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Climate change adaptation strategies by small-scale farmers in Yatta District, Kenya

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Climate change is a great environmental challenge facing humanity today. In Yatta District, residents report frequent crop failures, water shortages and relief food has become a frequent feature of their life. This study examines the adaptation strategies to climate change adopted by the dry-land farming communities in Yatta District. Study participants included 510 randomly sampled small-scale farmers. Key informants were district departmental heads from the Ministries of Water, Agriculture and Environment. Questionnaires, interviews, Focus Group Discussions and field observations were used to generate the data. Quantitative data was analysed using Statistical Package for Social Sciences (SPSS) whereas qualitative data was analysed through establishing the categories and themes, relationships/patterns and conclusions drawn in line with the study objectives. Findings indicate that most farmers adopted autonomous adaptation strategies that included planting drought tolerant crops (76.5%), charcoal burning (52.9%) and rainwater harvesting (20.2%) among others. Chi square results indicated that age, level of education and knowledge of climate change had significant influences on adaptation strategies. Some of these strategies had serious adverse environmental impacts on social, economic and biophysical domains of the environment like putting future agricultural production at risk since farms have been converted into sand mining fields. Major limitations to climate change adaptation were financial constraints (93.4%), lack of relevant skills (74.5%) and lack of scientific and technical knowledge (71.6%). The study concludes that farmers are engaging in adaptation strategies that are fundamentally changes in livelihoods and mainly unsustainable. Livelihood activities such as charcoal burning and sand harvesting in their fragile arid and semi-arid lands ecosystem are destructive and thus, not sustainable. These livelihood changes are significantly influenced by levels of education and climate change knowledge. The study recommends that agricultural extension services be enhanced to sensitize the farmers about climate change thus improving their perception and adaptation strategies.

Key words: Climate change, small-scale farmers, adaptation strategies.

INTRODUCTION

Climate change refers to a change in the state of the climate that can be identified by changes that persists for an extended period, usually decades or longer (IPCC, 2007). The United Nations Framework Convention on Climate Change (UNFCCC, 2007) have argued that climate change may have a permanent negative impact on the natural resource base upon which agriculture thrives especially considering that it is happening at a time of growing demand for basic human requirements such as food, fibre and fuel. Agriculture on the other hand is highly dependent on the climate and human dependence on agricultural livelihoods particularly the poor is high (Slater et al., 2007).

In Kenya, climate change has had far reaching effects since majority of the country's population depend on rain-fed agriculture. Seventy five per cent of Kenya's population depends on agriculture for food and income and the sector contributes 26% to the Gross Domestic Product and 60% to foreign exchange earnings (Perret, 2006). Over the past decade, the incidence and intensity of hunger and malnutrition has increased significantly and food availability has not kept pace with the rapidly growing population in Kenya (Shori, 2000).

The regions that are associated with hunger are mainly the arid and semi-arid lands. Decreased food production and famine are very regular in these areas despite the involvement of the largest proportion of population in agriculture. Increasing temperatures and frequent droughts have worsened the already fragile situation of the small-scale farmers who rely on rain-fed agriculture for survival. Indeed droughts have been a regular occurrence in the past in many parts of the world with grave consequences on food security and malnutrition (FAO, 2011). With climate change, severe droughts are likely to occur more often and to affect larger areas (FAO, 2011). Yatta District lies in these arid and semi-arid areas characterized by frequent droughts and food insecurity. Agriculture is the most important sector in this district contributing 70% of the district's household income (Republic of Kenya, 2009). However, inadequate and unreliable rainfall, environmental degradation, low investment in irrigation infrastructure, high post-harvest losses and poor farming methods in the district leads to food insecurity.

Presently in Yatta area, seasons that were predictable are no longer predictable. Season rains are erratic and droughts have become more frequent and severe (Mburu et al., 2014). The change of weather has brought many pests and diseases to the plants and animals. Rivers such as Ngomola, Kamanguli, Mukengesya, Iuuma and Inyanzaa have dried up as a result of climate change. Many plant species of social importance have also become rare over the years. Overall, climate change has brought poverty to the people of Yatta and relief food has become a permanent feature in their lives. To cope with these changes small-scale farmers have devised their own adaptation strategies.

According to UNDP (2004), adaptation is a process by which strategies to moderate and cope with the consequences of climate change can be enhanced, developed and implemented. Adaptation to climate change involves changes in agricultural management practices in response to changes in climate conditions and often involves a combination of various individual responses at the farm-level (Shashidahra and Reddy, 2012).

