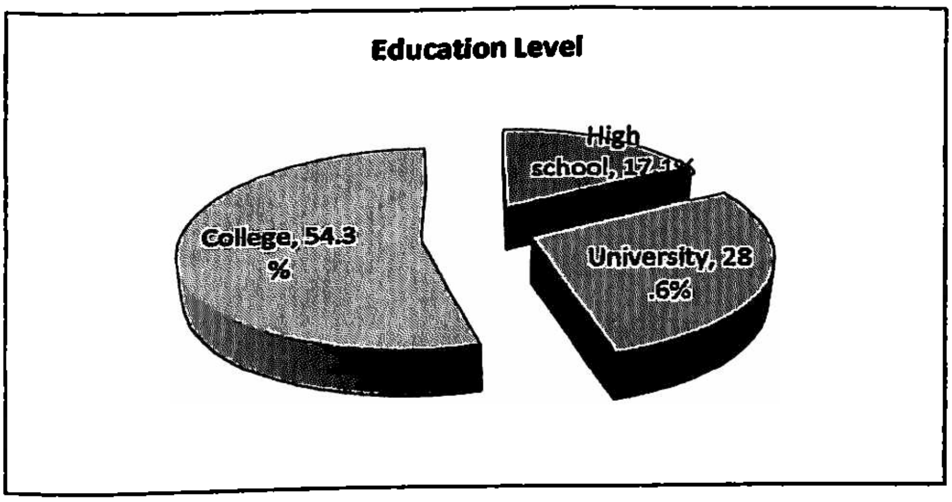
Table 4.3 Respondents Education Levels

Education Level	Frequency	Percent
High school	6	17.1
University	10	28.6
College	19	54.3
Total	35	100.0

Source: Fieldwork, 2011

This result above was further demonstrated by the graphical presentation in graph 4.4

Graph 4.4 Respondents Education Levels



Source: Fieldwork, 2011

4.2.4 Age of Respondents

The study sought to find out the population cohorts with high adoption rate of the Hydraform-ISSBs technology in different localities of Nakuru County. This was done by classifying the population into 10 years age difference, the result of which showed that age groups ranging between 35-44 years represented 45.7 per cent of technology adoption rate. This was followed by 45-54 years (28.6 per cent), 25-34 years (22.9 per cent), and finally 55 years and above, had the lowest adoption rate at 2.9 per cent.

This result showed that the age groups of respondents in the age cohorts of 35-44 years had the highest adoption rate. This was summarized in table 4.4

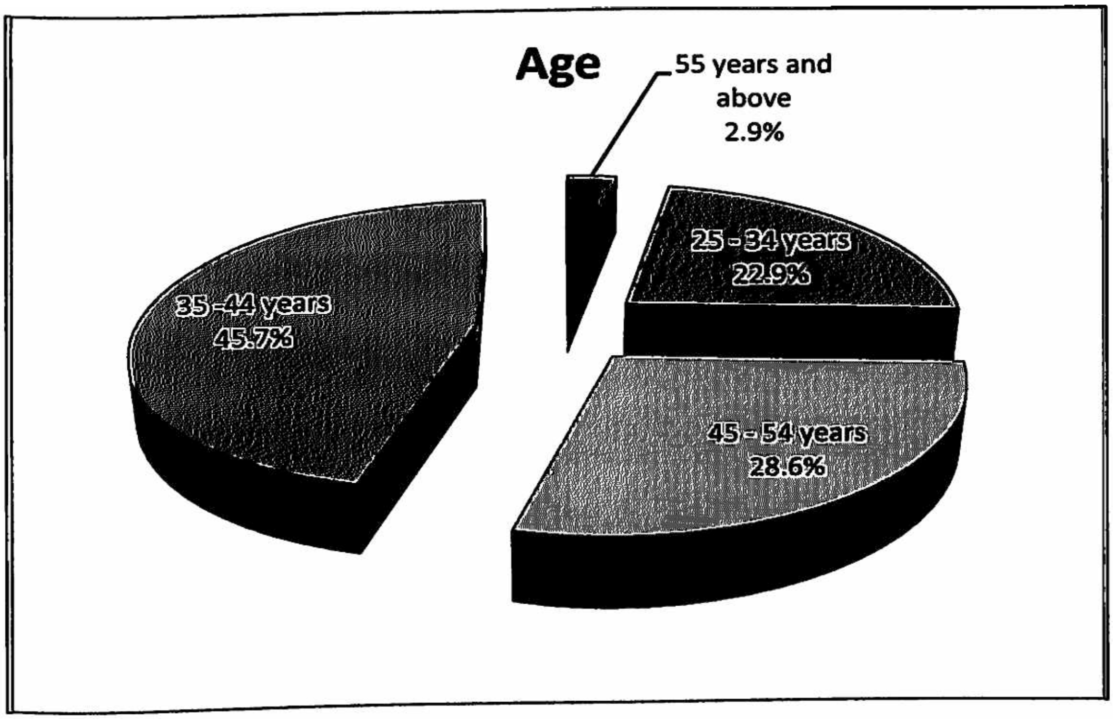
Table 4.4 Age of Respondents

Age	Frequency	Percent
55 years and above	1	2.9
25 - 34 years	8	22.9
45 - 54 years	10	28.6
35 -44 years	16	45.7
Total	35	100.0

Source: Fieldwork, 2011

Further demonstration of age dynamics in the technology use was provided by graph 4.5

Graph 4.5 Age of Respondents



Source: Fieldwork, 2011

4.2.5 Occupation of Respondents

The study sought to establish whether occupation of local residents within the study area played a role in Hydraform-ISSBs adoption and use. The Hydraform-ISSBs output process required resource availability, more so in form of raw materials, labour and machine maintenance. The result demonstrated that respondents with formal employment had the highest adoption rate represented by

74.3 per cent compared to those with informal employment whose adoption rate was 25.7 per cent as indicated in table 4.5

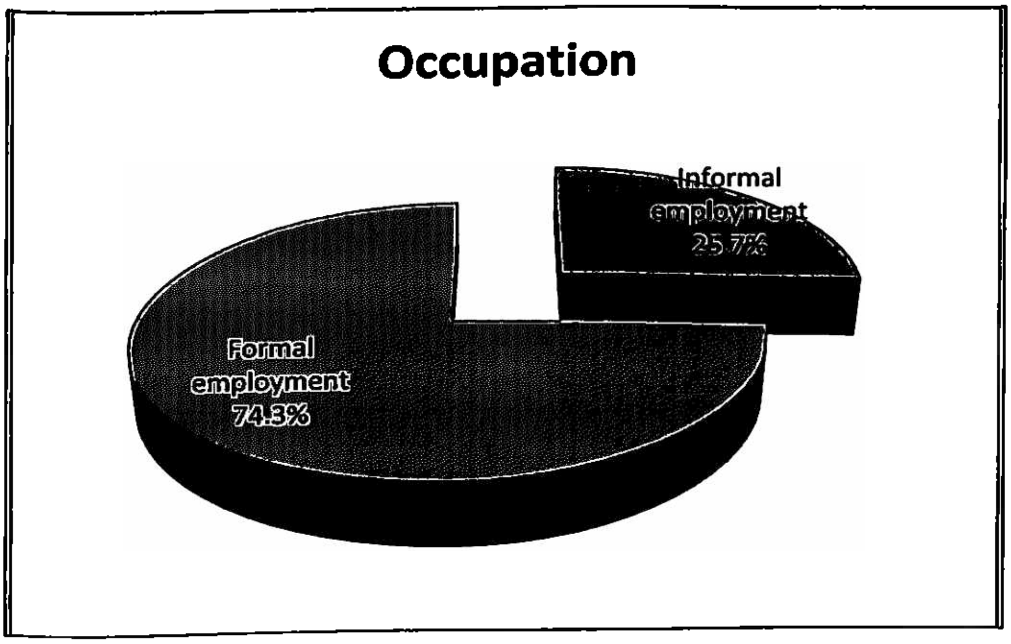
Table 4.5 Occupation of Respondents

Occupation	Frequency	Percent
Informal employment	9	25.7
Formal employment	26	74.3
Total	35	100.0

Source: Fieldwork, 2011

The extent of technology use among various actors in terms of occupations they have in the society showed great disparity as further depicted in graph 4.6

Graph 4.6 Respondents Occupations



Source: Fieldwork, 2011

4.2.6 Period of Residence

The researcher sought to establish the period respondents had dwelt in the area. This was to help know which group between indigenous and migrants were more passionate on use of Hydraform-ISSBs in their home ownership efforts. From the respondent data analysis, the residents who had stayed in the area within the first ten years formed 62.9 per cent of the technology users, with those between 20-30 years of residence comprising 28.6 per cent, and finally, area residence of 10-20 years formed 8.6 per cent of the users. There was thus a clear demonstration that the Hydraform-ISSBs technology found wider use among the newly settled residents at 62.9 per cent compared to other group of settlers. The findings were as outlined in table 4.6

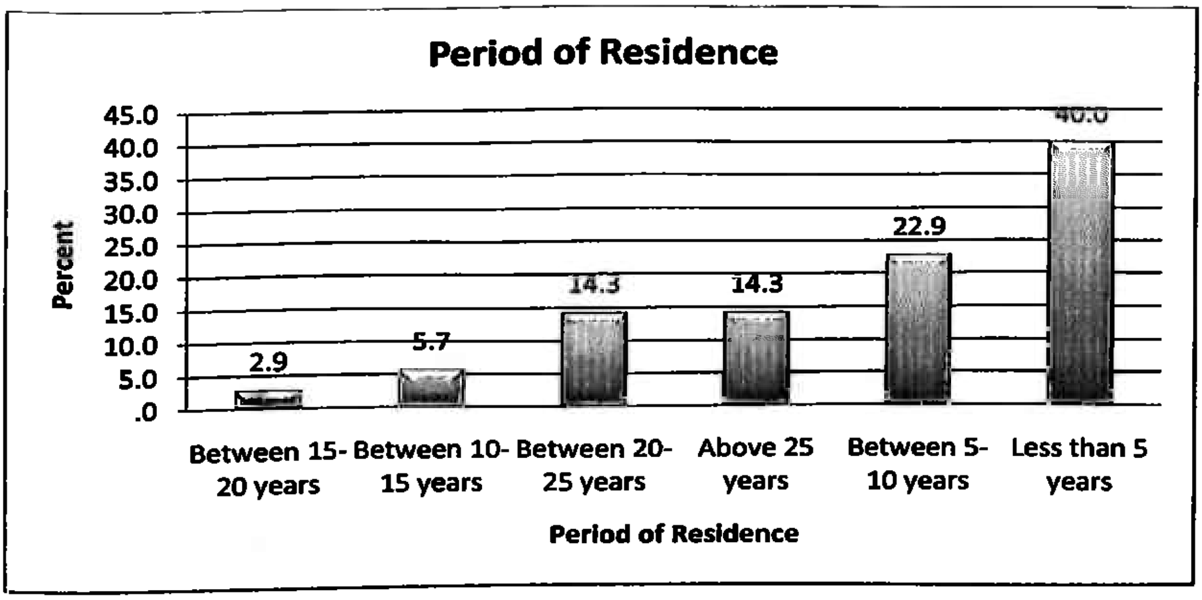
Table 4.6 Period of Residence

Period of Residence	Frequency	Percent
Between 15-20 years	1	2.9
Between 10-15 years	2	5.7
Between 20-25 years	5	14.3
Above 25 years	5	14.3
Between 5-10 years	8	22.9
Less than 5 years	14	40.0
Total	35	100.0

