African Journal of Education, Science and Technology, 2(3): 228-241: ISSN: 2309-9240

Adaptation to Rainfall Variability by Smallholder Farmers in Kwale County: A Case Study of Samburu and Tsimba Locations

Ochieng' Richard
School of Education
University of Eldoret
snrochieng@gmail.com

Masakha Edward
National Environmental Management Authority
jumamasakha@yahoo.com

Wegulo Francis
Department of Geography
Egerton University
mununi1993@gmail.com

Koskei Ednah
Department of Arts & Social Sciences
Kabarak University
koskeiednah@gmail.com

Abstract

Rainfall received in Kwale County is highly variable negatively affecting agricultural production. Due to these variations, smallholder farmers in Kwale County have attempted to implement various adaptation mechanisms to help them cope. These include: sending children to school to enable them avail remittances when they get employed, seeking for seasonal jobs, work for food, embracing non-farm economic activities, planting of early maturing and drought tolerant crops, shifting from crop to livestock production or change in herd composition among others. These approaches have met a number of challenges such as: lack of improved seeds and information on weather incidences, inadequate capital to practice modern methods of farming, limited market to dispose of livestock during drought, frequent attack by pests and diseases. This study was conducted in Kwale County using survey research design and sought to determine effects rainfall variability and adaptation mechanisms used by the smallholder farmers in Kwale County. A sample of 272 households was picked through stratified and systematic sampling technique from Samburu and Tsimba Locations. Data was collected by use of pretested questionnaire from the sampled respondents and analyzed using Microsoft Office Excel and SPSS softwares. The study made the following recommendations to help improve the farmers' ability to adapt to rainfall variability: the number of functional meteorological stations in the County should be increased; the poor smallholder farmers should be empowered to fully implement rainwater harvesting technique, diversify and engage in both farm and non-farm economic activities that will ensure that the risks associated with rainfall variability are spread; the smallholder farmers should be supplied with adequate, high yielding and drought tolerant seed and encouraged to implement agroforestry programmes.

Key words: Seasonal Rainfall Variability · MAM rainfall · OND Rainfall · Adaptation Mechanisms · Agro-ecological Zones

1 Introduction

The agricultural sector has a multiplier effect on any nation's socio-economic and industrial fabric because of the multifunctional nature of the sector (Ogen, 2007). It serves as the main source of food and employment to the rural population. Rain-fed farming dominates agricultural production in Sub-Saharan Africa, covering around 97% of total cropland and exposes agricultural productivity to high seasonal rainfall variability (Alvaro et al., 2009). This region experiences highly variable climate that manifests in climate extremes such as droughts and floods (Mwangi and Desanker 2007; IPCC 2007). According to WWF (2006), the Global circulation models predict that the global warming will cause rainfall variability by up to 5-20% in Kenya by the year 2030. This prediction calls for the country to put in place the right infrastructure to save the smallholder farmers from sliding into abject poverty due to total loss of crops and livestock. Implementing the most appropriate adaptation techniques could significantly reduce the negative effects of rainfall variability (Parry *et al*., 2009).

The extreme weather events have severe socio-economic impacts on agricultural production (Galvin *et al*., 2004). Reduction in rainfall amount leads to reduced soil moisture, affecting pasture availability and length of growing season (Thornton *et al*., 2002). Rainfall variability has significantly impacted on the rural smallholder farmers who rely mostly on natural rainfall for land tillage and agricultural production and according to IPCC (2007), rain fed agricultural production in Africa in general is projected to be reduced by up to 50% by 2020, resulting to serious food security challenges for the continent unless effective and appropriate adaptation mechanisms are identified and implemented.