The objective of this study was to examine the adaptation strategies to climate change adopted by the dry-land small-scale farming communities in Yatta District. The study also assessed the environmental impacts of such adaptation strategies.

METHODOLOGY

Study area

The study was carried out in Yatta District in Kenya (Figure 1). Yatta is situated between longitudes 37^0 20' and 37^0 55' East and between latitude 0^0 50' and 1^0 30' South. Part of the district falls on Yatta Plateau, which is a long, flat-topped ridge formed by a stream of lava flow from OlDonyoSabuk Mountain. It covers a total area of 2,469 Km^2 and has a population of 299,435 inhabitants (Republic of Kenya, 2009). The main soil types are Acrisols, Luvisols, Ferralsols, Alfisols, Ultisols, Oxisols and Lithisols (Lezberg, 1988; Barber et al., 1981; Scott, 1963). These soils are all generally of low fertility and many are highly erodible. The dominant vegetation is dry bush (Lerberg, 1988). The district receives about 450-800 mm of rainfall per year and average temperatures range from 25 to 29°C (Republic of Kenya, 2009). The population density is influenced by land productivity and water availability.

Sampling and sample size

A representative sample size for the survey was determined by using Krejcieand Morgan's (1970) formula commonly used to calculate a sample size from a given finite population (P) such that the sample size will be within plus or minus 0.05 of the population proportion with a 95% level of confidence (Equation 1: sample size determination).

$$s = \frac{X^2NP(1-P)}{d^2(N-1) + X^2P(1-P)} \quad (1)$$

Where: X^2 = table value of Chi-Square for 1 degree of freedom at the desired confidence level (in this case 3.84), N = the population size, in this case 299,435, P = the population proportion (assumed to be 0.5 since this would provide the maximum sample size), d = the degree of accuracy expressed as a proportion (0.05). This formula gave 384 as the minimum sample size for the study. However, a larger sample size was considered to account for non-responses. Since sampling was farm based, to cover as much study area as possible, one sub-location was randomly selected in each of the 17 administrative locations. From each of the sub-location, 30 farmers were randomly selected, giving a sample size of 510 farmers in total. District heads of agriculture, environment

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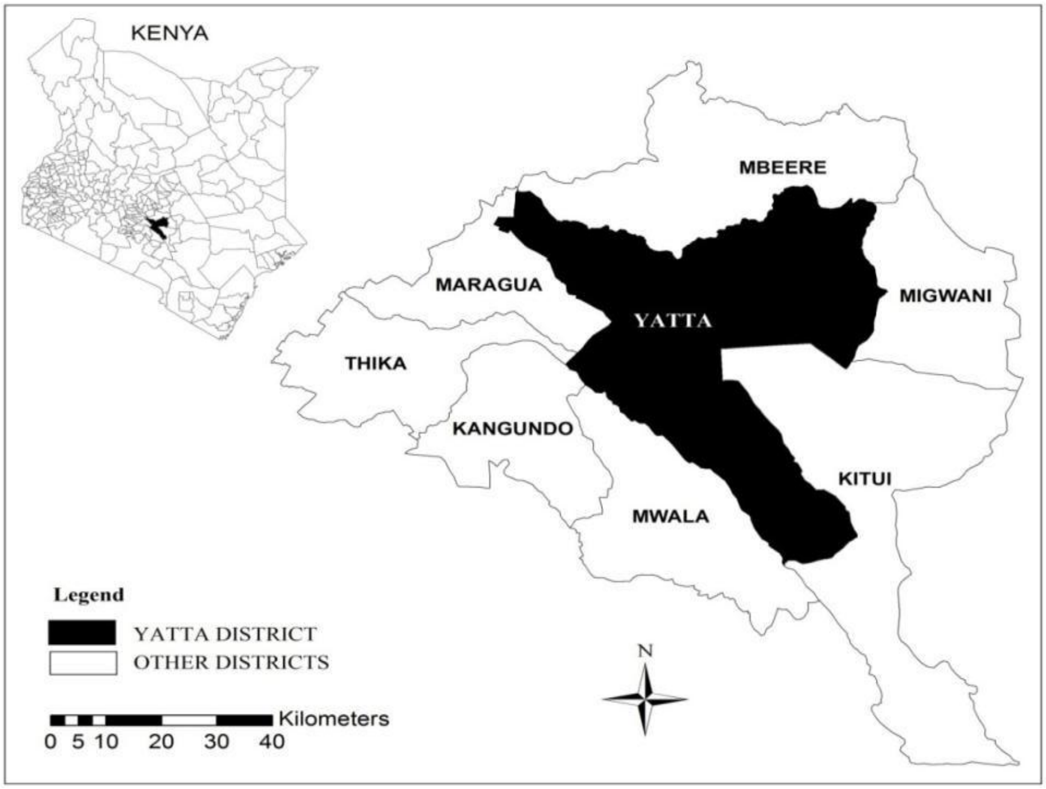

Figure 1. Study area location. Source (GoK, 2009).

and water departments were also interviewed. Four single sex Focus Group Discussions (FGDs) comprising of eight to twelve farmers were conducted.