Source: Fieldwork, 2011

The technology use among respondents in terms of the duration they have settled within the study area was well demonstrated in graph 4.7

Graph 4.7 Period of Residence



Source: Fieldwork, 2011

4.2.7 Wall Construction Materials used in the study Area

The research study revealed existence of a number of wall construction materials as used by locals in their shelter provision needs. However, from the respondent data analysis, there were multiple respondents on variuos building materials with Hydraform-ISSBs and Quarry Stone being the dominant materials in the knowledge of the respondents each having a proportion of 21.9 per cent. The multiple frequencies of respondents based on the sample size credits Quarry stone as the most commonly used material in wall construction as indicated in table 4.7

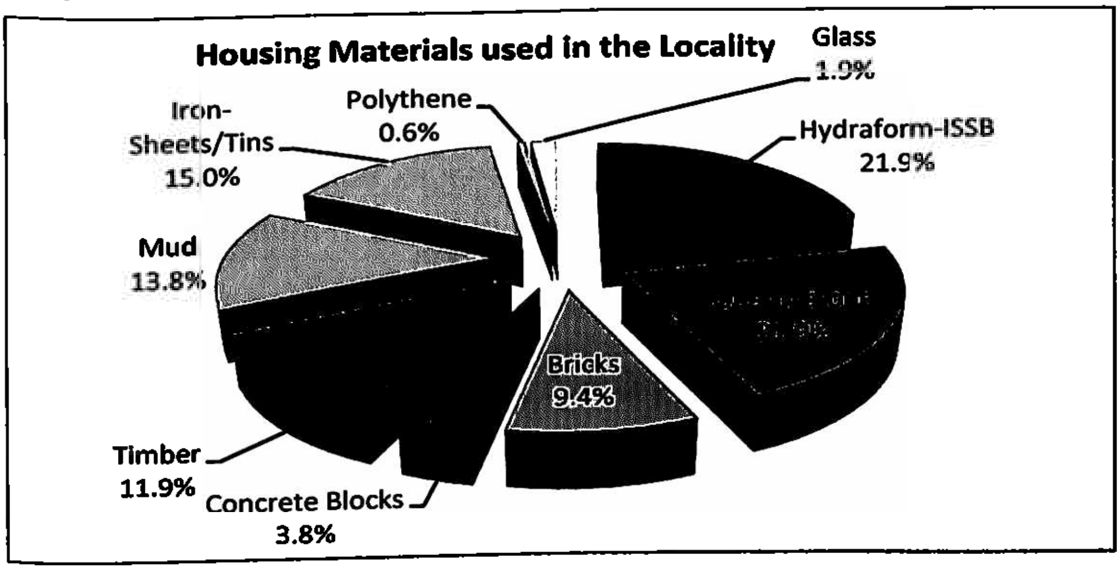
Table 4.7 Building Materials

Housing material	N	Percent
Hydraform-ISSB	35	21.9
Quarry stone	35	21.9
Bricks	15	9.4
Concrete Blocks	6	3.8
Timber	19	11.9
Mud	22	13.8
Iron-Sheets/Tins	24	15.0
Polythene	1	.6
Glass	3	1.9
Total	160	100.0

Source: Fieldwork, 2011

The distribution and frequency of wall construction materials utilization in the area was further depicted by graph 4.8

Graph 4.8 Housing Materials



Source: Fieldwork, 2011

4.2.7.1 Hydraform-ISSBs Production (Material Batching and Mixing) Process

The sieving process and assembling of all the materials required was followed by mixture preparation. The mixture ratio were gauged on standard measurement, especially on part number of Wheelbarrows or Buckets of soil against one part number of cement required to attain good mix and eventual resultant quality blocks. Material batching was succeeded by actual mixing done in two phases, that is, dry mixing and wet mixing. For Hydraform Machines that had no Mechanical Pan Mixer installation, manual labour intensive mixing was applied while Pan Mixers were used in the case of Machines that were fitted with such devices. A point to note was that ready/well prepared mix was recommended for use within one hour of preparation. A recent training conducted by the Government of Kenya in Conjunction with Hydraform-South Africa at the Eldoret South Constituency Appropriate Building Technology (ABT) Centre meant to equip Hydraform-ISSBs technology trainers in the Country with requisite skills deed establish ratios for use in different areas/needs as follows;

Walling	:	1 : 17
Foundation	:	1 : 12
Coping	:	1 : 12 or 1 : 10
Perimeter Fence	:	1 : 17
Topping Perimeter Walling	:	1 : 12 of ISSBs or Coping (1 : 12)
Double Storey	:	Foundation 1 : 12
		First Floor 1 : 12 or Second Floor 1 : 17

The standard Bucket used in this case implied 10 Liter Bucket as a unit of measurement. This therefore resulted to 5 % cement use in the case of ratio of 1 : 12 and 8 % cement use in the ratio of 1 : 17 which would yield block strength of 4Mpa and 7Mpa respectively. The mixture ratios provided above would however, vary from one soil type to the other depending on the Clay : Sand content of such soils as guided by the soil suitability test results that preceeds such exercise. Some Hydraform-ISSBs applicants indicated that they commenced construction with blocks upon attaining compressive strength in the range of 2.5Mpa. In the event that such situations of using block products with compressive strength below 4Mpa arouse, then it would be recommended that completed buildings and other related structures be uniformly finished by plastering both the interior and exterior wall surfaces.

4.2.7.2 Significance of Hydraform-ISSBs Adoption

The introduction and adoption of Interlocking Stabilised Soil Blocks in Nakuru County was significant in several ways. Most importantly, the technology could be viewed as a solution to three pivotal factors that ensure a truly successful housing project namely cost efficiency, community upliftment and environmental sustainability. First and foremost, the significance of local manufacture had far more than simply environmental value, and this was owing to the portable nature of the Hydraform Machine, that meant the blocks could be produced in any desired locality. For this, training could effectively take place on the job hence making rural development easier due to ease with which the machine could be transported to remote areas through hooking and towing by any available appropriate motorised mode. While most housing systems required influx of skilled workers, Hydraform housing required a small team of trained operators commissioned to involve the local communities' semi-skilled and unskilled people. This created additional skills and earning potential to the locals beyond the existing values of building their own houses, thus the employment opportunities were of considerable magnitude.

Further, the environmental appropriateness observed were in terms of cost-effective, labour-intensive, easy and fast to use, reduced wastage and equally ideal for both remote rural areas and high-density urban areas. The use of natural, locally-available materials could make adequate and affordable housing available to more people, and probably economically empower the local populace by retaining money to serve the local economy rather than it being spent to import materials, fuel and replacement parts. Fundamentally, the earth used in most instances was subsoil, hence leaving topsoil for agriculture. It was equally observed that, building with local materials could employ local people, and become more sustainable in unstable environments as well as economic difficulties.

It was significant to note that Hydraform-ISSBs required no firing/burning, thereby minimizing demand for firewood. This could significantly lead to reduced carbon dioxide emission into the atmosphere, thus leading to hypothetical projection of reduction in global warming and eventual mitigation of climate change effects. In the surveyed projects, there was little or no mortar needed in the block joints due to interlocking system, hence mortar was only applied in some specific areas such as the laying of the first block course above the slab and embedment between block courses above the lintel and on the gable sides of the structures under construction.

Some of the houses built with Hydraform-ISSBs in the study area were quite magnificient.

These were given in plates 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11 and 4.12

