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An appraisal of climate change and agriculture in Nigeria

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Climate change is a phenomenon that has the potential of affecting all natural and human systems and may be a threat to human development. This is particularly the case in developing countries. This paper is a theoretical article that uses secondary sources of data including weather events that occurred recently to appraise climate change and agriculture in Nigeria. The results have shown that human activities are largely responsible for climate change experienced in different parts of the globe today. These activities have led to increased concentration of greenhouse gases into the atmosphere and they are associated with the industrialised countries and some emerging nations. Agriculture in Nigeria is entirely dependent on climate and changes in climate are bound to affect it. This paper found out that climate change has already had a negative impact on agriculture in Nigeria especially in the last few years. It is therefore recommended that conscious efforts should be made towards mitigating the impacts of climate change on agriculture in Nigeria.

Keywords: Climate change, Agriculture, Nigeria.

INTRODUCTION

Changes in global climates are not new in the earth's history. For example the glaciation period or ice sheet age indicates large fluctuations in the last 200,000 years (Bilham-Boult et al., 1999). Such events occurred naturally, but changes today appear to be largely the result of human activities. Climate change is evidently linked to human actions and in particular from the burning of fossil fuels and changes in global patterns of land use (Salami, 2010).

The United Nations Environmental Programme (UNEP) defines climate change as extreme reactions of the weather phenomenon which creates negative impacts on agriculture, water resources, human health, depletion of ozone layer, vegetations, soil and doubling of carbon dioxide in the ecosphere (Ezra, 2010). According to the

Nigerian climates reports 490, climate change is any long term change in the statistics to averages, extreme or other measures, and may occur in a specific region or the earth as a whole (Ali, 2011). Climate change has the potential of affecting all natural and human systems and maybe a threat to human development and survival socially, politically and economically (Ali, 2011).

Agriculture is a major form of human activity on the surface of the earth. It involves cultivating the soil, producing crops and raising livestock and in varying degrees the preparation and marketing of the resultant products. In the developing countries agriculture is a major branch of the economy not only providing employment to a very large percentage of the population but also providing a source of food, raw materials and item

Figure 1. Map of study area Nigeria.

of trade and commerce. It is thus the main basis of the livelihood of the vast majority of the population as they engage in agriculture for their daily food supply, source of income and employment.

Agriculture is a primary activity that depends on natural conditions that is it is largely controlled solely by physical conditions such as temperature, precipitation and water supply, soil (edaphic factors), wind, altitude, angle of scope and aspect (Waugh, 1995). This is the situation in developing countries where agriculture is highly dependent on the climate elements such as temperature, precipitation and water supply.

Study area

Nigeria is located entirely in the tropical region between latitude 4° – 14° north of the Equator and longitude 3° – 15° East of GMT and positioned on the west coast of Africa between the Bight of Benin to the fringes of Sahara desert between Benin Republic and Cameroon. The country has a land area of 923,768 km^2 with a coastline of 853 km. Based on the 2006 National Population Census the country has 140,431,790 people which make

it the most populous in Africa. The 2012 estimates are 170,123,740 people which make it the 7th most populous country in the world (Wikipedia, 2013a). In terms of physical setting the climate is varied sub-equatorial climate in the south and tropical continental in the north. The vegetation consists of forests in the south and savannah grassland in the north. The drainage consists of two major rivers and other smaller ones and lakes. These can be seen in Figure 1.

It is important here to state that the two major rivers and other smaller ones found in the Northern part are important for agriculture as they supply water for irrigation for the production of a variety of food crops, cash crops and market garden crops.

METHODOLOGY

The paper is a theoretical (review) research that makes use of largely secondary sources of data to answer the research questions. These sources include textbooks, book of proceedings, published journal articles, internet sourced materials, daily newspapers etc. Statistical data were gathered from empirical studies and used to explain

Table 1. Proportion of global warming caused by the four greenhouse gases.

Gas	Percentage
Carbon dioxide CO_2	64
Methane CH_4	19
Chloro flouro carbons (CFCs)	11
Nitrous Oxide (N_2O)	06
Sulphur hexafluoride	0.4
Total	100

Source: Cunningham and Cunningham (2006).

climate change and agriculture in Nigeria. The data were collected over time and edited to suit the writing of the paper and the data were presented to answer the research questions. The research questions are:

i) What is responsible for present day climate change?
ii) What is the link between global climate change and agricultural products
iii) How has climate changed in Nigeria?
iv) What is the nature of agriculture in Nigeria?
v) What are the impacts of climate change on agriculture in Nigeria?

Climate change

Climate change is now widely recognised as the major environmental problem facing the globe (UNEP, 2013). It is due to this fact climate change is the most topical issue worldwide because of its impacts that are threatening the sustenance of man and his environment.

Human activities are largely responsible for climate change experienced in different parts of the globe today. These activities have led to increase in concentration of some gases called green house gases (GHGs) into the atmosphere. These GHGs are carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O) and Chloroflouro carbons (CFCs) (Cunningham and Cunningham, 2006). These four GHGs result in the increase in temperature of the globe otherwise referred to as global warming. The proportion of global warming caused by the four green-house gases can be seen in Table 1.

The countries responsible for the increase in the concentration of GHGs are the industrialised nations and some emerging nations. The top 10 cumulative energy related CO_2 emitters between 1850 – 2008 can be seen in Table 2.

The above figures are for GHG emissions from generation of energy that is fossil fuel burning. The first column shows the main countries involved in the emission and it could be observed that majority (80%) are the industrialised countries. The second column shows the percentage of world total with the United States

emitting 28.5% of the world total. The third column shows the metric tonnes CO_2 per person with the United States and United Kingdom having the highest per person.

Presently there are concerns on climate change chief of which is the increase in CO_2 levels due to emissions from fossil fuel combustion, followed by aerosols and cement manufacture. Other factors include land use, ozone depletion, animal agriculture and deforestation. Also of concern is the role they play both separately and in conjunction with other factors in affecting climate, microclimate, and measures of climate variables (Wikipedia, 2013b).

Since the beginning of the Industrial Revolution in the 1750s, atmospheric concentration of carbon dioxide has increased by nearly 30%, methane concentrations has doubled and nitrous oxide concentration has risen by about 15%. These increases have enhanced the heat trapping capacity of the earth's atmosphere. Increased concentrations of greenhouse gases are likely to accelerate the rate of climate change (Ayuba, 2005).

It is these atmospheric emissions and subsequent concentrations of GHGs over the years that have now reached optimum level leading to disruptions in the atmospheric patterns that have caused climate change (Ladan, 2012).

African countries in general contribute the least to the emissions that caused climate change. Nigeria like other developing countries contributes insignificantly to the greenhouse emissions. The areas of contribution are in gas flaring, animal agriculture and deforestation which constitute small percentage in comparison to other countries (Ladan, 2012).

The link between global climate change and agricultural products

Today despite advances in science and technology agriculture is still depended on climate. It is based on this that global climate change affects agricultural products in the following ways.

More extreme temperature and precipitation prevents crops from growing well. Extreme especially floods and drought harm crops and reduces yields. For example in 2008, the Mississippi River flooded just before the harvest period for many crops, causing an estimated loss of 8 billion USD for farmers (USEPA, 2014).

Heat waves which have started to increase with climate change have directly threatened livestock production. A number of States in the United States have each reported losses of more than 5,000 animals from just one heat wave. The heat waves affect animals both directly and indirectly. Over time heat wave increases vulnerability to diseases, reduces fertility and reduces milk production (USEPA, 2014).

The changes in temperatures and seasons affect the

Table 2. Top 10 cumulative energy related CO_2 emitters between 1850 – 2008.

S/No	Country	% of world total	Metric tonnes CO_2 per person
1	United States	28.5	1,132.7
2	China	9.36	85.4
3	Russian Federation	7.95	677.2
4	Germany	6.78	998.9
5	United Kingdom	5.73	1,127.8
6	Japan	3.88	367
7	France	2.73	514.9
8	India	2.52	26.7
9	Canada	2.17	789.2
10	Ukraine	2.13	556.4

Source: Wikipedia (2013b).

timing of reproduction and migration of fish and other aquatic animals. Many stages within an aquatic animal's life cycle are controlled by temperature and the changing of the seasons. For example in North West Europe warmer water temperatures affects the life cycle of salmon fish and increases the likelihood of diseases. This combined with other climatic impacts are projected to lead to decline in salmon fish production in the region (USEPA, 2014).

Increase in atmospheric carbon dioxide (CO2) is gradually making the world's oceans to become more acidic and this increasing acidity harms shell fish which are created from calcium and are vulnerable to increasing acidity. Ocean acidification can also threaten the structure of sensitive ecosystems which some fish and shell fish depend upon.

In the developing countries, one of the biggest effects of climate change on agricultural products is very unpredictable rainfall which affects the growth pattern of rain-fed crops such as maize and rice. In Southern Katsina State in Northern Nigeria for example, maize and rice are planted on farmlands at the beginning of the 2014 rainy season to take advantage of early harvest but there was a long delay in the rains for one month; this makes the crops to start drying which affects yield in the harvesting period. The farmers are experiencing an unusual situation where there is shortage of rainfall in the month of July and August (Mahmud, 2014).This situation primarily caused by climate change will affect maize and rice productivity both in terms of quality and quantity.

Due to climate change, temperatures are higher and it is in higher temperatures that most diseases thrive. new diseases are appearing at vegetables at alarming rates, a rate so fast that scientists find it difficult to keep up with tracking, naming and classifying them. The bird flu is a great example of this problem (Epperson, 2014).

The increase in temperature due to global warming has resulted that some food crops like wheat which was previously cultivated in Northern Nigeria at the Hadejia-Jamaare River Basin Development Project could not be produced today as the crop cannot get the lower temperature it requires for its growth. This situation of non cultivation of wheat has resulted in shortage of wheat in the region and has prompted importation of the crop from foreign countries to meet up domestic demands within Nigeria.

Climate change in Nigeria

Climate change is a global problem and many countries are experiencing different aspects of it.

In Nigeria, both temporal and spatial variations were observed in air temperature distribution. The temporal air temperature trend has remained generally on the increase since 1901 and within 105 years, temperatures increased by $1.2^{o}C$ in the coastal cities of the Niger Delta and $2^{o}C$ in the Northern extreme of Nigeria (Ojugbo, 2010).A mean air temperature of increase of $1.7^{o}C$ was observed in Nigeria for the last 105 years. The lowest mean annual temperature was recorded on the Mambilla, Obudu and Jos Plateau because they experience semi-temperate climatic condition.