Data collection and processing

The study being primarily a survey research employed several methods for data collection including the use of questionnaires, interviews schedules, FGDs, desk research and observations from the field. The study adopted the Participatory Vulnerability Profiles (PVP) approach as used by Haan et al. (2001). The PVP focused on current vulnerability, risk of present and future climatic variations and responses to reduce present vulnerability and improve resiliency to future risks. This approach placed the stakeholder at the centre of the research, which is important because the people in the region have developed indigenous knowledge systems that have enabled them to cope so far with the climate change phenomenon.

Data analysis methods

The collected data was analysed using both quantitative and qualitative techniques. Frequency counts, means and percentages were computed for all quantitative data and results presented using frequency distributed tables. Chi-square test was used to determine relationships between adaptation strategies and background variables like age, level of education and knowledge of climate change. FGDs results were transcribed and translated and then analysed qualitatively which basically involved establishing the categories and themes, relationships/patterns and conclusions drawn in line with the study objectives (Gray, 2004).

RESULTS AND DISCUSSION

Farmers in Yatta district were engaging in various strategies to adapt to climate change (Table 1). Such adaptation strategies included planting drought tolerant crops, charcoal burning, rainwater harvesting and joining community based organizations (CBOs) addressing climate change challenges among others (Table 1). These adaptation strategies were mainly autonomous adaptations where farmers changed their livelihoods in response to changing climate. These kinds of adaptations are based on accumulated knowledge and experiences over the years by the residents.

These results corroborate findings by Boko et al. (2007) who noted that strategies of adaptation already observed in Africa include diversification of livelihood activities, adjustments in farming operations and selling of labour. According to Benedicta et al. (2010), the main adaptation strategies of farmers in Sekyedumase District in Ghana include change in crop types, planting short season varieties, changing planting dates and crop diversification.

According to Sekaleli and Sebusi (2013), some of the farmers' adaptation strategies in Lesotho include water harvesting technologies, conservation tillage, use of

Table 1. Adaptation strategies to climate change.

Adaptation strategies	Frequency	%
Planting drought tolerant crops	372	76.5
Charcoal burning	257	52.9
Joining CBOs addressing climate change challenges	100	20.6
Rainwater harvesting	98	20.2
Apiculture (honey production)	96	19.8
Sand scooping	91	18.7
Hunting	73	15.0
Irrigation agriculture	64	13.2
Migration to other areas	37	7.6
Greenhouse farming	5	1.0
Fishing	15	3.1

keyhole and trench gardens, agro-forestry and application of traditional medicine to control pests and diseases. Women farmers in Peru take advantage of the knowledge inherited from ancient Peruvian culture. They adapt though postponing planting season when the rains delay, crop rotation, production diversification, production of native crops and migration to look for jobs among others (Abeka et al., 2012).

In china, farmers have implemented their own adaptation strategies, such as changing cropping patterns, increasing investment in irrigation infrastructure, using water saving technologies and planting new crop varieties to increase resistance to climatic shocks (Wang et al., 2010). In the USA farmers adapt to the changing climate by choosing crops resilient to drought and pest risk, plant different crops according to slope, aspect and other highly site-specific conditions. They also apply different practices such as tillage, technological advances including information to manage market risk (Antle, 2009). Farmers in Europe adapt to climate change through infrastructural measures such as on-farm harvesting and storage of rainwater, management measures and technical measures (Iglesias et al., 2007). The main adaptation strategies in Yatta District are discussed below.