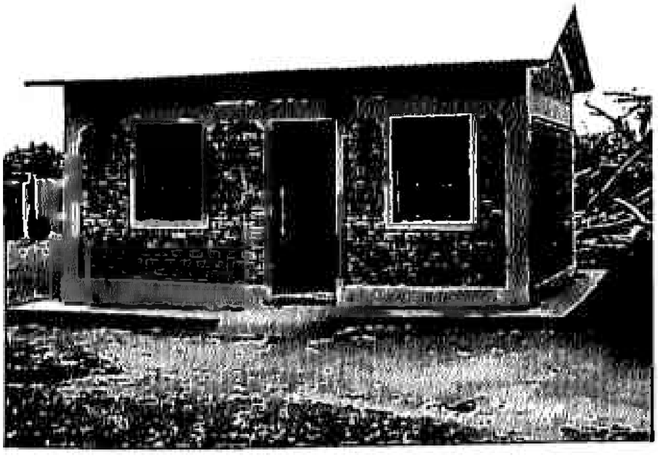


Plate4.1 Two-roomed house at Makutano, Rongai

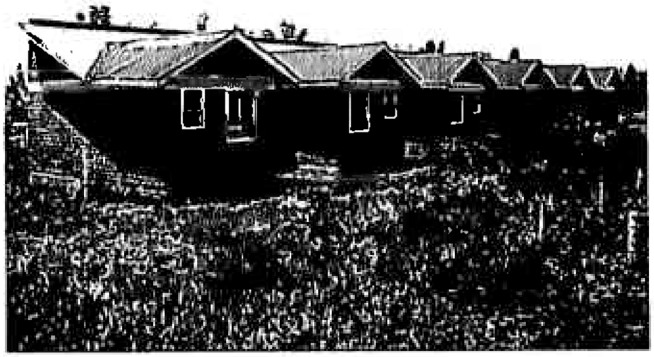


Plate4.2 One-bedroomed houses, Nakuru

Plate4.3 One-bedroomed houses, Nakuru

Plate4.4 Three-bedroomed house, Molo

Plate4.5 Four-bedroomed house, Rongai

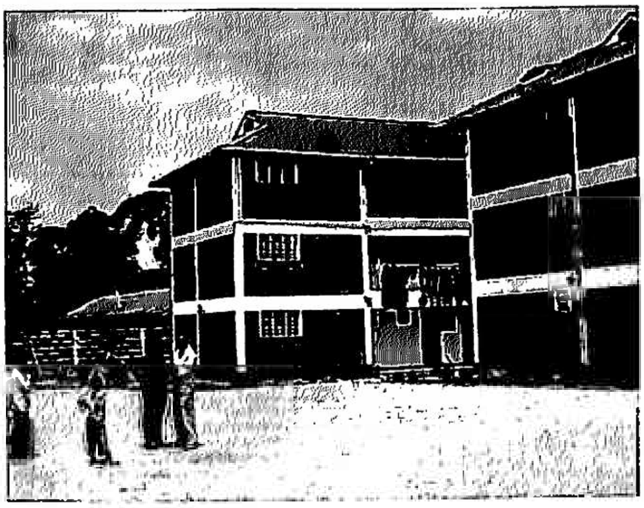


Plate4.6 Residential flats, Nakuru

Plate4.7 Five-bedroomed massionnette, Nakuru

Plate4.8 Four-bedroomed house, Nakuru

Plate4.9 Children's Orphanage, Rongai

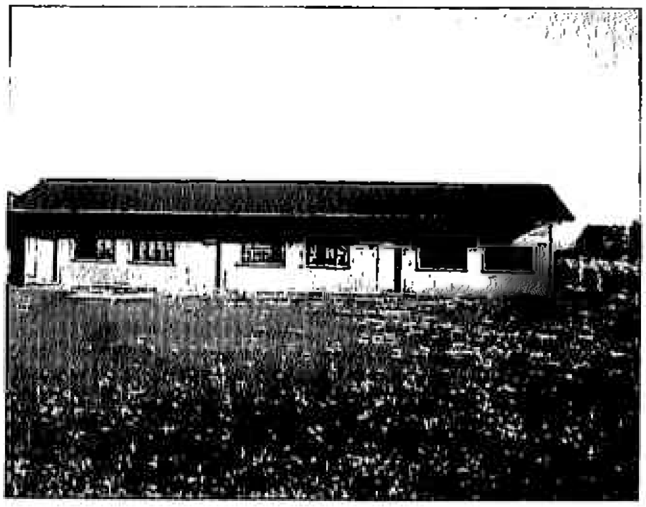


Plate4.10 Classrooms, Rongai

Plate4.11 Teachers College, Molo

Plate4.12 Mission School, Subukia

4.2.8 Factors Influencing Hydraform-ISSBs Adoption

The study revealed that the success of Hydraform-ISSBs technology adoption and use in Nakuru County depended on a number of factors whose level of importance as provided by the respondents were indicated in Table 4.8

Table 4.8 Hydraform-ISSBs Adoption Factors

Factors that Influence Adoption of Hydraform-ISSBs Technology within Nakuru County	Level of Importance by Percentage (%)					
	Not Important	Less Important	Moderately Important	Very Important	Extremely Important	Total (%)
1. Information Dissemination	5.7	-	17.1	22.9	54.3	100
2. Availability of land	2.9	2.9	25.7	37.1	31.4	100
3. Availability of Building materials	2.9	5.7	25.7	25.7	40.0	100
4. Availability of Construction technologies	2.9	8.6	14.3	37.1	37.1	100
5. Labour force availability	2.9	2.9	2.9	25.7	65.7	100
6. Environment influence in Technology adoption	5.7	2.9	22.9	34.3	34.3	100
7. Water availability	2.9	-	11.4	34.3	51.4	100
8. Government policies	2.9	5.7	14.3	28.6	48.6	100
9. Income level	-	2.9	11.4	31.4	54.3	100
10. Role played by financial agencies	2.9	5.7	22.9	31.4	37.1	100
11. Saving in Energy	2.9	2.9	14.3	42.9	37.1	100
12. Security of the building	-	-	14.3	42.9	42.9	100
13. Weather conditions	-	-	17.1	45.7	37.1	100
14. Cultural perceptions of the Technology	17.1	37.1	20.0	20.0	5.7	100
15. Professional services by players in the construction industry	-	2.9	5.7	22.9	68.6	100
16. Availability of other Appropriate Technologies	8.6	8.6	37.1	20.0	25.7	100
17. Affordability of the Technology	-	-	5.7	20.0	74.3	100
18. Environmental considerations.	2.9	17.1	11.4	48.6	20.0	100
19. Ease of construction with the Technology.	-	-	-	22.9	77.1	100
20. Employment opportunities	-	2.9	5.7	48.6	42.9	100
21. Savings in transport cost.	-	-	2.9	14.3	82.9	100
22. Quality of the material.	-	-	8.6	28.6	62.9	100
23. Quality of Workmanship	-	2.9	-	34.3	62.9	100
24. Material re-use	-	-	11.4	48.6	40.0	100

Source: Fieldwork, 2011

The respondent data analysis showed high percentages of respondents who were in support that important factors existed that influence decisions on Hydraform-ISSBs adoption and use as showed in

Table 4.9. The level of importance accorded to adoption factors by respondents were as follows; information dissemination (77.2 per cent), availability of land (68.5 per cent), availability of other construction technologies (74.2 per cent), labour force availability (90.4 per cent), role played by the surrounding environment (91.5 per cent), availability of water (85.7 per cent), Government Policy (76.2 per cent), income level (85.7 per cent), role played by financial agencies (68.5 per cent), energy saving (80 per cent), security of buildings (85.8 per cent), Weather Conditions (82.8 per cent), cultural perception (54.2 per cent), role played by professionals in the housing sector (91.5 per cent), availability of other appropriate technologies (45.7 per cent), affordability of the technology (94.3 per cent), environmental consideration (68.6 per cent), ease of construction with Hydraform-ISSBs (100 per cent),

Table 4.9: Summary on Factors for Technology Adoption

S/No	Adoption Factor	Percentage (%) of Respondents on its Importance Level
1.	Ease of Construction with the Technology	100.0
2.	Savings in Transport Cost	97.2
3.	Quality of Workmanship	97.2
4.	Affordability of the Technology	94.3
5.	Professional Services by Players in the Industry	91.5
6.	Quality of the Material	91.5
7.	Employment Opportunities	91.5
8.	Labour Force Availability	91.4
9.	Material Re-Use	88.6
10.	Security of the Building	85.8
11.	Income Levels	85.7
12.	Water Availability	85.7
13.	Weather Conditions	82.8
14.	Saving in Energy	80.0
15.	Government Policies	77.2
16.	Information Dessimination	77.2
17.	Availability of other Construction Technologies	74.2
18.	Environment Influence in Technology Adoption	68.6
19.	Environmental Considerations	68.6
20.	Availability of Land	68.5
21.	Role Played by Financial Agencies	68.5
22.	Availability of Other Building Materials	65.7
23.	Availability of other Appropriate Technologies	45.7
24.	Cultural Perception of the Technology	25.7

Source: Fieldwork, 2011

The study further provided that other factors considered to influence decision on adoption of Hydraform-ISSBs technology by respondents were; employment opportunities (91.5 per cent), saving on transport cost (97.2 per cent), quality materials (91.5 per cent), quality of workmanship (97.2 per cent), material re-use (88.6 per cent). Regarding soil suitability, the field survey tool did not originally capture the factor. From the respondent data analysis however, it was found to have been provided as an additional factor by about 9 respondents comprising of about 25 per cent of the total respondents, all of whom (100 per cent) considered it important and consequently influenced their decision to adopt ISSBs technology.

According to Browne (2009), soil used in block making normally varies considerably in different locations depending upon the geology and soil formation processes, more so, in tropical areas, the soil type is mainly laterite soil with similar properties to fine grained sedimentary clays produced from primary chemical weathering of rocks often containing quartz. Further, the minerals of kaolinite, goethite, hematite and gibbsite formed contain aluminium, and iron oxides causing the red-brown colour of laterites. It was further observed that, sandy-loam soil was ideal for production of quality Hydraform-ISSBs. Other soil-types could, also be used, upon blending with river sand using a pre-determined ratio established during the soil suitability test with the exception of black cotton soil, which was noted; to be unsuitable for use since such soil possesses higher clay percentage above the recommended range of between 10-35 per cent. In the overall, majority of technology users preferred Red Volcanic Soil in block production as the resultant blocks colour was more appealing. This soil type also yielded heavy blocks that gained high strength within a shorter period.

For in-depth analysis of adoption factors, average tendencies of the factors were given by computation of the factor mean. From the analysis, the combined average mean for adoption factors was 4.17 which was higher than the moderate impact level of factor 3. This strongly demonstrated that the factors were highly regarded by the respondents to be important in influencing their decisions to adopt and use the technology. The result of this analysis was provided in table 4.10

The Null Hypothesis for the study which stated "there were specific factors affecting use of Hydraform-ISSBs technology in Nakuru County" was accepted after being validated by the students (t) statistics tests results which demonstrated that there was insignificant difference in the means of the factors considered for adoption of Hydraform-ISSBs technology in Nakuru County. All the factors had their t-calculated value greater than the t critical value (at α 0.05) with degree of freedom (df) 33. The inferential analysis as provided by Levene's Test for Equality of Variances further revealed the views held by various projects categories by ownership (Individual Versus Community).

For interpretation of the t-statistics results, when F is significant (big), that is, when Levene's test shows a significant level which is ≤ 0.05, then the lower reading of the t-values are taken and vice versa. The adoption factors such as; information dissemination, availability of land, availability of other construction technologies, labour force availability, role played by the surrounding environment, Government Policy, income level, energy saving, security of buildings, Weather Conditions, perception according to status of various groups in the society, role played by professionals in the housing sector, availability of other appropriate technologies, environmental consideration, ease of construction with Hydraform-ISSBs, employment opportunities, saving on transport cost, quality of the materials, quality of workmanship, and material re-use, were all found to exhibit insignificant mean difference. This implied existence of no difference in the views held by the respondents in terms of project categories by ownership, hence, it could be deduced that the given adoption factors equally contributed in influencing the decisions of the respondents in Hydraform-ISSBs technology use in Nakuru County and any difference could be due to natural variability.