According to Kori *et al.* (2012) and Allamano *et al.* (2010), marginal rain-fed agricultural areas with low and erratic precipitation are the most vulnerable and worst affected, depicting low and unpredictable level of crop production with the only option being development and implementation of appropriate adaptation. Admassie *et al.* (2006) and Deressa *et al*. (2008) indicate that female headed households, small-scale, rain-fed, smallholder farmers and pastoralists are the most vulnerable groups to climate change and rainfall variability. The poor smallholder farmers are more vulnerable to rainfall variability compared to the wealthy farmers who are capable of identifying and implementing the most adaptive strategies to reduce the impacts (Orindi and Eriksen, 2005; Mworia and Kinyamario, 2008). According to Field (2005), small stocks such as goats, breed rapidly and therefore able to recover quickly from impacts of rainfall variability as compared to cattle. Based on its impacts on crops and livestock production, rainfall variability has emerged as one of the major threats to livelihoods in sub-Saharan Africa (Galvin *et al.*, 2004; IPCC 2007). According to Mureithi and Opiyo 2010, rainfall variability leads to decline in the number, distribution and productivity of permanent pastures and water points that livestock depends on and affects crops yields.

The magnitude of variability, frequency of event occurrence and rate of change within climate systems are examples of important attributes as they can affect farmer's ability to respond, cope and to adapt (Dessai and Hulme, 2003). Jerie and Ndabaningi (2011) found out that investing in rain-fed farming systems is of paramount importance if hunger and poverty are to be eradicated. Understanding the impacts of rainfall variability is of great importance if successful agricultural production is to be realized. The study established that farmer-training initiatives coupled with adequate and affordable inputs can reduce the problem of declining yield.

Agricultural production in Kwale County is majorly rain-fed. It is highly affected by inter-annual and seasonal rainfall variability which is attributed as a major cause of famine in the County. High variability in rainfall occurrence and amount create severe constraints for livestock and crop production because rainfall is one of the most critical factors for ecological and environmental processes. In rain-fed agriculture, the amount of water available to plants and for livestock production strongly depends on the rainy season's onset, length and cessation (Ati *et al*., 2002; Saber, 2009).

Given that most farmers in Kwale County lead a peasantry nature of life, they are vulnerable to rainfall variability, where extreme conditions such as lack of rainfall, unpredictable pattern of rainfall, early or late onset and cessation of rains easily translates into low agricultural yields. Equipping smallholder farmers with comprehensive knowledge on rainfall variability empowers them to plant at the right time, identify the most reliable crop to plant and livestock to keep. Late onsets reduce the crop growing period and moisture availability for pasture development. Rainfall variability interferences with land preparation (clearing and ploughing), harvesting and planting time and influence the cost of farm inputs. Variation and reduction in number of rainy days results in conditions inadequate to effectively support crop and livestock production and therefore decline in livestock and crop yields. The effect of rainfall variability is spatially variable but strongly felt in arid and semi-arid areas.

2 Study Area

Kwale County is in Coast Province (Figure 2.1). It lies within latitudes $3^o 30'$S and $4^o 40'$S and longitudes $38^o 27'$E and $39^o 40'$E. The County borders Taita Taveta County to the West, Kilifi County to the North, Mombasa County and Indian Ocean to the East and Republic of Tanzania to the South. It has a total population of 649,931 people, 122,047 households and total area coverage of 8,270.1 square kilometers (RoK, 2010a). Samburu and Tsimba Locations have a total population of 33,036 people, 5,415 households and area coverage of 445.7 square kilometers. Samburu and Tsimba Locations are mainly inhabited by the Duruma and Digo communities respectively but other communities such as Kamba, Kikuyu, Waitharaka, Luo, Duruma and even Europeans have significant presence (RoK, 2009; 2010a). Most of the farmers depend on rain-fed agriculture and therefore an accurate forecast and proper dissemination of information about rainfall pattern directly influences their vulnerability to rainfall variability.

The overall study site has monsoon type of climate; hot and dry from January to April and cool between June and August of every year. The study area experiences a bimodal rainfall pattern with the short rains occurring between

October to December and the long rains occurring between March and June. The average annual rainfall ranges between 400mm and 1200mm (RoK, 2005).

The county is divided into three constituencies: Matuga, Kinango and Msambweni and 5 divisions: Kinango, Kubo, Matuga, Msambweni and Samburu. Matuga and Msambweni divisions occupy the Coastal plains, Kinango and Samburu divisions are part of the semi-arid Nyika plateau while Kubo division covers the Coastal uplands. Samburu Location is in Samburu Division, semi-arid, L5-6 agro-ecological and livestock farming livelihood zone while Tsimba Location is in Matuga division, coastal plains, L4 agro-ecological and mixed farming livelihood zone. 32% of the population is classified as food insecure while 40% are in absolute poverty category (RoK, 2005; 2010a; 2010b).