A further support of the evidence of climate change in Nigeria is the increase in rainfall in the coastal areas since the 1970s and a constant decline in rainfall amount and duration in the continental interiors of the semi-arid region of Nigeria. The increase in rainfall in the coastal cities is partially responsible for the increasing floods devastating the coastal cities like Calabar, Port Harcourt, Warri and Lagos as observed by Ojugbo (2010).

The increasing temperatures and decreasing rainfall in the semi-arid regions of Sokoto, Katsina ,Kano, Nguru and Maiduguri have resulted in increasing evaporation, drought and desertification in Nigeria which have resulted in either reduction in water levels or total dry up of some rivers in Northern Nigeria; while Lake Chad is reported to be shrinking in size at an alarming rate since the 1970s (Ayuba, 2005). Dami et al (2011) in their study on Adaptation Strategies to Climate Change in Nigeria's

Section of the Chad Basin observed that the reduction in the size of the lake is associated with climate change and human demand for water. The climatic factors are the declining frequency and volume of rainfall received within and outside the basin. The human factors are mainly related to land use and are driven by an increasing demand for water even as its supply is decreasing (Dami et al., 2011).

Another study by Sawa (2010), using daily rainfall records of 30 years (1996-2005) for 15 selected meteorological stations in Northern Nigeria concluded that places in the Sudano-Sahelian region of Northern Nigeria are already experiencing the impact of global climate change in form of increasing number of dry spells during the rainy season from May to September of the years under study. This increasing dry spells result in that little vegetation growth which leads to drought and desertification as the vegetation gets degraded or completely removed due to human activities particularly fuel wood extraction and grazing by animals.

The occurrence of extreme weather events is one of the manifestations of climate change in Nigeria. Floods due to heavy rains have being experienced in parts of the country particularly in the southern parts and the Middle Belt in the years 2011 and 2012.In Ibadan, for example on August 28th 2011 heavy down pour in more than five decades wreaked havoc across the city. The rains that fell on that day hit an all time height of 187.50 mm accompanied by wind gust reaching 65 km/hr. The previous highest recorded was 178.30 mm in September 1987 (IITA, 2011).

The worst flooding in decades was witnessed in the months of July to September 2012 which affected several state close to the major rivers, Niger and Benue that burst their banks due to hours of incessant rains. The floods led to the death of 140 people, hundreds and thousands were displaced, schools and businesses were closed and thousands of hectares of farmlands were submerged. Thousands of people lost properties and lived in displacement camps for three to four months in Benue, Niger, Kogi, Edo and Rivers States. The President of Nigeria while visiting some of the affected States called the floods a national disaster (Daily Herald, 2012).

Rising sea level and ocean surge as a result of global warming are evidences of climate change in Nigeria. Awosika and Folorunsho (2005) reveal that Victoria Island is one of the fastest eroding beaches as it losses about 30 meters to the ocean annually .Ugborodo /Escavors loses around 24 metres yearly and by the end of the 21st Century Lekki and Victoria Island will lose 602 and 584 square kilometres. The Niger Delta will be worse with about 15,000 square kilometres under the sea. Lagos in recent times has suffered from ocean surges and the degradation of beaches such as Alpha, Kurama and Lekki with properties destroyed and lives lost. For example, in early August 2012 the people of Lekki were

displaced from their homes when the Atlantic Ocean water surged into their residences. The Lekki Beach was totally wiped off as it remained under water for some days.

The weather condition in the Niger Delta region has presently changed primarily as a result of the activities of crude oil extraction companies that operate there. Gas flaring is the singular and most common source of global warming and contributes to the emission of carbon monoxide, nitrogen (II) oxide and methane which cause environmental pollution and ecological disturbances (Ubani and Onyejekwe, 2013).Gas flaring contaminates the atmosphere and produces emissions that cause thermal pollution as the immediate impact of gas flaring is experienced in high and rising temperature in the communities close to the flare sites and beyond, acidification of rain water and deposit of black powder cover (Alaba et al., 2013)

AGRICULTURE IN NIGERIA

Agriculture used to be the principal foreign exchange earner of Nigeria from independence in 1960 up to the mid 1970s; at that time Nigeria was the world's largest of groundnuts, cocoa and palm oil and a significant producer of cocoanuts, citrus fruits, maize, pearl millet, cassava, yam and sugar cane. About 60% of Nigerians work in the agricultural sector and Nigeria has vast areas of underutilised arable land (Wikipedia, 2013c).

In Nigeria today agriculture is the main source of food and employer of labour employing about 60 – 70 percent of the population. It is a significant sector of the economy and source of raw materials used in processing industries as well as source of foreign exchange earnings for the country (Ayinde et al., 2011).

Agriculture in Nigeria is mostly rain fed. In the north where rainfall is seasonal farmers clear their land and await the commencement of the rains mostly in May/June. Food crops produced are mainly grains and cereals such as millet, guinea-corn, maize, rice, wheat, beans and cash crops include cotton, groundnut, sugar cane. The occurrences of droughts since the 1970s have necessitated the building of dams to supply water for irrigation agriculture. Examples include Tiga and Kadawa dams in Kano and Jigawa States, Zobe and Jibia in Katsina State, Goronyo and Bakalori dams in Sokoto State.

In the Middle Belt food crops produced are mainly root crops like yams, cassava, cocoyam, potatoes, and beniseed. There are also highland temperate mixed crops produced on the high Plateaux of Jos and Adamawa and examples are Irish potatoes, tea, temperate fruits like apple etc.

In the southern part the main crops are roots and tree crops such as yams, cocoa yams, plantations, cocoa, rubber, palm produce, kola nuts etc. There is double

maxima rainfall in the south which favours the growth of these crops. Some of these crops are grown for commercial purposes in plantations. Shifting cultivation remains the major farming system among the peasant/local farmers who produce a large percentage of the total food supplies in the country (Akor, 2012).

Forestry is another major activity in Nigeria. In 2005 forestry production shows that 86.7% of the wood is used as fuel while the remaining 18.3% of the wood is used for producing sawn wood, veneer, railways sleepers, pulp and other products (Macmillan, 2007). These are products mainly from the southern forest region and some from the Middle belt and the north where there are forest reserves, communal forest areas within the savannah vegetation zones. Deforestation is however severe in the northern and southern parts and moderate within the north central and middle belt areas of Nigeria. Desertification is severe along the extreme north and moderate in the surrounding areas.

A cattle rearing is predominantly practiced in the northern part by the Fulani herdsmen who are nomadic in nature. They move in search of pasture grass and water for their cattle from the north to the middle belt up to the southern parts of Nigeria. There are also mixed farmers who rear cattle and sedentary rearers found in different parts especially in the northern parts. The main livestock reared are sheep, goats, pigs, cattle and poultry and the products include lamb and mutton, goat meat, pork, beef, milk and eggs (Macmillan, 2006).

Fishing is carried out on inland rivers, fish farms lakes and dams and along coastal waters. Fish production for the year 2005 shows that fishing on fish farms account for 8.6%; inland rivers and lakes, 40.78%; coastal waters, 44.7%; shrimps, 2.8%; and fish, 3.2% (Macmillan, 2007). Fish production for the year 2006 was 620,000 tonnes. Fishing is a major source of income and occupation to many people along inland rivers, riverine areas of the Niger Delta and the coastal areas of Nigeria.

CLIMATE CHANGE AND AGRICULTURE IN NIGERIA

The effects of climate change have already been felt in many parts of the country with the modification of intensity and seasonal nature of the rains, elevation of average annual temperatures, and intense frequency of widespread, high impact weather phenomena including drought and flooding. These effects of climate change directly have an impact on agriculture in Nigeria. Agricultural activities in Nigeria such as rain fed agriculture, livestock rearing, fisheries and forest products extraction are sensitive to climate change (Salami, 2010).

Climate change has impact on agriculture in Nigeria in the following ways.

Increase in temperature

Increase in temperature especially in the semi arid region

has resulted in the less farm work as farmers and other farm workers get tired easily due to dehydration and constant sweating. This was supported by Bello *et al* (2012) who indicate that sudden increase in air temperature in Nigeria was observed as from the early 1970s until 2005 which is linked to the effect of climate change and its associated global warming which was previously reported by several studies. The mean air temperature from 1901-1970 was 26.3^0C and increases to 27.8^0C from 1971-2005 (Bello et al., 2012). Also farmers continue to complain that agricultural produce has been very poor these days as they are facing declining crop yields due to weather fluctuations and other environmental threats. The result is that some farmers in Nigeria are abandoning farming for non-farming activities.

Drought

Due to drought in the north east, the Lake Chad is receding at a very fast rate so much so that the quantity of water is one third of its original volume. This has affected farming activities around the lake particularly dry season farming. According to Dami et al. (2011), the reduction in the size of the lake is associated with two main factors: climate change and human demand for water. The climate factors include declining frequency and volume of rainfall received within and outside the basin from Rivers that drain into the Lake Chad such as Hadejia-Jamaare and Chari. The human factors are mainly related to land use and the increasing demand for water even as the supply is decreasing from the lake due to the climatic factors. The problem of drought had remarkably impacted the socio-economic life of the people in the region as the major activities in the basin are fisheries, rain-fed and irrigated farming which solely depend on the prevailing climatic conditions (Dami et al., 2011).A study by Joshua and Ekwe (2013) state that field interaction and discussion with the farmers on the farm reveal that many farmers are willing to do dry season farming but the available water is not enough for any meaningful production.

Serious and severe floods

In 2010, there was serious flooding due to heavy rains in different parts of the country which destroyed vast fertile farmlands at that time and subsequently resulted in higher food prices, increasing the fear of food insecurity and aggravating rural poverty. The problem of incessant floods and erosion continue to expose peasant farmers to the hazards of climate change. In 2011, there were severe floods in different parts of the country which directly affected agriculture. For example a heavy down pour that lasted six hours on 26th August, 2011 in Ibadan, Oyo state swept away poultry farms and fish ponds filled with chicken and fishes worth millions of Naira (Sunday

Tribune, 2011).Again in 2012, the worst floods in over five decades submerged and destroyed farmlands of rice, yams cassava, maize, melon as well as plantain and banana in the State around River Niger, Benue and Cross River as the rivers were filled to capacity by heavy rains and thus over flow from their banks. This has also occurred in the far northern states of Katsina, Jigawa and Kano where farmlands of millet, guinea corn, maize etc were destroyed by the floods (Ibekwe, 2012).