Further to this, adoption factors such as availability of water, role played by financial agencies, and affordability of the technology possessed significant mean difference thereby implying that different views were held by project categories by ownership and were more important to individuals than to community projects' owners. This analysis was provided by the independent samples test in table 4.11

Table 4.10 Mean Factors Influencing Decision on Hydraform-ISSBs Use

Adoption Factors	N	Mean	Std. Deviation
Savings in transport cost.	35	4.80	.473
Ease of construction with the Technology.	35	4.77	.426
Affordability of the Technology	35	4.69	.583
Quality of Workmanship	35	4.57	.655
Professional services by players in the construction industry	35	4.57	.739
Quality of the material.	35	4.54	.657
Labour force availability	35	4.49	.919
Income level	35	4.37	.808
Employment opportunities	35	4.31	.718
Water availability	35	4.31	.900
Material re-use	35	4.29	.667
Security of the building	35	4.29	.710
Weather conditions	35	4.20	.719
Information Dissemination	35	4.20	1.106
Government policies	35	4.14	1.061
Saving in Energy	35	4.09	.951
Availability of Construction technologies	35	3.97	1.071
Availability of Building materials	35	3.94	1.083
Role played by financial agencies	35	3.94	1.056
Availability of land	35	3.91	.981
Environment influence in Technology adoption	35	3.89	1.105
Environmental considerations.	35	3.66	1.083
Availability of other technologies	35	3.46	1.221
Cultural perceptions of the Technology	35	2.60	1.168
Combined Average Mean	35	4.17	

Source: Fieldwork, 2011

The considerations accorded to the above factors clearly corroborated some findings by earlier researchers. For instance, UN-Habitat (2009) and Montgomery (1998) demonstrated that quality of blocks and structural works were achievable through additional supplements during soil stabilization and interlocks respectively. The factor on land and soil suitability further supported information provided by Hydraform Building System (2009) on mix proportions and plasticity index for quality block production. Section of the factors above also confirms assertions by Kintingu (2009) that adoption of appropriate, easy, fast and cost-effective mortarless ways in wall construction was able to save upto 50% in both wall construction's cost and cement consumption, hence leading to 40% reduction in carbon emissions.

Table 4.11 Sample analysis of t-test on Hydraform-ISSBs technology adoption factors

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Information Dissemination	Equal variances assumed	1.026	.319	.423	33	.675	.160	.379	-.610	.931
	Equal variances not assumed			.428	29.361	.672	.160	.374	-.605	.925
Availability of land	Equal variances assumed	1.764	.193	.873	33	.389	.291	.333	-.387	.968
	Equal variances not assumed			.865	28.477	.395	.291	.336	-.398	.979
Availability of Building materials	Equal variances assumed	.957	.335	.944	33	.352	.346	.367	-.400	1.093
	Equal variances not assumed			.938	30.695	.355	.346	.369	-.407	1.100
Availability of Construction technologies	Equal variances assumed	5.377	.027	.790	33	.435	.288	.364	-.453	1.028
	Equal variances not assumed			.778	25.062	.444	.288	.370	-.474	1.049
Labour force availability	Equal variances assumed	.136	.714	.826	33	.415	.258	.312	-.377	.894
	Equal variances not assumed			.829	32.849	.413	.258	.311	-.375	.892
Environment influence in Technology adoption	Equal variances assumed	4.523	.041	1.581	33	.123	.578	.366	-.166	1.323
	Equal variances not assumed			1.559	25.718	.131	.578	.371	-.185	1.342
Water availability	Equal variances assumed	.016	.900	2.107	33	.043	.611	.290	.021	1.201
	Equal variances not assumed			2.085	28.439	.046	.611	.293	.011	1.211

The factors regarding quality of workmanship, professional services offered by technical personnel, quality of materials and Government policies supported the findings attributed to Gooding (1995) that Stabilised Soil Block technology was supported by quality control measure (KS02-1070) approved in the year 1992. They also affirmed concerns by Kimani and Musungu (2010) that the building code (1967) being a replica of British Building Regulations of 1948, was material based with several outdated and inappropriate provisions, hence susceptible to multiple interpretations, thereby creating anxiety among new technologies and materials users. In relation to policy and standard measures applicable in Kenya, the factor confirms the findings by UN-Habitat (2006) that financial institutions normally adhere to standards and building codes in ways that limits access to affordability schemes for the working poor. The factors on affordability of the technology and labour force availability were critical as they supported assertions by both Agevi (1999) and Terry (1986) whose findings were that walling constituents comprised about 60%, and that building materials and labour cost accounts for 82% respectively.

4.2.9 Environmental Impacts of Hydraform-ISSBs Technology

The study results demonstrated that adoption and use of Hydraform-ISSBs technology had both negative and positive impacts to the surrounding environment with varying levels of impact and value of technology use respectively.

4.2.9.1Negative Environmental Impacts of Hydraform-ISSBs Technology Use

The study findings revealed respondents perception pertaining to negative impacts associated with adoption and use of Hydraform-ISSBs within the study area, as provided in table 4.12. The negative impacts to the environment mainly related to health hazards and natural resources depletion. These were elaborated in the discussion below.

4.2.9.1.1 Hydraform-ISSBs Technology Use Health Hazards

The technology application involved use of soil as a raw material in the block production process. The soil excavation at times results into burrows whose impacts may include; holding stagnant water, accidents, loss of life, loss of biodiversity, change of drainage pattern, loss of agricultural land. The stagnant water may create conditions favourable to breeding of disease causing vectors such as Mosquito which may cause Malaria to the inhabitants of the area. The other phases of the technology use like material preparation, production and curing stages may be associated with negative impacts such as; inhalation of dust, dusty environment affecting flora in the vicinity, noise pollution, air pollution and use of diesel fuel. In situations where these negative impacts may be high, then they may lead to impoverishment of the technology users and make the technology to be unsustainable.

4.2.9.1.2 Hydraform-ISSBs Technology Use and Natural Resources Depletion

Hydraform-ISSBs production and curing processes involved use of water in the preparation of various mix proportions and at block curing stage. The production process also required a fairly large surface for block laying. The two activities could lead to dwindling water resources as well as agricultural land for the area residents. In addition, activities could also compete with other land uses and natural resource base, a situation that at times may create conflict in times of scarcity, more so with shared natural resources.

Table 4.12 Negative Environmental Impacts of Hydraform-ISSBs Use

Negative Environmental Impacts of Hydraform-ISSBs Technology	Level of Impact by Percentage (%)					Total Percentage
	No Impact	Small Impact	Moderate impact	High Impact	Very High Impact	
1. Stagnant Water	17.1	31.4	20.0	22.9	8.6	100
2. Accidents	28.6	37.1	14.3	14.3	5.7	100
3. Loss of Life	57.1	22.9	11.4	8.6	-	100
4. Loss of Biodiversity	34.3	37.1	22.9	2.9	2.9	100
5. Change of Drainage	68.6	11.4	8.6	8.6	2.9	100
6. Loss of Agricultural Land	34.3	25.7	31.4	5.7	2.9	100
7. Inhalation of Dust	5.7	40.0	37.1	5.7	11.4	100
8. Dusty Environment	48.6	31.4	14.3	2.9	2.9	100
9. Noise Pollution	25.7	45.7	22.9	2.9	2.9	100
10. Air Pollution	42.9	40.0	17.7	-	-	100
11. Diesel Fuel Use	62.9	22.9	11.4	-	-	97.1
12. Depleting Water resources	51.4	28.6	14.3	5.7	-	100

Source: Fieldwork, 2011

During the study, the dimensions (Length, width and Depth) and location positioning of various burrows for Hydraform-ISSBs projects visited were also taken in order to estimate the volume of soil excavated for each project and assess environmental threats posed by existing burrows. The result of the burrow dimensions computation was provided in table 4.13.

Table 4.13 Computation of Burrow Dimensions

Measurement	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation
LENGTH	35	48.00	3.00	51.00	373.95	10.6843	9.79002
WIDTH	35	14.00	2.00	16.00	213.85	6.1100	4.16692
DEPTH	35	11.5	1.0	12.5	89.4	2.554	2.0053
VOLUME	35	1268.75	11.25	1280.00	7833.20	223.8058	331.93307

Source: Field data, 2011

In addition, the burrow dimensions were taken as depicted in plates; 4.13, 4.14, 4.15, 4.16, 4.17 and 4.18 respectively.

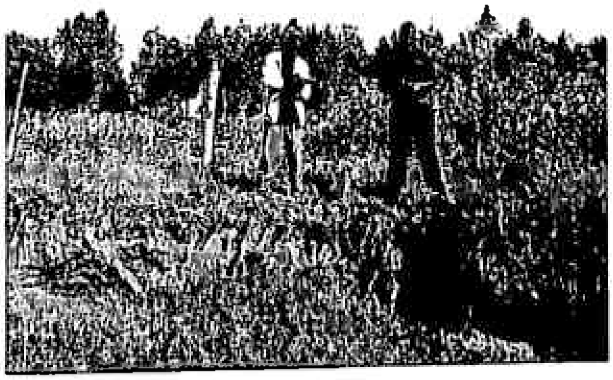


Plate4.13 burrow site at St. Mark's TTC, Molo

Plate4.14 Burrow site at Mbatia's site, Molo

Plate4.15 Burrow site at Cherono's site, Rongai

Plate4.16 Burrow site at Amoche's site, Rongai

Plate4.17 Burrow site at Orphanage, Rongai

Plate4.18 Burrow site at CTS School, Rongai

The technology implementation stages that could pose negative impacts to the surrounding environment were noted to be; raw materials sourcing, mix preparation, machine operation and construction stages. The study results showed that the technology-environment interaction had little impacts to the surrounding environment as depicted in table 4.12. This was further supported by combined average mean impact, which was found to be 2.02. This combined average mean fell below the moderate impact level hence depicting low overall impacts of the technology to the surrounding environment as provided in the table 4.14

Table 4.14 Mean Negative Impacts of Hydraform-ISSBs Use

Environmental Impacts	N	Mean	Std. Deviation
Inhalation of dust during sieving and mixing in a windy environment	35	2.77	1.060
Stagnant water can be a Mosquito breeding grounds	35	2.74	1.245
Accidents	35	2.31	1.207
Loss of agricultural land	35	2.17	1.071
Noise pollution by the production machines	35	2.11	.932
Loss of biodiversity	35	2.03	.985
Dusty environment leading to deteriorating health condition of the inhabitants	35	1.80	.994
Air pollution from the exhaust fumes	35	1.74	.741
Depleting water resources	35	1.74	.919
Loss of life	35	1.71	.987
Change of drainage patterns	35	1.66	1.136
Machine operated on diesel fuel	34	1.47	.706
Mean Average	34	2.02	

Source: Fieldwork, 2011

The Null Hypothesis for the study stated "Hyraform-ISSBs technology has no adverse impacts on the environment of Nakuru County", was accepted after being validated by the t-statistic result at α 0.05 and 33 df. According to Levene's Test for Equality of Variances, the impacts of the technology use to the environment especially; burrows holding stagnant water that result in Mosquito breeding grounds, abandoned burrows leading to accidents, burrows resulting in loss of life, emerging burrows leading to loss of biodiversity, burrows resulting in change of drainage pattern, burrows leading to loss of agricultural land, inhalation of dust during sieving and mixing of raw materials, noise pollution by the production machine, and depleting water resources were all insignificant between the project category by ownership. On the other hand, dusty environment leading to deteriorating health condition of inhabitants had significant result with individual project owners demonstrating that they had less consideration for its impact within the study area. From the findings, the researcher deduced that there were no associations on the views held by individuals and community project owners on majority of the impacts that could be associated with Hydraform-ISSBs use in the study area. The t- tests results were provided in sample table 4.15.