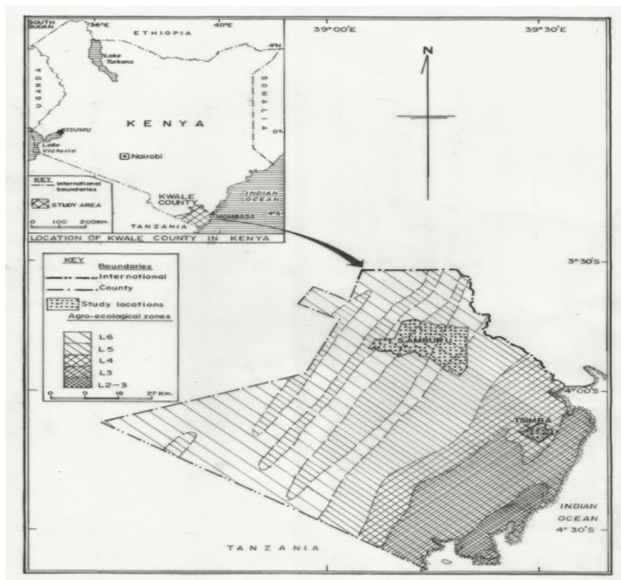


Figure 2.1: Study Area
Source: Modified from Great World Atlas, 2005

3 Methodology

3.1 Data Collection

This study used questionnaire and Key Informant Interview as instruments of data collection. A sample size of 272 households was picked through stratified and systematic sampling procedures to form the sample. A questionnaire that contained both closed and structured questions was used to collect data. Data collected through Key Informant Interview assisted in clarifying issues arising from the survey process. Secondary data was obtained from published books, relevant journals, theses and policy research working papers.

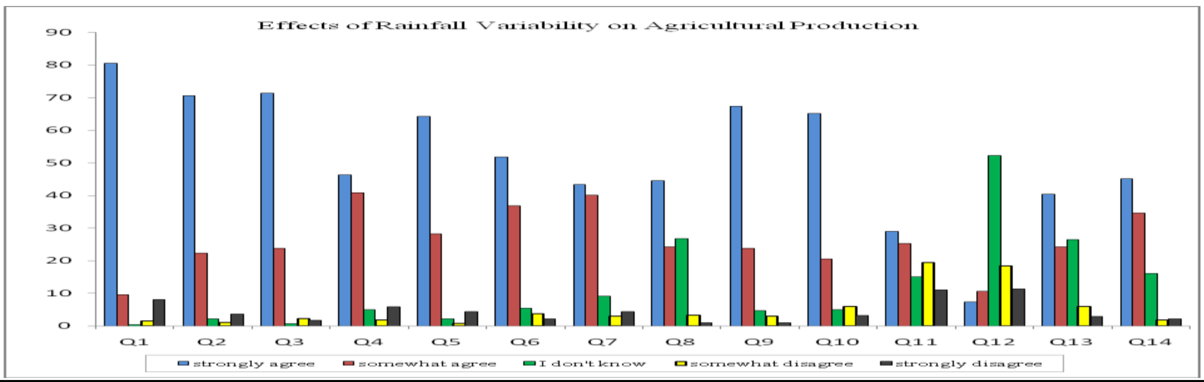
4 Results and Discussion

4.1 Effects of rainfall variability on crop and livestock production

Kwale County experiences three main types of rainfall variability: spatial variability -differences in total rainfall received across the agro-ecological zones; Inter-seasonal – deviations from long-tem averages or the differences in rainfall between seasons: and Intra-seasonal – variations within the individual seasons. These variations are the causes of stress to agricultural production and yields in Kwale County. This conclusion concurs with the findings of Adejuwon (2005) who indicated that rainfall variations are the causes of great stress to farming activities, crop production and yields in the Guinea Savanna of Nigeria. According to FAO (2001), extremes of droughts and floods and various forms of weather phenomena have wrecked havoc on the agricultural systems in Sub-Saharan Africa. Though the extreme events arising from rainfall variability are inherently abrupt, random and disastrous, the risks can be reduced through improved preparedness and planning, better information, stronger institution and new technologies.