Global climate change has brought heavy rainfall where rains that are to fall in different days in one month fall within one or two days leading to massive flooding as witnessed presently in 2014 in parts of India, Pakistan, USA, United Kingdom and Japan. The average tempe- rature in regions across the globe goes up, as more rain has fallen. This happens because warm air holds more moisture and when warm air holding moisture meets cooler air, the moisture condenses into tiny droplets that float in the air. If the droplets gets bigger and become heavy enough, they fall as rain (UCS, 2010). In Nigeria, this is the case where heavy seasonal rains fall particularly in the month of July to September were experienced in 2010, 2011, 2012 and 2013 which causes massive flooding that results in the bursting of rivers, collapse of earth dams, release of water from large dams which displace people especially farmers in rural areas, submerging of farmlands and destroying crops, poultry and fish farms, contaminating water sources and sanitation facilities (IFRC, 2013).

Weather fluctuations

Fluctuation of the weather arising from climate change causes insurgence of infectious diseases such as malaria, cholera and meningitis particularly among rural dwellers thereby affecting their output in farming activities. This affects the health of farmers and market transactions, reducing their quality of life and agricultural output. Indeed many prevalent infections including malaria, dengue fever and cholera are climate sensitive as they are transmitted by mosquitoes which cannot survive if temperatures are too low and thus thrive when the weather conditions are warmer with global warming. According to Akingbade (2010), investigations revealed that in the year 2009 that over 200 people were killed by meningitis in Nigeria and Niger Republic in one week. There were 25,000 sus- pected cases and 1,500 deaths in the first quarter of 2009.Experts have found a correlation between weather and meningitis which affects people in periods of erratic and unpredictable weather (Akingbade, 2010). In many areas in northern Nigeria fluctuating weather does not only cause diseases which affect the health of the farmers, but also confuse farmers about the start of the planting season.

Gas flaring and crude oil pollution

The flaring of gas in the Niger Delta area has over the years raised the heat level in many host communities (e.g Ode in Edo State) which creates environmental hazards that destroy the environment and makes it difficult for agricultural activities such as fishing and farming to thrive due to increase in heat arising from thermal pollution. Empirical studies carried out on the impact of gas flaring on agriculture showed a direct relationship between gas flaring and productivity that tends to decrease for farmlands close to the flare sites. One of such studies was by Ubani and Onyejeke (2013), whose results obtained show that gas flaring is responsible for the contamination of water bodies which affects the survival of fishes and other aquatic animals. Acid rain has eliminated insect life and some fish species over the years due to the gas flaring and dangerous gaseous emissions. The acid nature of the soils has attendant effect on the soil usually used in agricultural purpose. Farmers and fishermen have for decades being con- fronted with difficulties arising from gas flaring.

Crude oil pollution includes oil spillages on farmlands, oil flow sites, gas flaring sites, burrow pits, pipelines and other oil and gas activities which affect crop production in the Niger Delta. Ojimba and Iyagba (2012) in their study on the effects of crude oil pollution on horticultural crops in Rivers State reveal that the output of fruits, banana, pepper, okra and leafy vegetables in non- polluted farms were considerably higher than the output in crude oil polluted farms. The average output per horticultural crop farm produced in crude oil polluted farms was 384.58 and 550.94 kg in non-polluted farms, which indicate that crude oil pollution had a negative effect on the quantity of output (Ojimba and Iyagba, 2012).

Extreme weather events

Besides floods and drought, there is another extreme weather event as hailstones that accompanied heavy rains caused widespread destruction of houses of rural farmers, farmlands and agricultural products in some local government areas of Jigawa and Katsina States in September 2012.According to the residents of the areas the hailstorms and the destructions they cause were not seen by the people in their entire life time (Ibrahim, 2012). In June 2013 a late night heavy downpour showered large ice pellets on maturing plants destroying most of the crops which include okra, maize, vegetables and sugar cane on some irrigated farms in Mairuwa near Funtua in Katsina State. Most of the farmers have to bear the loss as the okra and the maize were not ready for harvest and cannot be sold (Abubakar, 2013). Also in the same State, Katsina and in the same month of June 2013 hailstorm consisting of ice pellets destroyed okra ,maize and other vegetables in farmland whose cost is worth N10 million in villages of Faskari Local Government area. About 2,000 farmers were affected as most of their crops planted were completely damaged by the hailstorm which occurred when the crops were not ready for

harvesting. Some of the farmers interviewed said that unless the Government helps the affected farmers, most of them will not be able to farm in the next planting season because they have lost all they have in the disaster (Ibrahim, 2013).In Nigeria's tropical weather, hailstorm was not normal but presently has being occurring frequently and in different locations in the country due to climate change.

Drought conditions

Drought condition created by climate change especially in the north eastern part leads to decrease in pasture grass and water availability in the region. This leads to decrease in livestock production resulting in an impaired availability of milk, meat, egg and animal products such as hides and skin. The decrease in pasture grass can causes migration of herdsmen further down South and can increase the rate of Farmers-Fulani clashes as was recently witnessed in May 2013 near Abuja, the federal capital territory. The persistent drought conditions and desertification in the North East have been identified as the primary cause of reduction of the inflow of water into the Lake Chad, causing shrinking of the lake and resulting in conflicts between farmers, fishermen and pastoralists living along the border of the lake. The shrinking of the lake led to a reduction of land for cultivation and grazing (Fagbohun, 2010). According to Akingbade (2010) agriculture in northern Nigeria in general has being affected by drought as the dryness has led to dry farmlands, water beds and movement of people and their livestock to the southern region thus causing tension and conflict between the original inhabitants and the newcomers.

Increasing number of environmental refugees

Increase in the number of environmental refugees has drastically increased as people were forced to leave their homes in search of relief from harsh environmental conditions. These include floods, drought, oil spillage/ crude oil pollution, hailstorm/windstorm, pest incidence etc (Gwaram et al., 2004). For example many victims of 2012 devastating floods who were farmers were still living in displacement camps as at January 2013 which is bound to affect food security as many farmlands are idle and unprepared for the coming planting season. Drought conditions in the North east has led to the reduction in the size of the lake Chad apart from intensifying the conflict between pastoralists, farmers and fishermen had also led to the emergence of environmental refugees (Fagbohun, 2010). Oil spillage and crude oil pollution has created climate refugees as flare motivates change in climatic conditions making large part of the Niger Delta land uncultivable and water resources economically unviable which has pushed people to migrate in order to seek alternative source of livelihood (Alaba et al., 2013).

Furthermore on the occasion of World Environment Day 2014 with the theme :"Raise Your Voice not the Sea Level", the Minister of Environment warned that about 32 million Nigerians living along the coastlines of the Niger Delta might be displaced by rise in the sea level and thus become environmental refugees. An accelerated sea level rise of 0.5 meters, 35 per cent of the Niger Delta land mass would be lost, with an accelerated rise of 1.0 meters, 7.5 per cent of the Niger Delta gone under the sea (Blueprint,2014).

Conclusion

Climate change is now a reality and its effects are felt all over the globe. These effects are largely negative and have serious repercussion for human beings, their source of livelihood and the environment. It is due to this that climate change is the single biggest environmental issue facing the world today. Nigeria is one of the most vulnerable countries to climate change in Africa due to her varied climatic zones, coastal location and more people are living and working in climate change prone areas. Agriculture in Nigeria is largely dependent on the climatic conditions and changes in these conditions can have impact on agricultural activities. Based on the discussions in this article it could be observed that climate change has brought negative impacts on agri-culture in Nigeria. However, conscious efforts must be made towards mitigating the impacts of climate change on agriculture in Nigeria.

Conflict of Interests

The author has not declared any conflict of interests.

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Full Length Research Paper

Perceived housing satisfaction in public estates of Osogbo, Nigeria

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The study assesses residents' housing satisfaction in public housing estates of Osogbo, Nigeria. Condition of housing, adequacy of housing facilities and residents' perception of housing satisfaction in public estates in Osogbo were assessed. The study necessarily relied on both the primary and secondary data. Both qualitative and quantitative data were also used. Data were obtained from six (6) public housing estates in Osogbo. A structured questionnaire was administered on 312 household heads forming 30% of the sample frame; random-systematic sapling technique was used. Residents' perception of satisfaction with their housing condition and neighbourhood quality were collated using Likhert scale ratings. Mean Weighted Values (MWV) were computed upon which comparisons were based. The study observed a general deficiency in infrastructural development. Almost all the estates lack basic facilities. Only one of the estates scored up to 50% of expected basic infrastructure benchmark. Laro, Oke Oniti and GRA housing estates with MWV of 0.54, 0.56 and 0.89 respectively fell short of 0.97 overall mean value measurement of residents' satisfaction. Housing condition at GRA, Oroki and Laro Timilehin housing estates with MWV of 4.76, 3.91 and 3.92 respectively were a bit better than the overall assessment value of 3.90. The study therefore recommends urgent improvement of quality and provision of infrastructure through Public-Private Partnership Initiatives (PPP), resuscitation and/or creation of Estate Management Board and the use of local building materials so as to enhance efficient management, create employment opportunity and forestall the looming volatility of movement within and outside the housing estates.

Key words: Housing satisfaction, public estates, housing policy, perception.

INTRODUCTION

Increase in population and uncontrolled urbanisation are associated with increasing demand for housing, presenting communities with extraordinary challenges (Awotona, 1982b; Lee and Schwab, 2005; Lawanson, 2006; Akeju, 2007). Huge government investments have not produced appreciable easement in housing because the provisions were grossly below the quantitative and qualitative housing needs of the nation (Ajakaiye and Fatokun, 2000; Ibem, 2010). Statistics recently show that occupancy ratio of houses in Nigeria is about 6 persons per room of 20m2; 60% of Nigerians are inadequately and/or indecently housed. Residential home ownership is less than 25% compared with 75% international benchmark. Existing housing deficit of 12-14 million

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housing units requires an estimated US$150-200M (World Bank Report, 2012).