Table 4.15 Sample analysis of t-test on Hydraform-ISSBs technology Negative Environmental Factors

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Differen-ce	Std. Error Difference	Lower	Upper
Stagnant water can be a Mosquito breeding grounds	Equal variances assumed	2.469	.126	-1.485	33	.147	-.614	.414	-1.456	.227
	Equal variances not assumed			-1.494	32.309	.145	-.614	.411	-1.452	.223
Accidents	Equal variances assumed	.224	.639	-.181	33	.857	-.075	.414	-.918	.767
	Equal variances not assumed			-.182	32.612	.856	-.075	.412	-.914	.764
Loss of life	Equal variances assumed	.219	.643	-.978	33	.335	-.327	.334	-1.007	.353
	Equal variances not assumed			-.974	31.835	.337	-.327	.335	-1.010	.357
Loss of biodiversity	Equal variances assumed	.030	.864	-1.215	33	.233	-.402	.331	-1.075	.271
	Equal variances not assumed			-1.211	32.077	.235	-.402	.332	-1.078	.274

Source: Fieldwork, 2011

The question to the respondents on their perception to whether Hydraform-ISSBs was a Green Building Technology provided a "YES" response thus recording 100 per cent approval of their views. This was however, not enough to conclude that the technology was a green building technology, but together with the low negative impacts and high benefit use values; there could be an indication for consideration of Hydraform-ISSBs as an environmentally appropriate technology.

4.2.9.2 Benefits/Values of Hydraform-ISSBs Technology Use

The study revealed high values for the benefits that accrued from adoption and use of Hydraform-ISSBs technology as depicted in table 4.16. The technology use benefits included; burrow use benefits, environmental friendliness, and economic benefits.

4.2.9.2.1 Hydraform-ISSBs Technology Burrow Use Benefits

The technology application involved use of soil as a raw material whose extraction resulted in the emergence of burrows. These burrows could be presumed to possess harmful effects to the surrounding environment. This study however, revealed that burrows could be modified and applied for various economic uses. These included use in the construction and development of structural/building foundations, septic tanks, ablution blocks, organic manure pits, water pans/storage facilities, fish ponds, burial sites, swimming pools, crop gardens. and waste dumpsites.

4.2.9.2 .2 Hydraform-ISSBs Technology Environmental Friendliness

The study revealed that Hydrafrom-ISSBs use was quite friendly to the environment due to; use of non-pollutant curing means (cured by water), reduced transport hazards, and earthquake resistance. For non-pollutant curing, it was observed that water is used for curing of the blocks rather than the traditional way of using woodfuel to fire the bricks, thereby enhancing healthy growth of forests. Further, the production process is conducted on-site of the construction area thereby eliminating the cumbersome process of transporting building materials to construction sites, a situation that could lead to reduced vehicular emissions and associated global warming whose effects may be devastating to the environment. In most instances, the trucks used to transport building materials are old and un-roadworthy, thus emissions curbs from this process could be important in mitigating against climate change and its effects to the environment.

4.2.9.2.3 Hydraform-ISSBs Technology Economic Benefits

The technology use was advantageous in that it was accompanied by; reduced material wastage, conservative mortar use and employment opportunities. The savings realized by the adopters has the potential of being ploughed back to support other segments of their economic needs including healthcare provision, education, food supplements and facilitation to access other social amenities. In addition, adoption of the technology could play a significant role in providing means of livelihood earnings to the residents as it entirely involved labour intensive. It could thus be noted that a single-chamber Hydraform-Machine with daily (8 hrs) block production capacity of 1500 blocks require a labour force of between 8-10 labourers while a double-chamber machine with a capacity of 3000 blocks working the same hours required a labour force of between 16-20 labourers. The labour force management in the use of the technology takes cognizance of social inclusion as both men and women, have equal chance of using the technology due to its simplicity.

Table 4.16 Value of Hydraform-ISSBs Use Benefits

Benefits Derived from Hydraform-ISSBs Technology Use	Value of Benefit by Percentage (%)					Total Percentage
	No Value	Small Value	Moderate Value	High Value	Very High Value	
1. Construction Foundation	11.4	8.6	14.3	25.7	40.0	100
2. Septic Tank	-	2.9	14.3	20.0	62.9	100
3. Ablution Block	2.9	5.7	8.6	22.9	60.0	100
4. Organic Manure Site	-	2.9	14.3	20.0	62.9	100
5. Water Storage	-	2.9	2.9	31.4	62.9	100
6. Fish pond	-	-	2.9	37.1	60.0	100
7. Non-Pollutant Curing	-	-	-	14.3	82.9	97.2
8. Reduced Transport Hazards	-	-	-	22.9	74.3	97.2
9. Reduced Material Wastage	-	-	2.9	40.0	51.4	94.3
10. Conservative Mortar Use	-	-	-	17.1	80.0	97.1
11. Earthquake Resistance	2.9	-	14.5	40.0	31.4	88.6

Source: Fieldwork, 2011

A summary of descriptive data showed the support for high value of benefits related to technology use as outlined in table 4.17.

Table 4.17 Summary of Value of Hydraform-ISSBs Use Benefits

S/No	Technology Benefits	Percentage (%) of Respondents on Value of the Benefit.
1.	Cured by non-pollutant means	97.2
2.	Reduced transport related hazards	97.2
3.	Conservative mortar usage	97.1
4.	Can be turned into fish ponds	97.1
5.	Used for water storage/water pans	94.3
6.	Reduced material wastage	91.4
7.	Burrows used for construction of septic tanks	82.9
8.	Used for preparing organic (compost) manure	82.9
9.	Used for construction of ablution blocks	82.9
10.	Earthquake resistance technology	71.4
11.	Used as construction foundation	65.7

Source: Fieldwork, 2011

The average mean computed indicated high values attached to the resulting activities generated from various technology implementation stages by the respondents. The combined average mean of technology benefit values was given at 4.47 which was remarkably above the moderate value for benefits, thereby depicting high affirmation for the benefits derived from Technology use. This was summarized in the table 4.18

Table 4.18 Mean Values of Hydraform-ISSBs Use Benefits

Values for Hydraform-ISSBs Use Benefits	N	Mean	Std. Deviation
Cured by non-pollutant means	34	4.85	.359
Conservative mortar usage	34	4.82	.387
Reduced Transport related hazards	34	4.76	.431
Can be turned into fish ponds	35	4.57	.558
Used for water storage/water pans	35	4.54	.701
Reduced material wastage	33	4.52	.566
Use for preparing organic (compost) manures	35	4.43	.850
Burrows used for construction of septic tanks	35	4.43	.850
Used for construction of ablution blocks	35	4.31	1.051
Earthquake resistance technology	32	4.16	.954
Used as a construction foundation	35	3.74	1.379
Combined Average Mean	32	4.47	

Source: Fieldwork, 2011

The results depicting the strength of support accorded to the alternative uses of the Hydraform-ISSBs related burrows was as provided in table 4.19.

Table 4.19 Hydraform-ISSBs Burrow Uses

Ways for burrow uses/management	Percent
Road construction	26.3%
Water storage/pan/dam/tank	18.4%
Construction of building foundation	15.8%
Re-filling	7.9%
Construction of ablution blocks/toilets	5.3%
Construction of fish pond	5.3%
Construction of septic tank	5.3%
Organic/compost manure site	5.3%
Burial/Grave sites	2.6%
Construction of swimming pool	2.6%
Crop/tree planting	2.6%
Waste dumpsites	2.6%
	100.0%

Source: Fieldwork, 2011

In practice, these applications were adopted across the projects stratifications in terms of location (Town/Rural) and ownership (Individual/Community) as demonstrated by the photography results in plates; 4.19, 4.20, 4.21 and 4.22

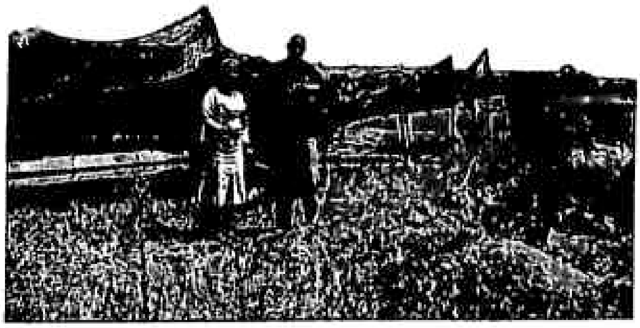


Plate4.19 Fish pond at PCEA, Nakuru west

Plate4.20 Banana Garden at Sitienei's home

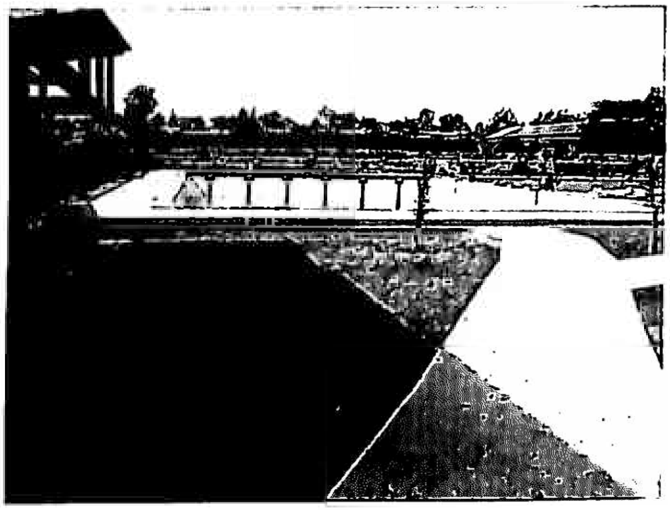


Plate4.21 Swimming pool at Mustard seed Sch.