Planting drought tolerant crops

The results of this study show that most farmers (76.5%) (Table 1) planted drought tolerant crops such as *Sorghum bicolor*, *Cajanus cajan, Vigna unguiculata, Vigna radiata, Dolichos lablab* and *Manihot esculentum* among others. Chi square results indicated that age had a significant influence on planting drought tolerant crops (X^2=9.259, df=3, $p<0.05$) whereby the elderly farmers are more likely to plant drought tolerant crops. This can be explained by the farming experience gained over the years by the older farmers. Periodical droughts are part of the climate system in Yatta district and due to this the older farmers have learnt to plant drought tolerant crops. Maddison (2006) argued that, if farmers learn gradually about the change in climate they would also learn gradually about the best techniques and adaptation options available. According to Shongwe et al. (2014) in a study in Swaziland, the choice of adaptation strategies by households was significantly influenced by age of household head. The age of the household head represents experience in farming. Experienced farmers perceive climate change better as they are exposed to past and present climatic conditions over their life span and hence the higher chance of planting drought tolerant crops. Additionally, the level of education had a significant influence on planting drought tolerant crops also (X^2=12.87, df=3, $p<0.05$). The higher the farmers' level of education, they are more likely to plant drought tolerant crops. Knowledge gained through education exposes the farmers to the advantages of drought tolerant crops hence planting them. Looking at the combined factors of education and age, the latter is more significant in Yatta since most of the educated people prefer seeking employment in urban areas to farming.

The characteristics of drought tolerant crops such as withstanding low water and high heat conditions (Borel, 2009) leads to reasonable harvests even with low rainfall. These characteristics lead to reasonable harvests even with low rainfall. The crops offer an alternative to suffering from hunger through seasons due to crop failure.

However, during FGDs farmers observed that planting *Sorghum bicolour*is unpopular since they have to wake up very early in the morning to drive the birds away. According to the District Crops Production Officer, farmers in this region are faced with perennial famine because they rely on maize and other crops that need plenty of rain. There is need to diversify the varieties of drought tolerant crops they plant in order to alleviate poverty.

Charcoal burning

The study established that 52.9% of the farmers burn charcoal mainly for commercial purposes in order to meet their domestic needs. Chi-square test results showed that knowledge of climate change had a significant influence on charcoal burning (X^2=18.405, df=2, $p<0.05$) whereby the higher the knowledge level, the less likely they are to burn charcoal. The level of education also had a significant influence on charcoal burning (X^2=11.207, df=3, $p<0.05$) in that the less educated the farmersare, the more likely they are to burn charcoal. Education exposes the farmers to the role played by trees in mitigating climate change and as such the more educated the farmers are, the less likely to burn charcoal. As verified by the results, those farmers with a good knowledge about climate change would not cut down trees for charcoal burning. This is because they understand the consequences of cutting down trees on the climate of the area. Indeed Tadesse (2010) observed that knowledge and access to information are essential for effective environmental management and have significant impacts on the economy and the livelihood choices people make.

The farmers pointed out that they use species such as *Terminali abrownii* (*Fresen*)**,** *Dalbergia melanoxylon* (Guill.&Perr)*, Acacia tortilis* (Forssk.)*, Acacia Senegal* (*L.*) *Willd, Melia volkensii, Albizia anthelmintica* (Brongn)and *Acacia mellifera* (*Vahl*) *Benth* among others for charcoal making. All these are trees of significant ecological importance in the dry lands. From field observations and farmers' responses regarding species that used to be common in Yatta area but are now very difficult to find, it was evident that charcoal burning has contributed to the disappearance of some of these species. Species such as *Dalbergia melanoxylon* and *Albizia anthelmintica* are quite rare in Yatta district. Indeed *Dalbergia melanoxylon* is listed in the IUCN Red List (2010) as a near threatened species.

Sand harvesting

The results show that 18.7% (Table 1) of the respondents were involved in sand harvesting as a form of adapting to climate change. Sand is harvested on the farms and in the rivers both seasonal and permanent. Harvesting is also carried out along the road sides and wherever sand is available. It is a business that has attracted many young men in this region. The National Environmental Management Authority (NEMA) has tried to regulate this business through issuance of national sand harvesting guidelines (NEMA, 2007). However, this has been without much success in Yatta District mainly due to lack of personnel to enforce the guidelines and also the fact that the government is yet to gazette them. The county government also encourages sand business as a source of revenue. The District Environment Officer concedes that issues of illegal sand harvesters are a serious problem especially in Thika River and in areas around Kamburu and Masinga dams.

Rainwater harvesting

The study reveals that only 20.2% of the respondents were involved in rainwater harvesting both in their homesteads and on farms (Table 1). This is dismal bearing in mind that Yatta is a semi-arid area where droughts are becoming more frequent and rains more erratic and unreliable. According to Ngigi (2009), farmers in Ethiopia and other parts of Kenya have shown high adoption rates for farm ponds and other rainwater harvesting technologies. Indeed rainwater harvesting can offer a partial solution to the issue of climate change. Majority (93.4%) of the respondents attributed their lack of harnessing rainwater to inadequate finances. Among these 20.2% of the respondents harvesting rainwater, majority were using small containers such as drums, buckets and jerry cans. Very few had water tanks. Other homesteads had grass thatched rooftops which are not suitable for rainwater harvesting.