However, the multifaceted importance of housing encapsulates in life's basic necessities: shelter, physical and mental health, economic and social wellbeing (Mabogunje, 1975; UN–Habitat, 2006, Gilbertson et al., 2008). Housing provides security, privacy, neighbourhood and social relations, status, community facilities and services, access to jobs and control over the environment (Olotuah, 2006; FGN, 1962). Housing provision in Nigeria has been largely through private efforts of individuals and organisations. However, there have been state involve-ments through Federal Low Cost and other Housing Schemes which occasioned the construction of various mass housing estates, provision of site and services and other infrastructure in urban centres for all income groups among others. However, the public housing so far, have been badly maintained owing to poor implementation of National Housing Policy, inadequate funding, lack of continuity of projects upon change in government, the insecurity and abandonment of those projects (Hegedus and Mark, 1994; Jiboye, 2004; 2008).

Researches have shown that decades of direct government interventions in the housing sector, both locally and internationally, have not been able to solve the problems of insufficient and sub-standard housing (Awotona, 1990; Onibokun, 1990; Akinola, 1998; Olotuah, 2000; Ajanlekoko, 2001; Mabogunje, 2003). The assess-ment of housing needs by various governments in Nigeria has concentrated on the number of dwelling units needed, playing down on the importance of quality, users' tastes and satisfaction, affordability and transfer process to the would-be buyer/residents. This results into failure to meeting the tastes of, and harnessing direct access to buyer/would-be residents. Consequently, there were mismanagement, misuse and abandonment of the housing estates, thereby accelerating the rate at which existing structures are degenerating and dissatisfying (Olateju, 1992; Mabogunje, 2003).

Satisfaction in housing occurs when housing and neighbourhood situation is consistent with the cultural, family and community housing norms. This measures the difference between actual and desired households' housing and neighbourhood situation (Galster, 1987; Galster and Hesser, 1981; Lu, 1999). Housing satisfaction thus, depends on residents' judgement of their residential and neighbourhood situation. This indicates the absence of complaints and a high degree of agreement between actual and desired situations, and the meeting of residents' daily needs for housing. On the contrary, incongruence between their actual and desired housing conditions may lead into dissatisfaction and abandonment (Lord and Rent, 1987).

There is therefore much more to research, for instance, how far is public housing able to solve housing deficit in our cities despite huge investments? Does public housing meet the standards for the definition and is it affordable by the targeted social class? What factors are responsible for their location, distribution and sustainability? What measures can influence residents' satisfaction of these provisions? These and sundry questions are the thesis of this study. To this end, the study assesses the residents' housing satisfaction in public estates in Osogbo with a view to providing information about the present state, thereby suggesting ways of improving quality of public estates in Osogbo. This was done by examining the conditions of housing in public estates in Osogbo, assessing the adequacy of housing facilities in the estates, examining residents' perception of housing satisfaction in the estates and making of relevant suggestions that may improve residents' satisfaction in the estates.

Housing Satisfaction

The concept of housing satisfaction is multi layered. It defines the gap between respondents' needs and aspirations concerning housing and the reality of the current residential context (Hui and Yu, 2009). However, the degree of contentment experienced by an individual or family is measured thereby given the prevailing housing situation. Other writers argued that housing satisfaction evaluates the perception of and feelings for the housing unit(s) of residents and the environment- a predictor on which individual's perception of the quality of life can be measured (Onibokun, 1974; Campbell et al., 1976; McCray and Day, 1977, Galster, 1987; Ogu, 2002).

Ramdane and Abdullah (2000) display similar views on the concept of housing satisfaction based on their observation on past studies. Their modifications are of the opinion that the concept of housing satisfaction has been used for five major objectives:

i. It serves as a key to predict an individual's perception on the overall quality of life.
ii. It serves as an indicator of individual mobility which later changes the demand on housing and influences surrounding area change.
iii. It is used as a specific measurement of private sector development success.
v. It serves as an evaluation tool to measure residents' acceptance of prevailing shortcoming for existing surrounding area development.
vi. It acts as a variable in determining the relationship between the resident's background and his attitude towards mobility.

Generally, owners are said to have a high satisfaction level towards housing compared to tenants and housing ownership gives a higher satisfaction to owners; not everybody can enjoy comfortable housing. It is only within the reach of those who can afford it. The rest are relega-ted to retiring in more affordable housing areas.

Table 1. Housing facility assessment.

A. Building type	Oke Oniti	Owode	G.R.A	Oroki	Laro	Osogbo	Total (%)
Bungalow (Brazillian)	5.4%	1.6%	1.9%	16.7%	2.9%	13.2%	41.7
Bungalow (Flat)	17.7%	8.3%	0.6%	9.0%	1.0%	3.8%	40.4
Duplex	0.3%	0.0%	6.5%	5.4%	0.3%	0.3%	12.8
Story Building	0.3%	1.0%	0.3%	2.6%	0.3%	0.6%	5.1
B. Number of Persons per room							
1-Person per room	22.7%	9.0%	9.3%	31.4%	3.5%	17.3%	93.2
2-Person per room	1.0%	1.9%	0.0%	2.3%	1.0%	0.6%	6.8
C. Number of Rooms in the Building							
2-rooms	3.8%	2.2%	0.0%	0.6%	0.6%	2.9%	10.1
3-rooms	11.9%	4.5%	1.3%	3.2%	1.0%	3.5%	25.4
4-rooms	6.7%	3.6%	2.2%	21.2%	1.9%	9.6%	45.2
5-room & above	1.3%	0.6%	5.8%	8.7%	1.0%	1.9%	19.3
D. Toilet Location within Building							
Within the house	22.7%	9.0%	9.3%	31.4%	3.5%	17.3%	93.2
Outside the house	1.0%	1.9%	0.0%	2.3%	1.0%	0.6%	6.8
E. Bathroom Location within Building							
Within the house	22.7%	9.0%	9.3%	31.4%	3.5%	17.3%	93.2
Outside the house	1.0%	1.9%	0.0%	2.3%	1.0%	0.6%	6.8
F. Kitchen Location							
Within the house	22.7%	9.0%	9.3%	31.4%	3.5%	17.3%	93.2
Outside the house	1.0%	1.9%	0.0%	2.3%	1.0%	0.6%	6.8
G. Sources of Water							
No well	0.3%	0.3%	0.0%	1.0%	0.0%	1.0%	2.6
Deep well (pumping machine)	19.9%	6.2%	1.2%	27.5%	2.6%	14.4%	71.8
Deep well	1.9%	2.2%	0.0%	2.6%	1.9%	1.3%	9.9
Bore Hole	1.6%	2.2%	8.1%	2.6%	0.0%	1.2%	15.7

Source: Author's field work, 2013.

METHODOLOGY

The study necessarily relied on both the primary and secondary data. Quantitative data were used. Descriptive and inferential statistics were used. Data were purposefully obtained from all the six (6) public housing estates in Osogbo, housing 10,400 residents. To measure housing satisfaction, a structured questionnaire investigating the perceived adequacy of basic housing facilities, ancillary housing neighbourhood facilities and the socio-environmental condition of housing was administered on 312 household heads; forming 30% of the sample frame; using random-systematic sapling technique. Residents' perception of satisfaction with their housing condition and neighbourhood quality were collated using Likert scale ratings. Mean Weighted Values (MWV) reminiscent of resident satisfaction index were computed upon which comparisons were based. Analysis of variance was used to explain variation in the perceived housing condition within and among the public estates.

DISCUSSION OF FINDINGS

Housing facility assessment

The indicators selected to measure housing facility in the study are presented in Table 1. They include: building type, number of persons per room, number of rooms per building, location of toilet and bathroom within building, kitchen location and water point sources to the building among others. It must be stated at this outset that sustainable electric power supply has always proven to contribute negatively in the qualitative assessment of housing in Nigeria. Very many houses has a stand-by generator (s) in varying sizes and wattage which contribute immensely to reduced environmental liveability for residents both locally and globally. The issue of the

use of electric power supply is the same in this study.

There are more bungalows (81.9%) observed in the public estates of Osogbo. There are 41.7% of the Brazilian type of bungalow and 40.4% of the flat system type. There are fewer duplexes (12.8%) and storey (5.1%) buildings. The housing connotation of this may be in two opposite directions when viewed against the background of quantitative and qualitative housing. The high incidence of lowest rise buildings against the low incidence of storey and duplexes is suggestive of housing shortage in the quantitative sense on the one hand. On the other hand, it presents with low density housing which is indicative of qualitative housing. This is corroborated by the fact that in the study, most of the room observed has a desirable room occupancy ratio of one person per room.

Nevertheless, just like any other area considered prime because of their proximity to jobs, city facilities, transport-tation and other services, sustainable environmental management is an imperative to keep the area in good shape. The houses are meant for low income earners and under normal circumstances are not supposed to be too expensive. There is a tendency the houses may become a succour to low income bracket members of the society and with the opportunity that Brazilian housing type offers, the place may become over-populated.

In the relative sense, there was observed a higher incidence (6.5% and 5.4%) of duplex at GRA and Oroki housing estates respectively compared to other housing estates. The reason was linked to the fact that both estates were the only low density residential areas in the study area. Majority of the respondents (93.2%) inhabited one person per room accommodation while the remaining (6.8%) resided in two-person per room accommodation. Only about 19.3% of the respondents resided in accommodation with more than 4 rooms whereas about 45.2, 25.4 and 10.1% of them lived in 4-rooms, 3-rooms and 2-rooms accommodation respectively across the study area.

The location of in-house facilities such as toilet, bath-room and kitchen was also observed and majority of the respondents (93.2%) had the facilities located indoor i.e. they were incorporated into the building so that it is not necessary that one comes out of the roof before using those facilities. The remaining 6.8% of the respondents had those facilities outside the building. This indicates a proper installation of basic facilities in the housing units. Very few of the respondents (2.6%) do not have direct access to any water point source but, get water from point sources in the neighbourhood whereas about 9.9, 15.7 and 71.8% of them had access to deep well, deep well with pumping machine and bore hole (Table 1).

Residents' perception of condition of housing

Data regarding perception in this study were collected using the structured questionnaire in ordinal ranking form.