Figure 4.1 show that the sampled respondents approved various effects of rainfall variability on crop and livestock production. More than 60% of the sampled respondents strongly agreed with the following as effects of rainfall variability: interference with land preparation (clearing, ploughing), increase in the cost of farm inputs, interference with planting time, inadequacy in the amount of rainfall received in a year in supporting crop production, increment in cost of food crops and loss of livestock. 51.8% strongly agreed that crop yields have generally declined due to rainfall variability. Around 40% of respondents strongly agreed that rainfall variability results into: interference with harvesting time, decline in livestock production, emergence of crop and livestock diseases, forced smallholder farmers to change livelihood systems and that its threat is more on crops than livestock production.

The survey further revealed that only 7.4% of the respondents strongly agreed that shift or change in livestock breeds was a response to rainfall variability, 11.4% strongly disagreed with this idea while 52.2% were not aware. It was observed that the change in livestock breeds was not necessarily due effects of rainfall variability but to acquire breeds that are high yielding or early maturing. There was a strong argument from a number of sampled respondents on whether rainfall variability has influenced rise in price of livestock products. 29% strongly agreed giving an example of milk, 25% somewhat agreed while 11% strongly disagreed, giving an example of cost of livestock that normally drops whenever droughts sets in resulting to drop in price of meat in the locality. With an exception of Q11 and Q12 (Figure 4.18), on average, 57.6 of the sampled respondents strongly agreed with the above mentioned effects of rainfall variability, 3.4% strongly disagreed and only 8.7% were not aware.



X - Axis Legend	
Q1	Rainfall variability interferes with land preparation (clearing, ploughing etc)
Q2	The cost of farm inputs has increased because of rainfall variability
Q3	Rainfall variability has interfered with planting time
Q4	Rainfall variability has interfered with harvesting time
Q5	The amount of rainfall received in a year is not adequate to support crop production as before
Q6	Crop yields have generally declined due to rainfall variability
Q7	Rainfall variability has led to decline in livestock production
Q8	Rainfall variability has led to crop diseases
Q9	The cost of food crops are increasing because of rainfall variability
Q10	Rainfall variability has led to loss of livestock
Q11	The cost of livestock products have increased due to rainfall variability
Q12	Rainfall variability has led to change in livestock breeds
Q13	Rainfall variability has led to the change of livelihood system
Q14	The threat of rainfall variability is more on crop production than livestock production

Figure 4.1: Effects of Rainfall Variability on Agricultural Production
Source: Survey Data, 2012

Table 4.1 shows outcomes of correlating mean rainfall received across the study period and crop and livestock production. Correlation analysis was used to establish the effects of mean rainfall received on crop yields, herd size and milk production. It was observed that all the cases display positive correlation coefficients. Herd sizes for cows, goats, sheep and number of birds (poultry) have r values of 0.531, 0.449, 0.645 and 0.1 respectively. Mean annual milk production has r = 0.635, cassava r = 0.619, coconut r = 0.510, cowpeas r = 0.526, green grams r = 0.529, groundnuts r = 1, maize r = 0.736, pigeon peas r = 0.113 and sorghum r = 0.612. With r = 0.449 for goats herd size, r = 0.1 for number of birds and r = 0.113 pigeon peas, the correlation coefficients indicates a weak influence of mean rainfall amount on goats herd size, number of birds (poultry) and pigeon peas. This implies that the proportion in yield influenced by rainfall variability in the study area is 44.9% for goats herd size, 10% for the number of birds and 11% for the pigeon peas production. The weak influence of rainfall variability on goat herd size, number of birds and pigeon peas points to the fact that goats, poultry and pigeon peas have high adaptability and tolerance to rainfall variability, an observation that concurs with the findings of Mwang'ombe *et al*. (2011). The smallholder farmers in Kwale County rely more on maize and cassava production to meet household food demand.

Maize with r = 0.736 indicate a strong positive correlation between maize yield and mean rainfall received. This result implies that maize is the most affected by rainfall variability in the study area. The amount of rainfall received and proper timing determines efficiency of maize crop development and yields. Maize seeds require water for germination and seedling growth Maize is used mainly to make *ugali* and porridge and because it is used as staple food in the study area, instability in the maize yield has major consequences on population (Ayanlade *et al*., 2009; Fakorede *et al*., 2004: Okpara, 2003: Adejuwon, 2005). It was also observed that maize pests and diseases become dominant with rainfall variability, a finding that concurs with the observations of Ayanlade *et al*., (2009).