Less than 2% of the respondents practised road runoff water harvesting on the farms. Respondents attributed this deficit to lack of finances to dig retention ditches that are necessary for storing the storm water and allowing a slow seepage into the farm. Road runoff water provides additional environmental flows and additional water for food production and it is possible to double or triple crop yields through this technique (Ibraimo and Munguambe, 2007). Respondent farmers practising this technique reported improved food security in their households. These findings agree with the results of an evaluation of rainwater harvesting techniques conducted in Laikipia District that showed road runoff water utilization for crop production is already improving yields (Kihara, 2002). Responding to water scarcity stress and the threat of declines in crop yields require farm level intervention such as rainwater harvesting and establishing small-scale water reservoirs on farmlands (Osman-Elasha, 2010).

Other adaptation strategies

Other adaptation strategies devised by farmers in Yatta district included greenhouse farming (1%), apiculture (19.8%), hunting (15%), irrigation agriculture (13.2%), joining CBOs addressing climate change challenges (20.6%), fishing (3.1%) and migration to other places in search of casual labour (7.6%) (Table 1). Those who had joined CBOs consisted of 22% of all male respondents and 17.8% of all female respondents. During FGDs, respondents also reported that they are nowadays doing family planning, rationing food in their homes, forming self-help groups, establishing kitchen gardens, storing fodder and turning to goat milk as ways of adapting to climate change. Chi-square test revealed significant relationship existed between joining CBOs and planting drought resistant crops (X^2=23.88, df=1, $p<0.05$). Significantly more of those farmers who had joined CBOs

Table 2. Environmental impacts of farmers' adaptation strategies in Yatta district.

Impacts of sand harvesting N = 91	**F**	**%**	**Impacts of greenhouse N = 5**	**F**	**%**
School drop out	60	65.9	Improved harvest	5	100.0
Drug and alcohol abuse	85	93.4	Controlled plant diseases and pest	4	80.0
Insecurity	90	98.9	Improved export market	2	40.0
Sexual immorality	75	82.4	Efficient water utilization	4	80.0
STDs and early pregnancies	35	38.5	Altered land aesthetics	1	20.0
Divorce	15	16.5	**Impacts of joining CBOs N = 100**	**F**	**%**
Rivers drying increasing water distance	72	79.1	Sharing of knowledge and skills	65	65.0
Source of livelihood	90	98.9	Acquiring scientific and technical knowledge	12	12.0
Aquatic life poisoning by oil/fuel spills	3	3.3	Environmental conservation skills and knowledge	9	9.0
Derelict land	1	1.1	Tree planting	88	88.0
Vegetation destruction	8	8.8	**Impacts of rainwater harvesting N = 98**	**F**	**%**
Accidents	5	5.5	Clean water availability	90	91.8
Impacts of charcoal burning N = 257	**F**	**%**	Improved yields	30	30.6
Air pollution	103	40.1	Better sanitation at home	76	75.6
Low rainfall	7	2.7	More time to do other chores	90	91.8
Soil erosion and degradation	187	72.8	**Impacts of fishing N = 15**	**F**	**%**
Deforestation	111	43.2	Food	5	33.3
Biodiversity loss	8	3.1	Income	15	100.0
Health problems	134	52.1	Accidents	2	13.3
Source of livelihood	120	46.7	**Impacts of migration N = 37**	**F**	%
Impacts of planting drought tolerant crops N = 372	**F**	**%**	Family separation	25	67.6
Source of food	268	72.0	School drop out	18	48.6
Soil structures protection	7	1.9	Land left idle	7	18.9
Improved harvests	300	80.6	**Apiculture N = 96**	**F**	**%**
Loss of income	272	73.1	Income	13	13.5
Interference with following season planting	8	2.2	Food	17	17.7
Small scale irrigation N = 64	**F**	**%**	Bush fires	7	7.3
Food	22	34.4			
Income	21	32.8			
Water borne diseases	3	0.6			

(95.0%) were planting drought resistant crops as compared to 71.8% of those who had not joined CBOs.However, membership in CBOs had no significant effect on rain water harvesting.

Environmental impacts of adaptation strategies employed by farmers

To counter the effects of climate change, farmers adopted various strategies ranging from changes in livelihood to new farming strategies. These changes in agricultural management practices and livelihoods by the farmers in response to changes in climate often result into positive or negative effects to the land and ecosystems. The respondents were aware of both negative and positive environmental impacts of their adaptation strategies. It was quite evident that some adaptation strategies had serious adverse impacts on both social and biophysical domains of the environment. More so the future of agriculture is put at risk by some of these strategies. The impacts range from biophysical, social to economic impacts (Table 2).