Respondents had to rank between: 'very much satisfied', 'very satisfied', 'just satisfied', 'not satisfied' and 'not at all satisfied'. These ranks were allotted weights in descen-ding order of the way they have been listed. In essence, '4' was allotted to very much satisfied as the rank of highest value, and in that order, 3, 2, 1 and 0 were allotted to the rest four ranks. The choice of 4-0 in this scaling is based on the assumption that 'not at all satisfied' rank should not be presented as contributing to the positive assessment of housing condition. Each of the listed components of a building were variables assessed using this scale. It follows that, for each estate, the number of respondents multiplied by 4 is the maximum point achievable from each variable. This was used to standardize the weighing of the responses from the residents (Table 2). The total score for each variable, divided by the maximum point achievable multiplied by 100 becomes the standardized score for each variable. Since the answers will be different because of the difference in the individual mean of the variables, a mean average was computed for use as general mean for all the variables on the table. Thus, Residents Satisfaction Index is given by:

$$\frac{\sum_{i=1}^{N_1} d1 + \sum_{i=1}^{N_2} e1 + \sum_{i=1}^{N_3} m1}{\sum_{i=1}^{N_1} d1 + \sum_{i=1}^{N_2} e1 + \sum_{i=1}^{N_3} m1}$$

Analysis of variance was used to explain the difference both within and among the variable performance. It was observed that at 95% confidence level, there was no difference observed in the mean values of the condition of the housing components when they were compared with the mean average. In essence, the six public estates can be said to exude similar characteristics. However, relatively, some of the estates are performing better than the rest. For instance, the mean values of the housing condition in Oke Oniti, Owode, GRA, Oroki, Laro and Osogbo are 3.48, 3.39, 4.76, 3.91, 3.92 and 3.84 respectively. However, the overall average (mean) value of the considered building elements is 3.90 upon which comparison was based. From the foregoing, it is crystal clear that only GRA with mean value of 4.76 had a better housing condition, Oroki and Laro housing estates with mean values of 3.91 and 3.92 respectively were sharing a relatively good housing conditions compared with others in Osogbo. The reasons for their better score could be as a result of their location at low density residential zone(s) of (GRA) and at medium density residential zones as in Laro and Oroki).

Housing infrastructures and facilities

Thirteen common facilities were used to measure

Table 2. Residents' perception of housing condition.

S/N	Building Elements	Oke Oniti	Owode	GRA	Oroki	Laro	Osogbo	Total
		MWV	MWV	MWV	MWV	MWV	MWV	MWV
1.	Roof	3.54	3.54	4.75	3.95	3.93	3.86	**3.93**
2.	Walls	3.57	3.57	4.79	3.91	3.93	3.89	3.94
3.	Floors	3.43	3.43	4.83	3.90	3.90	3.17	3.78
4.	Doors	3.35	3.35	4.79	3.95	3.93	3.84	3.87
5.	Windows	3.35	3.35	4.79	3.93	3.90	3.90	3.87
6.	Painting (s)	3.31	3.93	4.50	3.78	3.88	3.77	3.86
7.	Staircase (steps)	4.00	4.00	4.76	4.00	4.00	4.00	4.13
8.	Toilet (s)	3.35	3.35	4.77	3.86	3.93	3.96	3.87
9.	Bathroom (s)	3.35	3.35	4.79	3.86	3.93	3.96	3.87
10.	Ceilings	3.57	3.57	4.75	3.95	3.93	3.86	3.94
11.	Ventilation	3.43	3.43	4.83	3.91	3.90	3.91	3.90
12.	Lighting	3.54	3.54	4.75	3.91	3.90	3.19	3.82
	Total	41.79	40.68	57.10	46.91	47.06	46.03	46.78
	Mean	3.48	3.39	4.76	3.91	3.92	3.84	3.90

Source: Field survey, 2013; ∑MWV/n 46.78/12= 3.90 = mean average.

Table 3. Residents' Satisfaction of Neighbourhood Infrastructural Facilities in Osogbo.

S/N	Neighbourhood Facilities	Oke Oniti	Owode	GRA	Oroki	Laro	Osogbo	Total
		MWV	MWV	MWV	MWV	MWV	MWV	MWV
1.	Primary/Nursery Schools	-	1.15	-	1.81	-	1.96	0.82
2.	Secondary School	-	-	-	1.86	-	1.96	0.64
3.	Shopping Centres/Shops	-	1.35	-	1.81	-	2.07	0.87
4.	Religious Centres	-	1.27	-	1.81	-	2.02	0.85
5.	Health Centre/Clinics	-	1.24	1.69	1.76	-	2.13	1.14
6.	Fire Service Station	-	-	1.69	-	-	-	0.28
7.	Police Station/Posts	-	-	1.76	-	-	-	0.29
8.	Public Water Supply	1.36	1.41	-	1.81	-	-	0.76
9.	Electricity Supply	1.06	1.35	1.45	1.43	1.86	1.64	1.47
10.	Access Roads	1.06	1.00	1.14	1.86	1.64	1.46	1.36
11.	Drainages	1.12	1.15	1.17	1.81	1.64	1.29	1.36
12.	Security	1.36	2.00	1.28	1.90	1.86	1.90	1.72
13.	Refuse Management	1.36	1.56	1.45	1.90	-	-	1.05
	Total	7.32	15.83	11.63	17.95	7.00	16.43	12.61
	Mean	0.56	1.22	0.89	1.38	0.54	1.26	0.97

Source: Field survey, 2013; ∑MWV/n 12.61/13= 0.97 = overall average.

resident's perceived satisfaction of environmental facilities. Data were again collected in the ordinal ranking form. Computations and operations similar to the one in Table 2 were used. There was a supportive evidence in that residents' satisfaction of their housing is influenced not only by the bricks and mortals of the buildings, but also by the social, behavioural and cultural factors within the socio-environmental system (Onibokun, 1974; Campbell et. al., 1976; McCray and Day, 1977, Galster, 1987 and Ogu, 2002) (Table 3).

Residents' satisfaction at Laro, Oke Oniti, and GRA with mean value of 0.54, 0.56, and 0.89 respectively fell short of the overall mean value of 0.97 for the entire study area. By implication, provisions of infrastructure in the said estates were below the expected level of infrastructural provision in the entire estates. Conse-quently, responses from the respondents showed that people from those estates are willing to relocate if there is such opportunity or if there is a slight pull or push from an external influence. On the contrary, residents from Owode, Osogbo and Oroki with mean value of 1.22, 1.26 and 1.38 respectively are not willing to relocate given

their level of satisfaction with their housing conditions.

One important lesson to be learnt in this study is that when people get used to a particular condition and they have no opportunity to experience another condition, they relish their experience as it is the best option they have and have to be satisfied with. Sometimes facility with the average performance would be rated the best because, when compared with similar facilities of poorer performance, it is still the best. From what is observable in this study, though, there is a lot of objective improvement to make houses in these public estates more habitable and to raise the satisfaction index, residents have introduced a lot of subjective biases to describing their dwellings which is the best they ever know. This emphasizes the need for competent advice from experts and stakeholders who hold the yardsticks for quantitative and qualitative housing assessment.

The standard for any residential estate should be one with an ideal population size, which relates to the provision of facilities, services, and the retention of identity as exemplified by the idea of the Neighbourhood concept by Perry (1910). This concept offers in concrete terms a model layout of a neighbourhood of a specified population size with specific prescriptions for the physical organisation of buildings, streets and ancillary facilities. Thus, the provision of infrastructure in any estate should not only be adequate, meeting residents' needs, but also functional.

RECOMMENDATIONS AND CONCLUDING REMARKS

The study observed a perceived poor quality of infrastructure. For a quality and a satisfactory housing environment, Government and policy makers need to attend urgently to this. Government may not be able to take direct responsibility over private properties but improvement on facilities may be done. One way to achieve this may be through the public-private partnership, where and when private organizations play complementary roles with the government and vice versa, to achieve the provision and maintenance of basic facilities; and thereby promote housing satisfaction in Osogbo. This may enhance both qualitative and quantitative housing delivery.

With the growth of urbanization, the city may soon run out of housing stock thereby putting pressure on the existing stock. Government may encourage the production of cheaper and reliable indigenous building materials through incentives. It is believed that this would improve the ease of private development and increment of housing stock. With these in place, there would be improvement in housing delivery and housing satisfaction in our cities.

Conflict of Interests

The author has not declared any conflict of interests.

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Full Length Research Paper

Land use, land cover change in urban pastoral interface. A case of Kajiado County, Kenya

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Suitable location and influx of immigrants have made pastoral peri-urban Kajiado County a centre of two conflicting interests; urban sprawl and agricultural intensification. To understand the resulting trends over the period 1984-2010 satellite image based analysis of land use cover changes and interviews with landowners were conducted. Interviews focused on the changes and trends in land use, their causes and future forecasts. Percentage changes in land use and land cover types for the years 1984 to 2004, 2004 to 2010 and 1984 to 2010 were determined. Between 1984 and 2010, significant (p < 0.05) changes occurred in built-up, crop land, rangelands, bare ground, rocky areas and woodlots and riverine vegetation. Only water bodies showed no significant changes. Land use and cover changes resulted from activities due to human population growth and agricultural expansion which in turn resulted in increase in riverine vegetation and woodlots. The interviews revealed that selling of land contributed to land use change depending on the intended use of the buyers who were mainly influenced by the physical location with respect to distance to Nairobi, urban centres, electricity supply and road networks. As per the findings of the study, the present scenario demands a revision in the zoning policy using the land use land cover maps produced, involvement of all stake holders and revision of implementation strategies given that the 2008 land use master plan for the area was not actualized.

Key words: Pastoral peri-urban, immigrants, land use change, intended land use, Kajiado County.

INTRODUCTION

Land use is defined by the purposes for which humans exploit the land cover. Proximate causes of land use change are the activities and actions that directly affect land use, for example road building whereas the underlying causes are the fundamental forces that underpin the proximate cause like demographic, economic, policy, technological, institutional and cultural factors (Lesschen et al., 2005). There is high variability in

time and space in biophysical environments, socio-economic activities, and cultural contexts that are associated with land-use change. Identifying the causes of land-use change requires an understanding of how people make land-use decisions and how various factors interact in specific contexts to influence decision making on land use. Decision making is influenced by factors at the local, regional, or global scale (Lambin et al., 2003).