Cassava with r = 0.619, reflects a strong positive correlation between rainfall amount and cassava yields, indicating that the proportion of variation in cassava yield determined by rainfall variability is 61.9%. Rainfall affects crop growth, tuber development and yield (Ayanlade, *et al*., 2009). Cassava is planted throughout the rainy season, but early enough to ensure there is enough moisture for partial tuber development. Early cessation of rains during the growing period creates water stress, reducing top and root biomass, affecting the yields (Agbaje & Akinlosotu, 2004). Cassava does well if planted early to allow for water utilization during vegetative growth, root and tuber development. For short growing seasons, it is prudent to plant early maturing or drought-tolerant varieties.

Positive correlation between the livestock and crop yields and rainfall received concurs with the findings of Ayanlade *et al.* (2009) which observed that rainfall variability is the key climate element that determines the success of agricultural production, and variations in yields is strongly influenced by fluctuations in seasonal rainfall characteristics.

Table 4.1: Correlation Analysis between Rainfall Amount and Livestock/Crop Production

Livestock and Crop Production	Pearson Correlation Coefficient (r)
Herd size of cows	0.531
Herd size of goats	0.449
Number of birds (poultry)	0.100
Herd size of sheep	0.645
Mean annual milk production	0.635
Cassava production (in bags per hectares)	0.619
Coconut production (in bags per hectares)	0.510
Cowpeas production (in bags per hectares)	0.526
Green grams production (in bags per hectares)	0.529
Groundnuts production (in bags per hectares)	1.000
Maize production (in bags per hectares)	0.736
Pigeon peas production (in bags per hectares)	0.113
Sorghum production (in bags per hectares)	0.612

Correlation is significant at the 0.05level (2-tailed)
Source: Survey Data, 2012

The study findings on effects of rainfall variability indicate that agricultural production in Kwale County depends on rainfall received during the OND and MAM season and therefore crop failures, livestock loss or low yields in the County is mainly due to high rainfall variability.

4.2 Adaptation Strategies

Table 4.2 displays a total of 30 strategies used by smallholder farmers in Kwale County to adapt to rainfall variability. It shows the number of respondents out of 272 sampled farmers who adopted the strategy, percentage and rank of the specific strategy. The widely used strategy despite the challenges involved was sending children to school to acquire education that would enable them secure gainful employment and support the household through remittances to provide for household food requirements or acquire farm inputs. 55.9% of the sampled respondents have been seeking for seasonal jobs as an alternative source of livelihood whenever the rains or crops fail or as source of income to acquire farm inputs and purchase livestock. 52.9% offered labour in return for food from relatively economically stable neighbours or non-governmental organizations such as the World Vision. The work for food program was majorly supported by World Vision Organization before terminating its programmes/projects and services in the County in the year 2010 following disagreement with the community. 42.5% of the sampled farmers engaged in non-farm economic activities such as sale of charcoal, handicrafts and brooms and operating kiosks. 38.2% relied on remittances from other family members who are in formal or informal employment.

For the purpose of risk-spreading, out of the sampled respondents, 31.6% had planted short duration crop varieties, 28.7% planted different crop varieties and 11.8% planted drought tolerant crops while 10.7 practiced mixed farming. 4.4% of the farmers increased the number of browsers while 0.4% replaced the exotic breeds of livestock with indigenous breeds because they are least affected by rainfall variability. To increase productivity and withstand rainwater shortages, 5.1% engaged in rainwater harvesting and 1.5% dug boreholes and sunk wells

Table 4.2: Adaptation Strategies used by Smallholder Farmers in Responding to Rainfall Variability