Environmental impacts of sand harvesting

The findings showed that sand harvesting is one of the adaptation strategies with serious negative impacts on both social and biophysical domains. Many social problems were associated with sand harvesting activities. Issues of early pregnancies (38.5%), children dropping out of school (65.9%), prostitution (82.4%), drug and alcohol abuse (93.4%) and insecurity (98.9%), sexually

Figure 2. Impacts of sand harvesting on the farms at Manaja area.

transmitted diseases such as AIDS (38.5%) and divorce (16.5%) among others were reported (Table 2).

In Manaja area, this strategy has put future agricultural production at risk since farms have been converted into sand mining fields. As observed during transect walks in the area, many farms have been dug up destroying most of the land that can be cultivated for growing crops. Some farms have been dug beyond two meters deep leaving behind derelict land (Figure 2). This further exacerbates the food security situation in Yatta District.

Sand harvesting has destroyed vegetation including cash crops such as mangoes and even encroached homesteads (Figure 2). Respondents observed that instream sand harvesting has led to drying of rivers further complicating the issue of water scarcity in Yatta area. In Kithyoko Location, respondents noted that sand harvesting has increased their average walking distance to fetch domestic water to three kilometres one way. Rivers like Mukengesya, Iyuuma, Inyanzaa and Kamanguli have dried up due to excessive and uncontrolled sand harvesting. However, economically the adaptation had positive impacts as a source of livelihood through the provision of employment opportunities.

In other areas such as India, fifteen adverse consequences of sand mining have been identified. They include depletion of groundwater; lesser availability of water for industrial, agricultural and drinking purposes; destruction of agricultural land; loss of employment to farm workers; threat to livelihoods; human rights violations and damage to roads and bridges (Saviour, 2012).

Environmental impacts of charcoal burning

The environmental impacts associated with charcoal burning in the study included air pollution (40.1%), low rainfall (2.7%), soil erosion and degradation (72.8%), deforestation (43.2%), biodiversity loss (3.1%), health problems (52.1%) and source of livelihood (46.7%). Some of the tree species preferred for charcoal burning by the respondents have become very rare in the area. Indeed the Environment Officer confirmed that charcoal burning has seriously affected tree species such as *A. senegal, D. melanoxylon* and *A. tortilis*.

Elsewhere, charcoal burning has been reported to result into loss of biodiversity, soil erosion, recurrent droughts, migration to urban centers, decline of wildlife, scarcity of woody resource and watershed degradation (MoPD&E& CLHE, 2004). Charcoal burning also negatively affects the environment through the emission of high levels of carbon dioxide, which is one of the major greenhouse gases that contribute to global warming and climate change (Wario and Bowa, 2011).

Environmental impacts of planting drought tolerant crops

Planting drought tolerant crops was reported by the respondents to have both positive and negative environmental impacts. These included alternative source of food (72.0%), soil structure protection (1.9%), improvement of harvest stability (80.6%), loss of income (73.1%) and interference with the following season's planting (2.2%). The respondent farmers observed that, even though they mostly focus on growing marketable crops like maize, they also grow some drought tolerant crops such as *Sorghum bicolor*, *C cajan, V. unguiculata, V. radiata, Dolichos lablab* and *M. esculentum* for their household consumption (Figure 3). These drought tolerant crops provide an alternative source of food in seasons where maize fail and improve harvest stability.

Drought tolerant crops such as *S. bicolor*, *C. cajan, V. unguiculata, V. radiata,* and *Dolichos lablab* among others lend greater resilience to agricultural production

Figure 3. Intercropping of *Vigna radiata*, *Zea mays* and *Cajanus cajan* in alley farming

under water stress conditions and may also reduce a farm's water requirements (FAO, 2012; CGIAR, 2012). Early maturing varieties of these crops such as *V. radiata* have proved especially useful for helping dry land communities get through the "hungry season"- period before harvest when the previous year's grain supplies have been exhausted. The successful harvests that farmers have had after sowing the drought tolerant crops suggest that food security could be better achieved if more farmers grew adapted crops which survive dry spells and erratic rainfall (ICRISAT, 2011).

The major negative impact reported by the respondents was loss of income since these drought tolerant crops are not in high demand in the market. This was found to be a major drawback to the acceptance of these drought tolerant crops. To improve on this the government supported by World Bank is running an Orphaned Crops Programme to sensitize the farmers in Yatta district to increase the acreage of these traditional high value crops (MoA, 2007). Other private organizations such as Kenya Breweries are promoting planting of Sorghum through distribution of free seeds and offering market. Another negative impact reported was that the tap roots of cow peas left behind after harvesting were affecting next season's planting. The respondents observed that as soon as the rain fell, these tap roots sprout and spread fast interfering with the germination of planted seeds.