Kenya has experienced rapid changes in land policies that have transformed former pastoral communal lands into group, individual ranches and private holdings. These changes in land tenure systems have led to an emergence of several land-use systems (Kristjanson et al., 2002; Mwangi, 2006). According to Olson, (2006) in East Africa the spatial pattern of land use change for the past 50 years has been characterized by increasingly intensively managed landscape. The driving forces in land use change include demographic changes (local population growth and migration), economic changes (higher relative returns to labour and land in crops than livestock), policies (e.g. land privatization, support for export crops), and changing quality of and access to services and infrastructure (Olson, 2006; Bee et al., 2002; Mwangi, 2006). The world is currently experiencing massive demographic changes through differing rates of natural increase and net migration. Cohen (2004) reveals that the absolute scale of urban change that will be faced in the African continent countries by 2025 will occur in smaller secondary cities and towns similar to Peri-urban Kajiado North District.

Peri-urban areas are the transitional zones between rural and urban landscapes that experience constant population change and disturbance of traditional social, environmental, and economic characteristics (Stockwell et al., 2013) reckons as a result sustainable community development initiatives are complicated in these frag-mented and often contested landscapes. The population increase naturally creates adjustment and readjustment of human and land use activities in space within urban systems thus causing lateral and structural changes (Oluseyi, 2006). Population data are considered the principle source of information on growth of cities (Cohen, 2006). Lateral changes occur when the city expands in geographic boundaries leading to sprawl and peripheral developments. The low density areas gradually become subjected to intensive use and thus become high density or medium density use (Oluseyi, 2006).

Initiatives by stakeholders and Kenyan Government from year 2000 try to limit the land cover land use change and offer guided development given that the area is dispersal and corridor for wildlife from Nairobi National park. A Wildlife Conservation Lease Program (WCLP) was started in year 2000 (Republic of Kenya, 2008: Reid et al., 2008) by the community in partnership with; the Wildlife Foundation, Friends of Nairobi National Park, African Wildlife Foundation, The Nature Conservancy and the World bank, the program requires participants to allow free movement of wildlife on their land, protect natural vegetation, and avoid fencing or sub-dividing their land. Under WCLP landowners are paid a lease fee of four dollars per year whereby entry and exit to the program is voluntary (Republic of Kenya, 2008; Reid et al., 2008). Similar initiatives have been done in USA successfully (Knight, 2002; Bernstein and Mitchell, 2005; Ferguson, 2009) to protect natural or cultural resources. The Kitengela-Isinya-Kipeto land use master plan (LUMP) covering the Kajiado North District drafted in 2008 zones and gives a guideline on minimum land holding sizes with respect to uses in livelihood production activities in designated areas (Republic of Kenya, 2008). This study sought to analyze the trends in land cover and land use changes, human population growth land price trends and assess the community perception on environmental easement and zoning with respect to land use master plan for the area.

METHODS AND MATERIALS

Study area description

The study was carried in the pastoral peri-urban area of Kajiado North District that lies between South of Nairobi City and Nairobi National Park in Kenya. The study area covers 1631.18KM^2 and is located between 36° 37'E to 37°8'E, and 1°23'S to 1°49'S (Figure 1). The District receives a bimodal regime of rainfall, short rains in October – December and long rains in March-May. The annual average rainfall is between 300 and 1300 mm, but it is both unevenly distributed and unreliable. Temperature varies between 13 and 25^{0}C throughout the year. The district is largely semi–arid and lies in agro-climatic zones III to VI with zones IV and V being the most predominant (Jaetzold et al., 2011). This means that the area is mainly suited for ranching activities and early maturing crop varieties. The soils are predominantly Vertlsols with poor drainage and cracking clay.

The area was originally occupied by the pastoral Maasai but currently the population is multi-ethnic due to immigrants who came from other parts of Kenya as land tenure policy changed (Rutten 1992; Olson, 2006). Crop production and intensive livestock production is done mainly by immigrants from other tribes (Jaetzold et al., 2011) while natives are in transition to agro-pastoralism. The district has many land use systems in place; some that have remained in their original uses while others have various uses as a result of single to multiple changes over time through activities like sub-division, sales, quarrying and diversification (Kristjanson et al., 2002). The area serves as a dispersal area for wildlife with calving sites for the wildebeest and movement corridor from Nairobi National Park that necessitated the easement programme (Reid et al., 2008).

Land use and land cover changes analysis

Satellite images were analyzed in conjunction with ground truthing observations as proposed by Thomas and Ayuk (2010) and Kumar et al. (2014). A hand held Global Positioning System (GPS) was used in the ground truthing exercise to ensure that features on ground are in their correct planimetric position on the images. Seven land use classes; range land, bare ground, water body, rocky areas, built-up, crop land, riverine vegetation and woodlots were delineated as the major land use cover types. Weeks (2003) recommends the use of at least two time-period data sets to detect
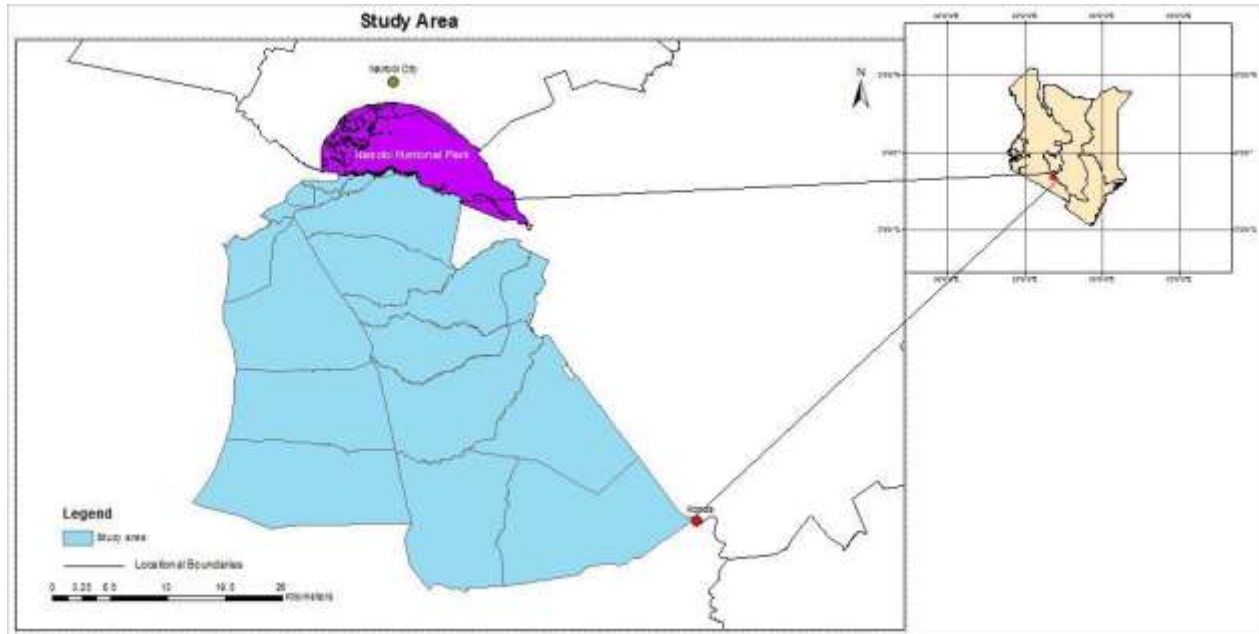
Figure 1. Map of Kenya showing the study area.

changes in land use and land cover through processes such as urban sprawl, because it is change in places over time that we must measure and analyses essentially measure the impact of human settlement by quantifying the change. In this study, three time period Landsat images, that is, one Thematic Mapper (5TM), and two Enhanced Thematic Mapper plus (7 ETM+), for the study area for the years 1984, 2004 and 2010 respectively were analyzed. The images were downloaded from USGS Global Visualization Viewer (GLOVIS, URL: http://glovis.usgs.gov). The selection of the image was based on the acquisition date (season), availability, spatial resolution, percent cloud cover as well as the user need and scale of the study area. A total of 21 spectral bands were downloaded and stacked according to construct 7 band Land Sat TM images for each date (27/8/1984, 23/9/2004 and 19/8/2010). All images coincided with dry season before the onset of short rains in October to avoid uncertainties.

Image classification

Land use and land cover maps were developed from the satellite images through defining spectral classes by clustering image data and assigning pixels into classes. Multi-temporal Landsat data processing was done using ENVI 4.7 software (ESRI, 2009). Regions of Interest (ROI) were defined to extract statistics for classification. Supervised classification was used with false colour composite bands (4, 3, and 2) to cluster pixels in a dataset into classes corresponding to the selected ROI. Supervised classification techniques used to classify the images included minimum distance and maximum likelihood (ESRI, 2009). Seven land use and land cover types were classified according to Andersen (1998)'s guidelines as; range land, bare ground, water body, rocky areas, built-up, crop land, riverine vegetation and woodlots.

Change detection

Change detection was done for the classified land use and land cover types. ENVI EX Software (ESRI, 2009) was used for thematic change detection by comparing two images of different time periods (1984 and 2004 images, 2004 and 2010 images) and overall change between 1984 and 2010.

Community interviews

The household survey was carried out with a sample of randomly selected respondents with a pre-tested questionnaire. Households to be interviewed were randomly selected from the sampling frame developed through generating of random numbers (Aaker et al., 2003) assigned after homestead mapping with help of the local sub-chiefs and village elders of administrative areas from the households in each sub-location. The household was the sampling unit whereby both natives and immigrants were interviewed in the settlement clusters of urban, rural/urban and rural sub-locations. For each household, husband and wife were interviewed. In cases where a man had multiple wives, the resident woman in the household was selected for interview. Interviews were also carried out with women who were heads of households. A questionnaire containing both open-ended and closed-ended questions was administered to four hundred and nineteen households.The interviews were done by trained enumerators under the supervision of the principal researcher. The parameters covered included causes of land use/land cover change, current and future trends, and community perception on environmental easement and zoning with respect to land use master plan.

Observations

Unstructured participant observation took place during household survey in the field (Taylor-Powell and Steele, 1996; Russell, 2006). Unstructured participant observation was used in particular because it allowed the researcher as an insider to be specific as to when and where to observe, what specific aspects of the setting or behaviour to observe, and how to make and record observations.
Photographs were taken of key indicators of trends in land cover

land use change.