Adaptation strategies	**Frequency**	**%**	**Rank**
Sending of children to school to get education to enable them secure employment and therefore avail remittances as adaptation strategy	169	62.1	1
Seeking for seasonal jobs as adaptation strategy	152	55.9	2
Work for food (offering labour in return of food) as adaptation strategy	144	52.9	3
Embracing non-farm economic activities as adaptation strategy	115	42.3	4
Reliance on remittances from other family members as adaptation strategy	104	38.2	5
Planting short duration crop varieties as adaptation strategy	86	31.6	6
Planting different varieties of crops as adaptation strategy	78	28.7	7
Shift from crop farming to livestock farming as adaptation strategy	57	21	8
Selling off livestock during dry seasons as adaptation strategy	55	20.2	9
Planting drought tolerant crops as adaptation strategy	32	11.8	10
Practicing mixed farming	29	10.7	11
Migration to other areas least affected by rainfall variability as adaptation strategy	24	8.8	12
Practicing crop rotation as adaptation strategy	17	6.2	13
Rain water harvesting as adaptation strategy	14	5.1	14
Increase in browsers (goats) as adaptation strategy	12	4.4	15
Transferring livestock to other areas least affected by rainfall variability as adaptation strategy	10	3.7	16
Use of composite manure as adaptation strategy	8	2.9	17
Use of mulching as adaptation strategy	8	2.9	17
Intercropping cereals with legumes as adaptation strategy	7	2.6	19
Development of water sources (e.g. Boreholes, pans, dams, wells) as adaptation strategy	4	1.5	20
Training on livestock husbandry and healthcare in response to diseases especially those related to rainfall variability as adaptation strategy	4	1.5	20
Reducing the number of livestock kept as adaptation strategy	3	1.10	22
Changing the extent of land under crop production as adaptation strategy	3	1.1	23
Selling portions of land to buy food as adaptation strategy	3	1.1	23
Changing the extent of land put under grazing as adaptation strategy	2	0.7	25
Practicing agroforestry as adaptation strategy	2	0.7	25

Change in livestock herd compositions	2	0.7	25
Zero tillage to conserve soil moisture as adaptation strategy	1	0.4	28
Strategic livestock feed reserves to be used during droughts as adaptation strategy	1	0.4	28
Leasing farms as adaptation strategy	1	0.4	28

Source: Survey Data, 2012

When the sampled respondents were asked whether the current adaptation strategies were effective and sustainable, 36% of the respondents admitted that the strategies were effective and sustainable and has helped improve yields of crops and livestock production while 64% had the opinion that the strategies were not effective and sustainable and did not have positive impact on crop and livestock production and therefore no improvement in livestock and crop production/yields. They pointed out lack of financial capital as the main obstacle towards implementation of adaptation mechanisms; a response that concurs RoK (2005; 2010a; 2010c) that indicates that 32% of the population of Kwale County is classified as food insecure while 40% are in absolute poverty category.

4.2.1 Most Adaptive Strategies

4.2.1.1 Planting High Yielding, Early Maturing and Drought, Disease and Pest Tolerant Crops

The sampled respondents acknowledged planting of high yielding, early maturing and drought, disease and pest tolerant crops as one of the most adaptive mechanisms that can reduce the effects of rainfall variability in Kwale County. It can enable the smallholder farmers realize high yields and reduce cost of controlling pest and diseases, but due to lack of financial resources, most of the poor smallholder farmers in the County cannot implement the strategy.

To improve crop productivity and reduce effects of rainfall variability, KARI-Mtwapa since 2007 produced certified seed of maize and clean planting materials of cassava and made them available to farmers in coastal districts in partnership with the Ministry of Agriculture. The certified maize seed known as the Coast Composite can yield 37 bags per ha compared to the locally produced seeds that give 12 bags per ha. Karembo, new improved cassava variety, resistant to cassava diseases can yield up to 70 tons per ha compared to 9-12 tons per ha of Kibandameno or Kaleso, the local cultivars which are low yielding (Wekesa *et al.*, 2003).

KARI do not distribute adequate seeds but advise farmers given seeds to multiply and distribute to neighbouring farmers for subsequent seasons. This has not been successful as a number of farmers cook the certified maize seeds and fail to plant due to poverty or fail to multiply the cassava seeds and share. More so, most farmers prefer Kibandameno cassava variety because it is tastier than Karembo.