Plate4.22 Water pan at Elma Barnett, Rongai

4.2.9.3 Crosstabulation of Variables

4.2.9.3.1 Use of building Materials by Age Cohorts

The study revealed that preference for building materials varies among different age groups. The result showed that adoption and use of Hydraform-ISSBs technology in the study area was much more prevalent among the Mid-Age groups ranging between 35-54 years representing about 74.3 per cent. These are youthful, active, and resource mobility population age cohorts who were associated with innovativeness and labour force supply. These attributes formed key ingredients for the promotion, adoption and application of Hydraform-ISSBs technology in any given environment. This was as outlined in table 4.20

Table 4.20 Building Materials use by Age Groups

Age (Years)	Freq and (%) Count	Hydraform-ISSBs	Quarry Stone	Bricks	Concrete Blocks	Timber	Mud	Iron-Sheets/Tins	Polythene	Glass	Total
25 – 34	Count	8	8	1	2	4	4	7	0	0	8
	% within $Materials	23%	23%	7%	33%	21%	18%	29%	0%	0%	
35 -44	Count	16	16	9	3	8	11	12	0	3	16
	% within $Materials	46%	46%	60%	50%	42%	50%	50%	0%	100%	
45 - 54	Count	10	10	5	1	6	7	5	0	0	10
	% within $Materials	29%	29%	33%	17%	32%	32%	21%	0%	0%	
55 and above	Count	1	1	0	0	1	0	0	1	0	1
	% within $Materials	3%	3%	0%	0%	5%	0%	0%	100%	0%	
Total	Count	35	35	15	6	19	22	24	1	3	35

Source: Fieldwork, 2011

4.2.9.3.2 Adoption of Hydraform-ISSBs Technology in Relation to Period of Residence

The study showed that preference for use of hydraform-ISSBs technology in construction projects within the study area was significant among new settlers in the area. The study results demonstrated th about 63% of the technology users had stayed in the area for less than 10 years as shown in table 4.21

Table 4.21 Adoption of Hydraform-ISSBs by Period of Residence

Period of Residence (Years)	Freq & (%) Count	Hydraform-ISSBs	Quarry Stone	Bricks	Concrete Blocks	Timber	Mud	Iron-Sheets/Tins	Polythene	Glass	Total
< 5	Count	14	14	4	4	5	9	8	0	1	14
	% within $Materials	40%	40%	27%	67%	26%	41%	33%	0%	33%	
5-10	Count	8	8	5	1	5	5	8	0	1	8
	% within $Materials	23%	23%	33%	17%	26%	23%	33%	0%	33%	
10-15	Count	2	2	2	0	2	2	1	0	0	2
	% within $Materials	6%	6%	13%	0%	11%	9%	4%	0%	0%	
15-20	Count	1	1	0	0	1	0	1	0	0	1
	% within $Materials	3%	3%	0%	0%	5%	0%	4%	0%	0%	
20-25	Count	5	5	0	0	2	3	3	0	1	5
	% within $Materials	14%	14%	0%	0%	11%	14%	13%	0%	33%	
25>	Count	5	5	4	1	4	3	3	1	0	5
	% within $Materials	14%	14%	27%	17%	21%	14%	13%	100%	0%	
Total	Count	35	35	15	6	19	22	24	1	3	35

Source: Fieldwork, 2011

4.2.9.3.3 Project Location Against Burrow Volumes

The results from various project burrow sites were reclassified by taking a range of 200 Cubic Metres, from where six (6) categories emerged. The results showed that projects burrows with a volume in the category of less or equal to 200m^3 were the majority representing about 74 per cent of the total projects. These were proportionately distributed within Town and Rural areas, represented by 71 per cent and 76 per cent respectively. The existence of this small margin in technology adoption between the Town versus Rural areas showed that respondents from these areas were ready to adopt and use the technology as depicted in table 4.22

Table 4.22 Burrow Volumes by Project Location

Volume Classified	Frequency and Percentage Count (%)	Project Area (Town or Rural)		Total
		Town	Rural	
Less or equal to 200	Count	10	16	26
	% within Project Area (Town or Rural)	71%	76%	74%
201-400	Count	1	2	3
	% within Project Area (Town or Rural)	7%	10%	9%
601-800	Count	2	0	2
	% within Project Area (Town or Rural)	14%	0%	6%
801-1000	Count	1	2	3
	% within Project Area (Town or Rural)	7%	10%	9%
1001 and above	Count	0	1	1
	% within Project Area (Town or Rural)	0%	5%	3%
Total	Count	14	21	35
	% within Project Area (Town or Rural)	100%	100%	100%

Source: Fieldwork, 2011

4.2.9.3.4 Project Category Against Burrow Volume

The crosstabulation results of these variables indicated that the individual projects category had the highest number of projects whose soil burrow volumes were in the volume under classification 'less or equal to 200'. Some of the projects in the community category however demonstrated use of higher soil amounts as supported by prevalence of large burrow volume numbers amongst them. This was given in table 4.23

Table 4.23 Burrow Volumes by Project Category

		Project Category		Total
Volume Classified	Frequency and Percentage Count (%)	Individual	Community	
Less or equal to 200	Count	17	9	26
	% within Project Category	94%	53%	74%
201-400	Count	1	2	3
	% within Project Category	6%	12%	9%
601-800	Count	0	2	2
	% within Project Category	0%	12%	6%
801-1000	Count	0	3	3
	% within Project Category	0%	18%	9%
1001 and above	Count	0	1	1
	% within Project Category	0%	6%	3%
Total	Count	18	17	35
	% within Project Category	100%	100%	100%

Source: Fieldwork, 2011

4.3 Mitigation Strategies and Ways of Up-scaling Technology Adoption

4.3.1 Proposed mitigation measures for environmentally friendly adoption of the technology

According to the study findings, the observed adverse impacts posed to the surrounding environment emanating from adoption and use of hydraform-ISSBs technology could be effectively minimized and sustainable use of the technology realized. These could be done through implementation of the suggested measures namely:- promoting re-use through alternative economic uses of burrows; ensuring efficiency of the Machine (Noise silencers, improvised exhaust, soil crushers, possession of both rear and front wheels); enhanced public education and awareness creation; promoting use of protective gear/clothing during block production processes; adequate training of technical personnel; collaborating and networking with financial institutions and other government departments to promote the technology; sourcing of soil from designated environmentally friendly sites and non-agricultural potential land.

Table 4.24 Proposed Mitigation Measures

Mitigation	Frequency	Percent
Promoting re-use through alternative economic uses of burrow	14	17.5%
Ensuring efficiency of the Machine (Noise silencers, improvised exhaust, soil crushers, possession of both rear and front wheels)	12	15.0%
Enhanced public education and awareness creation	11	13.8%
Promoting use of protective devices during block production processes	11	13.8%
Adequate training of technical personnel	8	10.0%
Collaborating and networking with financial institutions and other government departments to promote the technology	6	7.5%
Sourcing of soil from designated environmentally friendly sites and non-agricultural potential land	5	6.3%
Exploring use of alternative blending materials instead of sand	2	2.5%
Fencing off excavation area to avoid accidents	2	2.5%
Filling up/reclamation of burrows after soil extraction	2	2.5%
Operating under block shade during bad weather	2	2.5%
Reducing burrow depths by excavating horizontally to realize spread effect/depth control	2	2.5%
Conducting impact study before commencement of projects	1	1.3%
Regular monitoring and evaluation exercise of projects	1	1.3%
Screeding/Skirting of surface block layers and corner joints to safeguard against water infiltration into buildings	1	1.3%
Total	80	100%

Source: Fieldwork, 2011

Other Mitigation strategies included; exploring use of alternative blending materials instead of sand; fencing off excavation area to avoid accidents; backfilling/rehabilitation of burrows after soil extraction; operating under block shade during bad weather; reducing burrow depths by excavating horizontally to realize spread effect/depth control; conducting impact study before commencement of projects; regular monitoring and evaluation exercise of projects; and screeding/skirting of first 2-3 surface block layers above the slab work and corner joints to safeguard against water infiltration into buildings. The frequencies and percentage of respondents supporting the suggested mitigations were provided in table 4.24.

4.3.2 Suggestions on Ways to Upscale Adoption of Hydraform-ISSBs Technology

From the study results, various suggestions were put forward by the respondents on the strategies that could be introduced to realize wider acceptance and increased adoption of Hydraform-ISSBs technology in a sustainable way within the study area. These suggestions included but not limited to:- enhanced public awareness campaigns and mass education; training and skills development to technical personnel, curriculum development in tertiary/technical institutions; facilitating low-income technology users (both individuals and self help groups) to access subsidized loans/revolving fund kitty.

Table 4.25 Up-scaling Hydraform-ISSBs Technology Use

Suggestions on up-scaling use of Hydraform technology	Frequency	Percent
Enhanced public awareness campaigns and mass education	29	19.5%
Training and skills development to technical personnel/curriculum development in tertiary technical institutions	27	18.1%
Facilitating low-income technology users (both individuals and self help groups) to access subsidized loans/revolving fund kitty	23	15.4%
Sponsoring model buildings/demonstration units in every location/decentralize service delivery	17	11.4%
Availability of more hydraform machines to adequately serve the users	15	10.1%
Harmonize regulatory policies for professionals in the construction industry	7	4.7%
Conducting study/documentation for area specific appropriate materials and technologies for housing development	7	4.7%
Encourage use of technology in public institutions	6	4.0%
Subsidizing machine cost/exploring local dealership	6	4.0%
Exploring ways of commercial block production for sale to interested parties	5	3.4%
Facilitate material transportation by availing trucks for the exercise	4	2.7%
Enhance efficiency, quality products and workmanship	3	2.0%
	149	100%

Source: Fieldwork, 2011

Other ways of technology adoption upscaling included; Sponsoring model buildings/demonstration units in every location/decentralize service delivery to the grassroots; availability of more Hydraform Machines and personnel to adequately serve the users; harmonize regulatory policies for professionals in the construction industry; conducting study/documentation for area specific appropriate materials and technologies for housing development; encourage use of technology in public institutions; Subsidizing machine cost/exploring local dealership; exploring ways of commercial block production for sale to interested parties; facilitate material transportation by availing trucks for the exercise; Enhance efficiency, quality products and workmanship. These were summarized in table 4.25.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents summary of key research findings, conclusions, and recommendations with the aim of addressing research objectives. It summarized the findings on the extent of Hydraform-ISSBs technology usage, adoption factors, environmental impacts of the technology both negative and use benefits, mitigation measures for adverse impacts and suggestions on ways to upscale adoption and usage of Hydraform-ISSBs technology in building and construction within the study area.