Environmental impacts of greenhouse farming

Greenhouse farming was found to be undertaken by very few respondents in the study area basically due to the capital outlay involved. Several environmental impacts were associated with greenhouse farming. These included improved harvests (100%), controlled plant diseases and pests (80%), improved export market (40%), efficient water utilization (80%) and altered aesthetics of the land (20%). It was evident that the five respondents with greenhouses were economically better off than the rest. Crops grown in the greenhousesincluded vegetables such as tomatoes, onions and flowers for export.

Greenhouse farming is a very effective way to deal with the increasing rainfall unreliability in Yatta area since it is practised all year round and the water saving achieved by greenhouse production is impressive (Boulard et al., 2011). Four out of the five farmers with greenhouses reported efficient water utilization as a positive impact (Table 2). Greenhouse farming has the potential to feed the population and also generate income thus improving their economic status. The farmer just has to know when to plant and harvest his crops for maximum gains. The altered aesthetics of the land can be compensated by planting more trees in the area.

Greenhouse crops fetch higher remunerative prices due to their quality as a result of better controlled plant diseases and pest (Table 2). On the other hand, studies conducted in India indicated that the socio-economic impacts of the greenhouse farming are enormous (Government of India, 2009). However, according to Boulard et al. (2013), greenhouse farming can also have negative impacts such as ecotoxicology or human toxicology impacts.

Environmental impacts of joining CBOs addressing climate change challenges

Joining CBOs provided a forum for the farmers to interact and share adaptation knowledge and skills (65%). These communities based organizations helped farmers in

Table 3. Limiting factors to devising adaptation strategies by small-scale farmers in Yatta District.

Limiting factors	Yes		No	
	F	%	F	%
Financial constraints	454	93.4	32	6.6
Lack of relevant skills	362	74.5	124	25.5
Lack of scientific and technical knowledge	348	71.6	138	28.4
Lack of information	330	67.9	156	32.1
Lack of infrastructure/inputs	300	61.7	186	38.3
Reliance on relief food	192	39.5	294	60.5

acquiring some technical and scientific knowledge pertaining to climate change (12%). Respondents also reported gaining skills and knowledge of environmental conservation (9%) such as controlling water run-off and ultimately adjusting to climate change. Examples of these CBOs are the Water Resource Users Associations formed by the farmers in an attempt to conserve the water resources. Farmers in these groups engage in activities like tree planting and digging bench terraces. Others run community tree nurseries. Since these organizations have a core function of addressing themselves to the challenges of climate change, their environmental impacts were generally positive.

Environmental impacts of rainwater harvesting

The environmental impacts associated with rainwater harvesting in the study included availability of clean water (91.8%), improved yields (30.6%), better sanitation at home (75.6%) and availability of time to do other house chores (91.8%). Harvested rainwater provides clean water supply to the households at close proximity whereas harvested runoff water improves yield (Kihara, 2002). In a case study of rainwater harvesting for domestic, livestock, environmental and agricultural use in Kusa, Kenya, Orodi et al. (2005) found the impacts to be immediately noticed on the improved health of the residents and time saved. There was assured supply of domestic water at the homesteads and improved yields (Ibid).

In a study conducted by Aroka (2010) in Mwingi, Kenya the time spent for collecting water was found to have decreased while the general health of the community is thought to have improved as a result of water harvesting. Rainwater harvesting schemes have also made more water available closer to communities, meaning less time and energy spent on gathering water from distant and possibly unsafe water sources (Aroka, 2010). According to Malesu et al. (2006), water harvesting in Lare Division, Kenya has improved access to clean water and consequently improved health status of the local community. It has also increased agribusiness activities in the area that include the production and sale of livestock and farm products. Women are spending more time on their farms and are seeing their incomes from farming rise as their water-related workload decreases. There is also increased crop diversity resulting in improved food security and better nutrition in the area (Ibid)

In Yatta District, rainwater harvesting may not provide relief to the farmers since the low rainfall during droughts is unlikely to be sufficient for rainwater storage. Furthermore, climate change may exacerbate this problem in future. However, this notwithstanding, in areas where women walk for about six kilometres daily to fetch water for domestic use and spend some time queuing at the water points, rainwater harvesting can have some socio-economic benefits.