Human population and land price trends

Human demographic data spanning from 1979 to 2009 population census were collated from the Kenya National Bureau of Statistics (KNBS) of the Republic of Kenya. This was compared to the land use and land cover change data to establish if there was any relationship between land use change and human population trends. The household survey gave the price trends for the land with respect to physical location for the period 1980-2010.

Data analysis

The area of land under different land uses and cover was used to calculate percentage changes in land use and land cover using Excel software. This was also applied to prices of land under different physical locations. Overall land use and cover changes were calculated from the 1984 and 2010 land sat images analysis statistics and price trends were calculated from 1980-2010 household survey analysis statistics. Chi-square goodness of fit was used to determine if there were significant changes in land use and land cover (Wayne, 2010). Linear regression was used to show the relationship between land use change and human population growth with time (Wayne, 2010). Data from the household interviews were summarized into frequencies of responses.

RESULTS

Change in land use and cover

The Land sat images for years 1984,2004 and 2010 were classified and quantified to seven broad categories of land use and land cover types (FAO, 2011); range land, bare ground, water body, rocky areas, built-up, crop land, riverine vegetation and woodlots (Figure 2). The spatial extents of each category and their percentage changes are tabulated in Table 1. Rangeland, rocky and bare ground decreased while crop land built-up, woodlots and Riverine vegetation increased during the study period. By 1984, built up was confined to a small radius within urban centres but by 2010 it had spread along the road network near urban centres. The most drastic expansion occurred between 2004 and 2010 with more than 500% increase; meanwhile for the entire study period built up increased by 1531.72%. Crop land increased throughout the period of 1984-2010 by 1024%.

Rangeland which consists of forage shrubs and grass decreased throughout the period of the study by 31.45%. This change was significant ($p<0.001$) given that the area is pastoral but overall it covers the largest area in the study location by 44% equivalent to 71828Ha (Table 1). The change in woodlots and Riverine vegetation was impressive given their contribution to the environment. The overall change in Riverine vegetation and woodlots between the three time periods was 2960% increase. This was probably due to immigrants planting trees around their compounds and establishing woodlots of eucalyptus in addition to the spread of the riverine

vegetation along the seasonal rivers.

Between 1984 and 2004, major declining changes were observed mainly in rocky, rangeland and bare ground. Cropland increased from 3187Ha in 1984 to 35843Ha in 2010, which is equivalent to 1025% increase due to activities from the immigrants and natives who had adopted crop production over the years. Compared to all the other land use and land cover types, rangeland showed the least overall changes of 31.42%. Bare land showed the second least overall changes with a decrease of 34.31%. Bare ground and range land combined covered a total area of 95503Ha equivalent to 58% cover of the area by 2010. This means that pastoralism was still the main activity in the area given that the bare lands turn to grass lands during the rainy season. The water bodies had no significant change ($p>0.05$).The image classification result from the landsat images in land cover land use changes between 1984 and 2010 and chi square goodness of fit test to show whether the changes were significant (Table 2).

Human population trends

Human population increase in the district was steady and strongly related to time (Figure 3). Although human population increased throughout the three census periods, a sharp increase occurred between 1999 and 2009 compared to all other time periods. Overall, the study area had a population growth rate of 5.1% between 1989 and 1999 while the rate increased to 16.5% per annum for the period 1999 to 2009 with a population density of 111.6 individuals per Km^2 in 2009. From 1989 to 2009 the area experienced an average annual growth rate of 15.07 % (Republic of Kenya, 1989; Republic of Kenya, 1999; Republic of Kenya, 2009). The population trends between 1989 and 2009 are illustrated in Figure 3.

Land price trends

The urban areas exeprienced the highest price increase per acre during the period 1980-1990 of 190% per year while the rural areas experienced highest price increase during the period 1990-2000 of 90% per year. The respondents gave the average price of land per acre with respect to physical location as tabulated in Table 3.

Causes of land use change

The household survey revealed that sale of land was the major cause of land use change; 94% of the sold land under went change since the new buyers converted it to their intended use. While 6% was due to coping strategies adopted to ensure food security and meet other livelihood needs. Basic amenities like electricity, water, access roads and distance to urban centres influenced buyers' choice of physical location by 75%
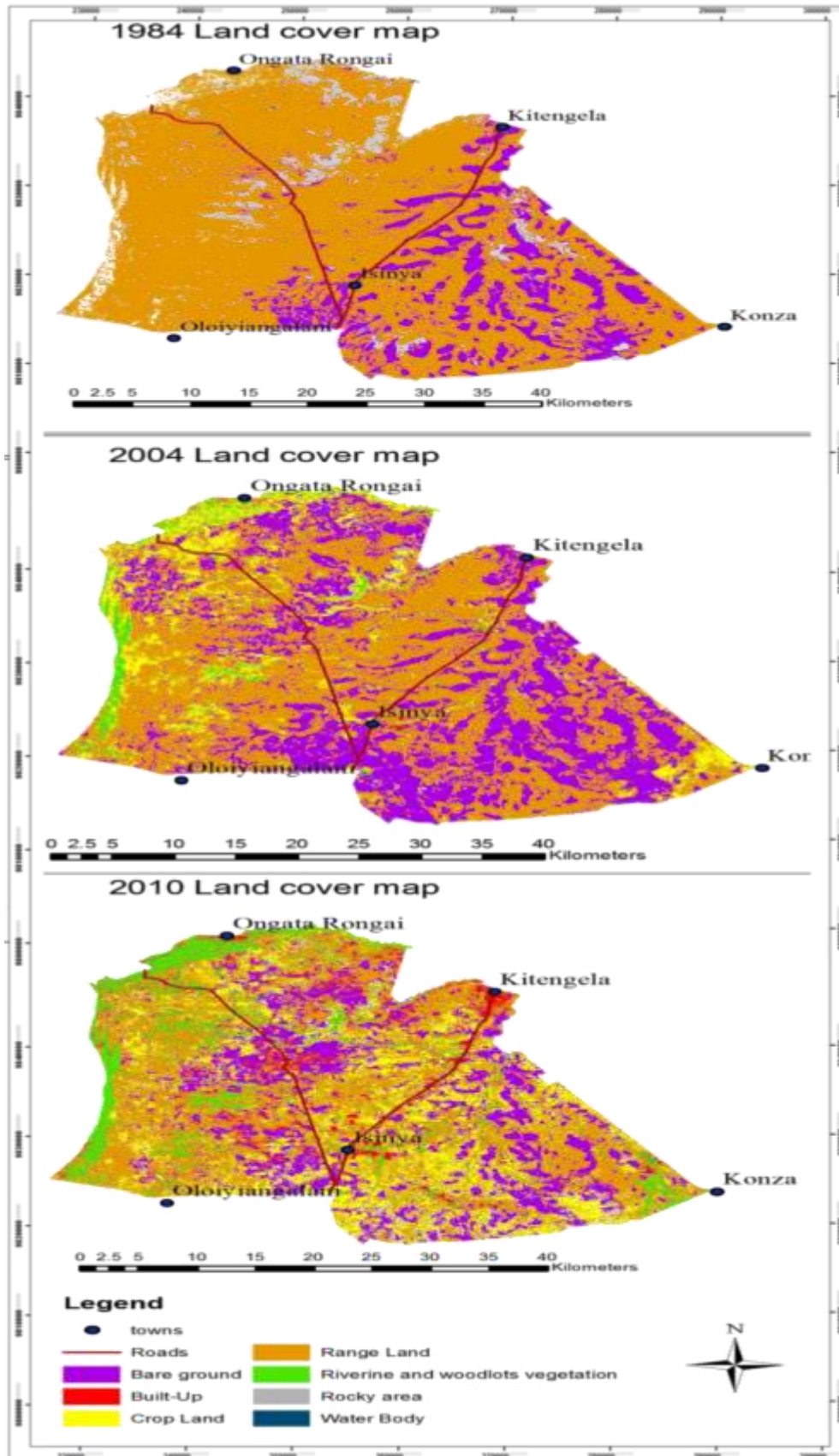
Figure 2. Land use/cover classification results.

Table 1. Extent and proportions of different land use/cover types for the period 1984-2010.

Class Name	1984 Area (Ha)	1984 % area cover	1984-2004 % change	2004 Area (Ha)	2004 % area cover	2004-2010 % change	2010 Area (Ha)	2010 % area cover	1984-2010 % change
Rocky area	18203.96	11.16	-35.34	11771.28	7.21	-25.24	8799.6	5.39	-51.66
Bare ground	36040.1	22.09	-5.24	34150.8	20.92	-30.68	23674.7	14.51	-34.31
Range Land	104740	64.18	-9.74	94540.1	57.93	-24.02	71828.1	44.02	-31.42
Riverine and woodlots	507.25	0.31	820.29	4668.21	2.86	232.57	15525.1	9.51	2960.62
Crop land	3187.28	1.95	427.07	16799.2	10.29	113.36	35842.6	21.96	1024.55
Built-Up	457.80	0.28	168.09	1227.32	0.75	508.65	7470.04	4.58	1531.72
Water Body	50.34	0.03	-40.79	29.80	0.018	56.15	46.54	0.029	-7.55

Table 2. Chi-Square goodness of fit test for the various land use /land cover changes in Kajiado North district between 1984 and 2010.