5.2 Summary of Findings

The continued dependancy on conventional building materials to meet the world's population demand for adequate housing faces the challenge of resources stock getting exhuasted and posing negative environmental impacts, thereby hindering sustainable environmentally friendly exploitation. The Government of Kenya through the Ministry in Charge of Housing has adopted Appropriate Building Materials and Technologies as a low-cost housing policy. This has been demonstrated through the promotion of Hydraform-ISSBs technology Countrywide. The increased use of Hydraform-ISSBs technology in the building and construction industry could negatively impact on the environment, thereby hindering realization of integrated sustainable housing and environmental development in Nakuru County and other parts of Kenya. This study was therefore designed to assess the impacts of Hydraform-ISSBs to the environment of Nakuru County. It was designed specifically to; establish the extent of Hydraform-ISSBs technology use; understand adoption factors; assess the environmental impacts of Hydraform-ISSBs technology adoption; and recommend mitigation measures for negative impacts as well as provide ways to upscale the technology use.

The study revealed increased adoption and use of the technology in various construction needs within Nakuru County, but the uptake rate was slow as demonstrated by the completion of an estimated 50 projects between the years 2008-2011. The level of awareness of other completed projects by the residents was also very low in the sampled clusters. In terms of categories of Hydraform-ISSBs technology adopters, Community focused projects overweighed individual household projects. These could be so due to nature of resourcc mobilization involved in the use of the technology. With community projects, it was found to bc much easier to organize required labour and mobilize raw materials as well as other logistical requirements affordably. Further to this, the technology was also common among youthful generation of between 35-44 years. This could mainly be attributed to adoption of innovative strategies in development facets associated with these groups in the society.

Factors influencing the adoption of the techonolgy by the residents of Nakuru County included; ease of construction with the blocks, savings in transport cost, existence of trained technicians and masons, low cost technology (materials and labour), and good extension professional services.

Adoption and use of Hydraform-ISSBs tcchnology had minimal negative impacts on the environment of Nakuru County where the particular areas of impact were; dust inhalation during material preparation; burrows holding stagnant water leading to mosquito breeding grounds; accidents from burrows and machine operation; burrows and block yards leading to loss of agricultural land; noise pollution by the production machine; and loss of biodiversity.

The number of community projects that adopted Hydraform-ISSBs technology out-numbered the individual projects in the study area. Among individual projects, there were more Men-adopters of the technology compared to Women lot. Further, Mid-Age groups of 35-44 years formed the bulk of technology adopters. All these leading categories of adopters demonstrated that economic empowerment and ease of resource mobilization were quite key in the successful implementation and use of Hydraform-ISSBs technology in Nakuru County.

Environmental mitigation measures included; promoting re-use of the technology through alternative economic uses of burrows; ensuring efficiency of the Machine (Noise silencers, improvised exhaust, soil crushers, possession of both rear and front wheels); enhanced public education and awareness creation; promoting use of protective gear/clothing during block production processes; adequate training of technical personnel; collaborating and networking with financial institutions and other government departments to promote the technology.

To upscale adoption and use of Hydraform-ISSBs technology, the following measures should be encouraged; enhanced public awareness campaigns and mass education; training and skills development to technical personnel; facilitating technology users with low-income levels (both individuals and organized community groupings) to acccss subsidized loans/revolving fund kitty at friendly repayment rates; introduce innovative collaboration strategies with technical and research institutions in the promotion of the technology; and harmonization of regulatory policies for professionals in the construction industry.

5.3 Conclusions

The level of Hydraform-ISSBs technology adoption and use in Nakuru County was low, but there was gradual improvement on technology uptake among the residents of Nakuru County. The Hydraform-ISSBs technology was being replicated in other parts of the Country through sustained Promotional activities by the Government through the Ministry in charge of housing.

Hydraform-ISSBs technology adoption factors mainly related to; cost/affordability, quality of materials and workmanship, environment impacts; and sectoral policy frameworks. There should be enhanced collobarotion with existing research institutions as well as revival of dominant ones such as HABRI so as to realize elaborate information dissemination and quality precision.

The technology had minimal negative impacts to the environment. This could provide an indication for being a form of environmentally appropriate building technology.

The technology adoption and use had high value benefits thus suitable for use by a cross-section of residents of Nakuru County and by extension, to the inhabitants of other parts of the Country.

The implementation of impact mitigation measures is crucial in achieving wider acceptance and ensuring sustainable use of the technology in Nakuru County and the Country at large.

Finally, the suggested up-scaling strategies are key in the realization of increased uptake of the technology in Nakuru County as well as in other parts of the Country. These strategies are vital to the construction industry with regard to embracing new technologies.

5.4 Recommendations

5.4.1 Policy Recommendation

From the conclusions above, the study recommended the following;

(i) Enact a harmonized policy on the use of new technologies in the building and construction industry.

(ii) Develop Countrywide ISSBs suitable soil maps and enhance adequate training programme to equip more professional service providers with Appropriate Building Technologies skills.

(iii) Enhance research and development on new building technologies, which are area specific.

(iv) Enhance public awareness and information dissemination on new technologies to the public by educating the beneficiaries on the use benefits.

(v) Adequately facilitate access to revolving funds for rapid uptake of the technology and subsidize the cost of technology use by providing trucks for raw materials transportation to manufacturing sites

(vi) Encourage new technologies use in the built environment (public housing and utilities) to minimize negative impacts to the environment and reduce climate change effects

5.4.2 Research Recommendations

From the study findings and conclusions, there is recommendation to carry out further research on the topic to determine;

(i) The contribution of Hydraform-ISSBs technology use to climate change effects mitigation

(ii) The Hydraform-ISSBs technology – poverty (pro-poor) relationship

(iii) The structural performance of the blocks as compared to other conventional walling materials

(iv) The viability of commercialization of Hydraform-ISSBs technology use

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APPENDICES

Appendix A Project Co-ordinates and Burrow Dimensions

SN	PROJECT NAME	CONSTI-TUENCY	TYPE OF SOIL	N	E	X	Y	L	W	D	V
1	Moses Irungu	Rongai	BLACK VOLCANIC	9981573	833018	35.99	-0.166	24.5	6.5	1	159.25
2	Nakuru ABT Centre.	Nakuru Town	BROWN VOLCANIC	9969129	172832	36.06	-0.278	5	3.5	2	35
3	Grace Mount School	Molo	BROWN LOAM VOLCANIC	9934372	833305	35.99	-0.592	9	8	1	72
4	Teret Secondary School	Molo	RED LOAM VOLCANIC	9949909	827563	35.94	-0.452	5.5	4.5	12.5	309.38
5	St. Mark's Njoro TTC	Molo	SANDY-LOAM VOLCANIC	9956060	829888	35.96	-0.397	15	9	1.2	162
6	John Mbatia	Molo	RED LOAM VOLCANIC	9971085	807463	35.76	-0.261	3.95	3.35	4.2	55.58
7	PCEA Nakuru west	Nakuru Town	BROWN LOAM VOLCANIC	9966307	166691	36.00	-0.304	18	10	5	900
8	Ruth Bosco	Rongai	BROWN LOAM VOLCANIC	9971544	831155	35.97	-0.257	3	2.5	2	15
9	Philip Sitienei	Molo	BROWN LOAM VOLCANIC	9968146	829646	35.96	-0.287	8	3.5	2	56
10	Joan Nyongesa	Nakuru Town	BROWN LOAM VOLCANIC	9971821	832285	35.98	-0.254	4	3	2.5	30
11	Shikamoo self help group	Nakuru Town	BROWN VOLCANIC SANDY	9966364	172981	36.06	-0.303	4.5	3.5	2	31.5
12	Mustard Seeds School	Nakuru Town	BROWN VOLCANIC	9966929	174959	36.08	-0.298	25	15	2.5	937.5
13	Merica Hotel	Nakuru Town	BROWN VOLCANIC	9967633	174981	36.08	-0.292	51	13.5	1	688.5
14	Charles Muthee	Rongai	BROWN LOAM VOLCANIC	9973414	166919	36.00	-0.240	12	7	4	336
15	Onesmus M. Kibe	Rongai	DARK BROWN VOLCANIC	9972994	167083	36.00	-0.244	7	4	1.5	42

16	Makao Mashinani Ltd.	Nakuru Town	BROWN LOAM VOLCANIC	9968820	174096	36.07	-0.281	4	3.5	2.5	35
17	Lily Amoche	Rongai	BROWN LOAM VOLCANIC	9982755	833137	35.99	-0.155	12	7	1	84
18	Amos Kibet Cherono	Rongai	RED CLAY LOAM VOLCANIC	9989546	826179	35.93	-0.094	5.5	5	2	55
19	Elma Barnett children's Centre	Rongai	RED CLAY LOAM VOLCANIC	9992736	819528	35.87	-0.065	18	7	3	378
20	Musa Cheberege	Rongai	RED CLAY LOAM VOLCANIC	9988266	827057	35.93	-0.106	3	2	4	24
21	Sun and Shield School	Rongai	BROWN ASH VOLCANIC	9983797	829085	35.95	-0.146	20	16	4	1280
22	AIC Kabarnet Farm Nursery School	Rongai	BLACK COTTON SOIL	9980274	831449	35.97	-0.178	3	2.5	1.5	11.25
23	CTS School	Rongai	DARK BROWN VOLCANIC	9981476	168041	36.01	-0.167	13	8	1	104
24	Nakuru Prisons	Nakuru Town	BROWN LOAM VOLCANIC	9970570	172150	36.05	-0.265	18	5	1.5	135
25	Regent Prolink Ltd	Nakuru Town	BROWN LOAM VOLCANIC	9969121	172824	36.06	-0.279	20	15	2.5	750
26	Lucy Njeri	Nakuru Town	BROWN LOAM VOLCANIC	9970397	172015	36.05	-0.267	4	3.5	2.5	35
27	Esther Wanjiru	Subukia	ROCK LAND	9980301	179431	36.12	-0.178	3.5	3	2	21
28	Samuel Waweru	Nakuru Town	BROWN LOAM VOLCANIC	9969290	178832	36.11	-0.277	5	3.5	2.5	43.75
29	Rev. Samson Owenga	Nakuru Town	BROWN ASH VOLCANIC	9967823	181959	36.14	-0.290	4	3.5	2	28
30	United Methodist Mission Schools	Subukia	RED VOLCANIC	9970866	186830	36.18	-0.263	18	15	3	810
31	Gilgil	Naivasha	GREY	9945234	201056	36.31	-0.494	3.5	2.5	2	17.5

	Good Sheperd Academy		LOAM VOLCANIC								
32	George Nyaga	Nakuru Town	BROWN LOAM VOLCANIC	9962442	184963	36.16	-0.339	3	2.5	2	15
33	Malewa Trust	Naivasha	RED LOAM VOLCANIC	9943381	208103	36.37	-0.511	5	4	3	60
34	Grace Korir	Rongai	BROWN LOAM VOLCANIC	9975786	820076	35.87	-0.218	12	5.5	1.5	99
35	Ayub Kiplagat	Rongai	BROWN LOAM VOLCANIC	9971525	832585	35.98	-0.257	4	3	1.5	18

Appendix B: Questionnaire:

Assessing Environmental Impacts of Hydraform-ISSBs Application as Building Materials: A Case Study of Nakuru County.