Limitations to adaptation strategies

It emerged from the study that Yatta small-scale farmers faced a host of challenges that limited their capacity to devise effective adaptation strategies. As shown in Table 3, the farmers in Yatta District experienced challenges such as financial constraints (93.4%), lack of relevant skills (74.5%), lack of scientific and technical knowledge (71.6%), lack of information (67.9%) and lack of infrastructure and inputs (61.7%) among others.

During the FGDs, it also emerged that finances are critical to rain water harvesting and adaptation to climate change in general. The farmers observed that, even with basic skills and knowledge of adaptation, they are just helpless due to poverty. This is clearly demonstrated by the words of one middle aged farmer from Eendei sub-location that;

"We just let the rain go because we do not have finances. We have the basic skills of knowing what to do but we do not apply those skills because we cannot harvest water. We know that we are supposed to have big tanks for storage and we also know about kitchen gardens and how to maintain them. However majority of us have no finances and we just let the water go to waste. Poverty has crept in because of the recurrent droughts. We don't have tanks. Also some of us don't have donkeys to fetch water for kitchen gardens. We know what needs to be done but have no resources to do so."

Lack of scientific and technical knowledge among the farmers can be attributed to the wide-ranging low levels of education in the district whereas lack of information can be attributed to the poor infrastructure in the district: there are no farmers' training facilities in the district and the road network is generally sparse and most of the rural population is not well connected (Republic of Kenya, 2009).

Reliance on relief food could be a limitation to adaptation in the sense that it can lead to the dependency syndrome. In a research study conducted by Harvey and Lind (2005) in Kenya and Ethiopia, a significant percentage of people interviewed (45%) reported that relief assistance has made some people lazy. Men in one remote village complained of an 'eat and wait' attitude among some community members. The existence of such views in remote communities suggests the power of the dependency syndrome argument where relief undermines initiative (Harvey and Lind, 2005).

The findings of this study corroborate an earlier research by Bryan et al. (2011), whose Kenyan study results revealed that lack of money or access to credit (63%) was a significant barrier to adaptation. Other findings by Bryan et al. (2011) corroborate the outcomes of this research, that lack of access to water (26%), in the case of irrigation and lack of money/credit (55%), lack of access to land (6%) and water (20%), lack of inputs (10%) and lack of information (5%) in the case of agroforestry, are significant impediments to adaptation to climate change.

These findings also corroborate the results of a study conducted by Gbetibouo (2009) in the Limpopo River Basin, South Africa where more than 53 percent of farmers cited lack of access to credit, poverty and lack of savings as the main barriers to adaptation. However, according to Gbetibouo (2009), few farmers designated lack of information or knowledge of appropriate adaptation measures as barriers to adaptations. On the other hand, lack of knowledge on climate change is considered by Nzeadibe et al. (2011) to be one of the major constraints to climate change adaptation by farmers in the Niger Delta.

Conclusion and recommendations

The study concludes that, small-scale farmers in Yatta District are engaging in various adaptation strategies to climate change that are not guided by any policy. These are fundamentally changes in livelihoods such as charcoal burning, sand harvesting, fishing and apiculture, rainwater harvesting and planting drought tolerant crops. They also join CBOs addressing climate change challenges among others.

Education levels and knowledge of climate change significantly influenced a number of these adaptation strategies. The adaptation strategies adopted have both positive and negative environmental impacts. Sand harvesting have serious ecological and social impacts ranging from crop land destruction, drying river beds and land degradation to prostitution and drug abuse. Charcoal burning has led to significant decrease of some plant species due to overexploitation. Conversely, planting of drought tolerant crops and joining CBOs addressing climate change issues have had positive environmental impacts. The main constraints to devising effective adaptation strategies were lack of finances, lack of skills and inadequate information on climate change and scientific knowledge.

Considering the importance of rain-fed agriculture in Yatta and Kenya in general and the fact that ambitious mitigation efforts can only lessen but not prevent future climate change, the study recommends that the Ministry of Agriculture formulates policies specifically focused on small-scale farmers' adaptation to climate change so as to improve food security. To improve food production and avert crop land destruction in Yatta district, rain-fed agriculture needs to be complemented with the development of small scale irrigation schemes and greenhouses. Water harvesting needs to be enhanced and promoted. This is because climate change is expected to have serious environmental, economic and social impacts on small-scale farmers whose livelihoods depend on rain-fed agriculture. Small-scale farmers should also be capacitated by the Ministry of Agriculture in terms of climate change knowledge and skills to avert further risks in agricultural production in the area. Further research should be conducted to establish the likely costs and effectiveness of these adaptation strategies in the small-scale dry land agriculture.

Conflict of interests

The authors did not declare any conflict of interest.

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