Class name	1984 Area Km^2	2004 Area Km^2	2010 Area Km^2	1984-2010% change	X2	df	P
Rocky area	182.04	117.71	88	-51.66	36.375	2	<0.001
Bare ground	360.4	341.51	236.75	-34.31	28.47	2	<0.001
Range Land	1047.4	945.4	718.28	-31.42	62.725	2	<0.001
Riverine and woodlots	5.07	46.68	155.25	2960.62	172.54	2	<0.001
Crop land	31.87	167.99	358.43	1024.55	289.64	2	<0.001
Built-Up	4.58	12.27	74.7	1531.72	94.71	2	<0.001
Water Body	0.5	0.3	0.47	-7.55	0	2	1
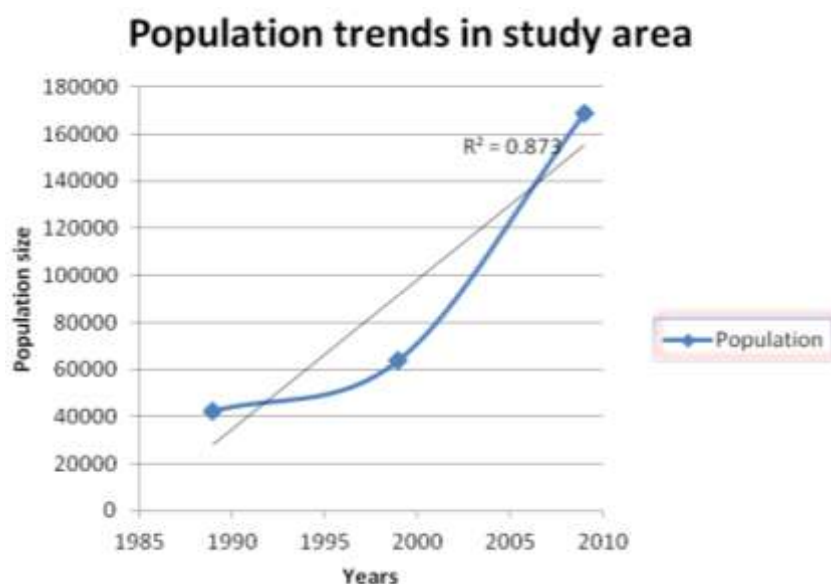
Figure 3. Human population trends between 1989 and 2009.
Source Kenya National Bureau of Statistics 1989, 1999, 2009.

while the rest bought for speculative purposes like price appreciation and the upcoming Konza techno-city. The sellers were influenced by peer pressure (60%) to enable them afford good lifestyles (cars and houses), temptation from appreciating prices (20%), low age of household head (5%) while 15% were influenced by several factors

Table 3. Trends in land prices and %change for years 1980-2010.

| Physical location | Land prices in ksh/acre ('000')and percent annual change | | | | | | |
	1980 Average Price/acre	1990 Average Price/acre	1980-90 annual % price increase	2000 Average Price/acre	1990-2000 annual % price increase	2010 Average Price/acre	2000-2010 annual % price increase
Urban	10	200	190	1,000	40	15,000	140
Rural	3	10	23	100	90	600	50

Table 4. Complaints associated with easement program.

Complaint	% of respondents affected
Discouraging low compensation rate	85
Stiff competition with the livestock for water and pasture especially during the dry periods given that there is a decline in land holding capacity	60
Wildlife facilitates the transmission of certain livestock diseases e.g. East Cost fever (ECF), increasing veterinary care costs and high mortality rates	50
Maintaining fences around homesteads and other structures, indirectly through labour	68
Livestock predation and destruction of crops by wildlife	90

which included but not limited to education level of household head and brokers.

Community perception on environmental easement and zoning with respect to land use master plan

The environmental easement level of awareness was low at the time of program inception, 27% with mistrust of the natives' thinking that it was a ploy to acquire their land forcefully and they were not certain that they will receive compensation. On the future of the program 72% of the respondents recommended that the easement programme to be done away with and make Nairobi national park a zoo. Meanwhile, 13% of the respondents recommended that the wildlife corridor land should be bought from farmers at market rate and fenced off to be used by wildlife alone and finally 15% felt that the residents should be encouraged to participate in the easement programme by increasing the compensation rate. The natives did not mind wildlife mixing with livestock but they had some complaints as Tabulated in table 4.

In the household survey results for LUMP, 68% recommended revision with more participation of all stakeholders on the ground since majority of buyers were absent when it was done last, 22% recommended enforcement due to land commoditization and degradation and 10% said the government should forget about it since the land was already too fragmented and trend was bound to continue with succession and population increase. Finally, 34% of the respondents considered the area to have undergone degradation due to human activities and invasive weeds during the study period.

Observations

Several cooperatives societies have bought large pieces of land for subdivision to members and private educational institutions for expansion purposes. Observations revealed that most immigrants have established woodlots which are about 10-15 years old as they plant trees and live fences around their compounds. There is increase riverine vegetation comprising acacia species, *A.kirkii* and *A.elatior* (*Olerai* –local maasai name) established along dry river beds of seasonal rivers as they are well adapted. Homesteads have been abandoned due to invasive live fencing of *Opuntia subalata;* meanwhile, large areas of rangelands are covered by the invasive ipomoea weed. Gypsum mines and stone quarries have left large un-rehabilitated areas with plenty of resultant wastes. Some indicators of land use change as captured in the field photographs are shown in Figure 4.

DISCUSSION AND RECOMMENDATIONS

Satellite image analyses showed that land use and land cover changes have occurred in the study area between 1984 and 2010. Pastoral and wildlife dispersal areas were converted to settlement areas leading to general increase in crop land, woodlots and Riverine vegetation. The household survey revealed that land use and land cover changes in this district have been occasioned by

Figure 4. Indicators of land use change as captured in the field photographs.

the increased demand for land resources for individual and institutional property developments together with agricultural activities, infrastructural improvement and population increase. Increased crop production was done to address food security and by immigrants from high potential areas (Jaetzold et al., 2011), who naturally do crop cultivation. Same scenario of increase in crop production has been witnessed in similar pastoral areas (Lynn, 2010) where pastoralists adopt crop production due to changing cultural and social norm to be food secure. McCabe et al. (2010) reckon that the Maasai in

North Tanzania had to adopt crop production to remain pastoralists. In semi arid Ethiopia (Desta and Coppock, 2004) and in Kenya (Bebe et al., 2012), decline in household per capita cattle holdings and population pressure led to diversification to crop production to achieve food security and improve their livelihood.

There was general decrease of both range land and bare ground between 1984 and 2010, leading to decline of part of the district which is also a pastoral and wildlife corridor/dispersal area. The degradation in the area also contributed to a decrease in range lands and was mainly

attributed to increased human activities like cultivation, waste disposal, and introduction of invasive species *like Opuntia subalata* (introduced for fencing to secure homesteads) and *Ipomoea kutensis* (covering large areas of the range lands), un-rehabilitated stone and gypsum quarrying mines. The future forecast of pastoral activities is bound to decrease since most range lands are either degraded or in accessible as they are fenced off by the new owners as observed during data collection (Reid et al., 2008: Nkedienye et al., 2009*)*.

The trends in water bodies can be attributed to decline in the water pans and dams which were done in the 1980s by the Ministry of Livestock Rutten (1992) and had silted in 2000 (Republic of Kenya (2008); but again individuals and the government initiated construction to address declining water availability through the Arid Lands Resource Management Project Republic of Kenya (2010). The time period coinciding with the highest population increase (1999 to 2009) also coincides with the highest increase in Riverine vegetation and woodlots, corresponding increase in human dominated activities of agriculture as the rocky decreased due to excavation of building material. The increase in woodlots and Riverine vegetation is actually beneficial to the ecosystem given that forests ecosystems play a key role of maintaining biological diversity and provide environmental services to humans and nature (UNEP, 2002).

Kajiado North area is experiencing increased fragmentation (Rutten M., 2008; Nkedienye et al., 2009); as a result of an influx of immigrants and institutions of higher learning, the most probable trend in the next five years will be an increase in built –up area and crop land. There appears to be a relationship between land use change and human population growth dynamics in Kajiado North district. Brockerhoff (2000) defines a sprawled urban area as one in which land is developed by roads, buildings, and other infrastructure at a faster pace than population growth which is actually the case given that built up increased by more than 1531% as population increased by 15.07% during the study period. Increased fragmentation of pastoral land in the peri-urban area of Kajiado North district is mainly caused by urban sprawl as can be confirmed by the population trends and increase in built-up areas. This situation is made worse as no physical plan (G.O.K., 2008: Kioko and Okello, 2010) is used to direct developments.

Uncontrolled sprawl resulting from informal settlements in the absence of government guidelines and enforcement is a reality in many Eastern African cities UN-Habitat, (2010) and in developing regions, urban expansion has taken the form of 'peripherization' that is characterized by large peri-urban areas with informal and/or illegal patterns of land use (UN-Habitat, 2013;UN, 2013). According to UNEP (2002), most activity addressing urban sprawl takes place at the planning level of government as found out when comparing Canada and USA; where in the former the government planned from the start by instituting long range transportation systems. However in much of

Sub-Saharan Africa (UN-Habitat, 2010), decision-making has been only consultative rather than genuinely participatory, with the attendant lack of effective impact, a scenario we can identify with in study area's LUMP of 2008; hence revision should be in accordance with the views of all current land owners to guide and control development.

The easement programme may not achieve much in the study area due to increase in population and fragmentation. There is need to explore other options while taking the residents' recommendation of government to buy the wildlife corridor like Transfer of Development Rights (TDR), (Pruetz and Standridge, 2009; Cohn and Lerner, 2003; Walls and McConnell, 2007), which is a mechanism for preserving farmland, open space, and natural resources practised in United States of America for more than 40 years. In the United States of America TDR and easements have success stories (Walls and McConnell, 2007; Jacobs, 2014; Ferguson, 2009) in several States where forests, wetland and landscapes have been conserved as TDR markets work as a land preservation tool when landowners are willing and able to sell development rights, and developers are interested in buying those rights. The low compensation rate can be addressed by benchmarking with Tanzania where a collaborative easement arrangement with the stakeholders achieved conservation of designated areas successfully as the local community earned more than compensation per hectare since creative mechanisms for channelling benefits to communities were developed as the natural resources were managed in a bottom-top approach (Sachedina and Nelson, 2012). In African communities, Elliott and Sumba (2010) identify six characteristics of a conservation enterprise that is more likely to work well through linking livelihood benefits with conservation gains: clear conservation logic, commercial success, right private sector partner able to perform collaboratively, sound community partner with appropriate governance in place, contractual community ownership and enforcement of benefit streams, transparent intra-community benefit-sharing arrangements and most of these were missing in the current easement program.

In conclusion, the adoption of major land use reforms through laws, plans, regulations, capital improvement plans, data and research reports can only occur when there is the right combination of leadership and public opinion in a comprehensive way as recommended by ILUASC (2010) and Belton (2012) in the USA. In essence all stakeholders must be involved in decision making and implementation for success of land use land cover initiatives. When considering the easement programme, the residents should get benefits from wildlife earnings and they should not feel exploited by low compensation rates.

Conflict of Interests

The authors have not declared any conflict of interests.

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