Hello, My name is Mr. Robert Sangori from University of Nairobi. I am carrying out a project research leading to award of a Master of Arts degree in Environmental Planning and Management. This research is being carried out in Nakuru County to assess the impacts resulting from the introduction and adoption of Hydraform Interlocking Stabilised Soil Blocks technology to the surrounding environment. You are kindly requested to voluntarily participate in this important exercise by answering some few questions relating to the subject matter that will help in understanding the factors for adoption of Hydraform-ISSBs, resulting environmental impacts and mitigation strategies. The information provided will be confidential and strictly used for the purpose of this research only. Please tick appropriately, where it applies.

SECTION A PERSONAL INFORMATION

1 Name of the division you come from?

1. Elburgon [ ]
2. Nakuru Mucipality [ ]
3. Bahati [ ]
4. Mbogo-ine [ ]
5. Naivasha [ ]
6. Gilgil [ ]
7. Njoro [ ]
8. Molo [ ]
9. Keringet [ ]
10. Rongai [ ]
11. Olenguruone [ ]

2 Project Name?:____________________________

3 Gender of the respondent: 1. Male [ ] 2. Female [ ]

4 Age of the respondent's

1. 18-24 years [ ]
2. 25-34 years [ ]
3. 35-44 years [ ]
4. 45-54 years [ ]
5. 55 years and over [ ]

5 Project Category? 1. Individual [ ] 2. Community [ ]

6 Occupation of the respondent? ____________________________

7 Highest level of education attained

1. Primary level [ ]
2. High School [ ]
3. College [ ]
4. University [ ]
5. Other(s) [ ]
   Specify: ____________________

8 For how long have you stayed in this location?

1. Less than 5 years [ ]
2. Between 5-10years [ ]
3. between 10-15years [ ]
4. Between 15-20years [ ]
5. Between 20-25years [ ]
6. Above 25years [ ]

9 What housing materials are used for constructing walls in your locality? ***(Tick all that apply)***

1. Hydraform-ISSBs [ ]
2. Quarry Stone [ ]
3. Bricks [ ]
4. Concrete Blocks [ ]
5. Timber [ ]
6. Mud [ ]
7. Iron-sheets/Tins [ ]
8. Polythene [ ]
9. Others (Specify) [ ]

____

SECTION B: FACTORS FOR ADOPTION OF HYDRAFORM-ISSBs TECHNOLOGY WITHIN NAKURU COUNTY

The last three years has witnessed increased utilization of Hydraform-ISSBs technology in Nakuru County. However, there could be some factors that influence residents of Nakuru County as they make decision on the adoption of the newly introduced technology. As a resident of Nakuru County, how would you rate the following contributing factors on a likert scale of 1 to 10, where 1 represents least important and 10 represents extremely important as shown below;

	YOUR RANKING SCORES / SCALE OF IMPORTANCE									
Information Dissemination	1	2	3	4	5	6	7	8	9	10
Availability of land	1	2	3	4	5	6	7	8	9	10
Availability of Building materials	1	2	3	4	5	6	7	8	9	10
Availability of Construction technologies	1	2	3	4	5	6	7	8	9	10
Labour force availability	1	2	3	4	5	6	7	8	9	10
Environment influence in Technology adoption	1	2	3	4	5	6	7	8	9	10
Water availability	1	2	3	4	5	6	7	8	9	10
Government policies	1	2	3	4	5	6	7	8	9	10

Income level	1	2	3	4	5	6	7	8	9	10
Role played by financial agencies	1	2	3	4	5	6	7	8	9	10
Saving in Energy	1	2	3	4	5	6	7	8	9	10
Security of the building	1	2	3	4	5	6	7	8	9	10
Weather conditions	1	2	3	4	5	6	7	8	9	10
Cultural perceptions of the Technology	1	2	3	4	5	6	7	8	9	10
Professional services by players in the construction industry	1	2	3	4	5	6	7	8	9	10
Availability of other technologies	1	2	3	4	5	6	7	8	9	10
Affordability of the Technology	1	2	3	4	5	6	7	8	9	10
Environmental considerations.	1	2	3	4	5	6	7	8	9	10
Ease of construction with the Technology.	1	2	3	4	5	6	7	8	9	10
Employment opportunities	1	2	3	4	5	6	7	8	9	10
Savings in transport cost.	1	2	3	4	5	6	7	8	9	10
Quality of the material.	1	2	3	4	5	6	7	8	9	10
Quality of Workmanship	1	2	3	4	5	6	7	8	9	10
Material re-use	1	2	3	4	5	6	7	8	9	10
Other Factor(s) : (List)	1	2	3	4	5	6	7	8	9	10
	1	2	3	4	5	6	7	8	9	10
	1	2	3	4	5	6	7	8	9	10
	1	2	3	4	5	6	7	8	9	10
	1	2	3	4	5	6	7	8	9	10
	1	2	3	4	5	6	7	8	9	10

SECTION C: ENVIRONMENTAL IMPACTS AND BENEFITS OF HYDRAFORM-ISSBs TECHNOLOGY

A The following factors are known to cause environmental impact during utilization of the Hydraform-ISSBs technology .Please rate the level of impact of the following factors using a likert scale of 1 - 5 where;

1. No Impact
2. Small Impact
3. Moderate Impact
4. High Impact
5. Very High Impact

Rate the Level of impact to the environment with the following activities	No Impact	Small Impact	Moderate Impact	High Impact	Very High Impact
1.0 SOIL EXCAVATION – (BURROW IMPACTS)					
1.1 Stagnant water can be a Mosquito breeding grounds	1	2	3	4	5
1.2 Accidents	1	2	3	4	5
1.3 Loss of life	1	2	3	4	5
1.4 Loss of biodiversity	1	2	3	4	5
1.5 Change of drainage patterns	1	2	3	4	5
1.6 Loss of agricultural land	1	2	3	4	5
2.0 MATERIAL PREPARATION, PRODUCTION AND CURING					
2.1 Inhalation of dust during sieving and mixing in a windy environment	1	2	3	4	5
2.2 Dusty environment leading to deteriorating health condition of the inhabitants	1	2	3	4	5
2.3 Noise pollution by the production machines	1	2	3	4	5
2.4 Air pollution from the exhaust fumes	1	2	3	4	5
2.5 Machine operated on diesel fu el					

2.6 Depleting water resources	1	2	3	4	5
3.0 ANY OTHER (S):					
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

B The following benefits are derived from the utilization of the Hydraform-ISSBs technology. Please rate the following benefits using a likert scale of 1 - 5 where;

1. No Value
2. Small Value
3. Moderate Value
4. High Value
5. Very High Value

Rate the benefit derived from the following activities	No Value	Small Value	Moderate Value	High Value	Very High Value
1.0 SOIL EXCAVATION – (BURROW BENEFITS)					
1.1 Used as a construction foundation	1	2	3	4	5
1.2 Burrows used for construction of septic tanks	1	2	3	4	5
1.3 Used for construction of ablution blocks	1	2	3	4	5
1.4 Use for preparing organic (compost) manures	1	2	3	4	5
1.5 Used for water storage/water pans	1	2	3	4	5
1.6 Can be turned into fish ponds	1	2	3	4	5
2.0 MATERIAL PREPARATION, PRODUCTION AND CURING					
2.1 Cured by non-pollutant means	1	2	3	4	5

2.2 Reduced Transport related hazards	1	2	3	4	5
2.3 Reduced material wastage	1	2	3	4	5
3.0 CONSTRUCTION AND UTILITY					
3.1 Conservative mortar usage	1	2	3	4	5
3.2 Earthquake resistance technology	1	2	3	4	5

SECTION D: MITIGATION STRATEGIES

For any observed negative environmental impact (s) of Hydraform-ISSBs technology, please propose some mitigation options ;

____

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SECTION D: SUGGESTIONS

a) Please state at least 3 reasons which make you prefer use of Hydraform-ISSBs in housing development

____

____

____

b) Green Building Technologies are defined as building practices and planning materials / or products that will result in the construction and renovation of buildings that are healthier for occupants; more energy-efficient; more resource efficient; healthier for global environment in long term; and more affordable to create, operate and maintain. As a resident of Nakuru County, would you consider Hydraform Technology as a green building technology?

1. Yes (...) 2. No (...)

If Yes above, please go to (c)

If No above, please give reasons;

c) Suggest at least three ways that can be used to upscale the adoption of Hydraform-ISSBs by the general public in housing provision.

METRICS DATA SHEET:

A) SOIL TYPE AND TRANSECT MEASUREMENTS DATA SHEET

S/No	Site	Location	Soil Type	Northings	Eastings	Length	Width	Depth	Duration
1.									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									
11.									
12.									
13.									

14.									
15.									
16.									
17.									
18.									
19.									
20.									
21.									
22.									
23.									
24.									
25.									
26.									
27.									
28.									
29.									
30.									
31.									
32.									
33.									
34.									
35.									

B) If Burrow does not exist in (A), what was it used for?

____
____
____
____

C) Are you aware of other people within this locality who have excavated soil for hydrform-ISSBs production? Yes ( ) No ( )

D) If Yes above, how many____________________________

E) For those who have used the technology, please state what they used the left burrows for____

Thank you!

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Name of Enumerator ____

Date of data collection ____

Respondent number: ____

Geospatial Location : N: ______________E:_________________H:_______________

Name of location:____