Other agencies that develop improved seeds include: The International Centre for Maize and Wheat Improvement (CIMMYT) and International Crops research Institute for the Semi-Arid Tropics (ICRISAT). CIMMYT develops and distribute maize varieties that are able to yield more than the locally available cultivars and can perform better in regions that experience unreliable rainfall and ICRISAT develops and distribute pigeon pea that is drought tolerant and early maturing varieties, taking three months to mature.

Due to lack of financial resources to acquire these seeds, the Government, NGOs and private sector should assist the smallholder farmers access the seeds at the right time, in adequate quantity and be used for the intended purpose. Farmers need training to make them embrace the new seeds. There is also need to establish policy framework that can easily facilitate the use of the improved seeds among the poor smallholder farmers.

4.2.1.2 Rainwater harvesting

Water harvesting has contributed to land rehabilitation enabling communities to adapt to drought or highly variable rainfall, with subsequent reduction of poverty (Orindi, *et al*., 2008). The harvested water can enable farmers to diversify and plant other crops such as vegetables, tomatoes, onions and fruits to meet household food requirements.

The technique used should aim at improving infiltration or storage of rainwater. The approaches include: roof catchment, deep tillage, manure application, macro-catchment techniques, stone bunds, trash lines and *Fanya Juu*.

Deep tillage, which is tilling of land at depths of more than 12 inches, ensures efficient absorption and storage of water in the soil though it requires high draft power that is expensive to access (Hatibu and Mahoo, 2000). Deep tillage can improve crop production in hardpan soils. It involves breaking of the hardpan soil, creating soil pores that influence good water infiltration and root growth. While trash lines involve laying of crop residues e.g. maize stock along contours, stone bunds involves the use of stones to trap surface runoff resulting from rainwater to increase rate of infiltration. *Fanya Juu* is a structure where a back slope trench is dug and soil from the trench is thrown up slope to form a riser bank that can trap rainwater. Application of organic manure helps improve the soil water holding capacity, making it available to crops. Macro-catchment techniques entail collection of surface runoff in dams or pans while roof catchment comprise of direct tapping of rainwater from building roofs into storage tanks. The trapped rainwater can be used during times of water stress to irrigate crops and therefore increase yields.

Water harvesting in dry lands has resulted in more vegetative cover due to increased infiltration rate resulting from slowed water movement on land (Musimba *et al*., 2004). Lack of water storage facilities, expertise and technology poses a major barrier to rainwater harvesting in Kwale County and therefore the need for the Government, NGO's, CBO's and private sector to empower the smallholder farmers through training and provision of the necessary technology.

4.2.1.3 Agricultural Diversification and Change of Herd Structure

Agricultural diversification helps improve food security, boost household income and reduce risk of total crop failure. This adaptation mechanism is multi-facet: it entails growing of crops and keeping of livestock; diversification in crops grown; and diversification in livestock kept. It allows smallholder farmers to spread risks in such a way that if crops fail, they can still realize income from livestock or when one crop type fails, they have an alternative crop to look forth to hence a contribution towards food security (Nyariki *et al*., 2005).

Reducing the species of livestock that are highly vulnerable to rainfall variability and increasing the herd size of those that are more resilient reduces the impact of rainfall variability on agricultural production. Due to the harsh climatic conditions especially in AEZ L5-6, farmers are supposed to engage more in goat and poultry keeping because they have high adaptability and can withstand hash climatic conditions (Table 4.8).

Since most of the smallholder farmers in Kwale County are poor, they encounter several barriers in their pursuit to implement adaptation mechanisms that can help reduce the effects of rainfall variability. Most of the adaptation mechanisms require financial resources to implement, prompting most farmers to implement only cheap and less effective mechanisms. This calls for the Government, NGO's and other Development Agencies to empower the farmers in terms of skills and resources that are needed in implementation of adaptation strategies.

The study findings on adaptation to rainfall variability suggests that adaptation requires farmers to understand how rainfall pattern has changed over time to enable them identify the most adaptive mechanisms. It further indicates that farmers have a wide choice of adaptation mechanisms in response to rainfall variability but implementation of the most effective adaptation mechanism is influenced mainly by availability of financial capital.

5 Conclusions

The study draws the following conclusions:

- Kwale County experiences highly variable seasonal rainfall that has negative effects on crop and livestock production. Rainfall variability interferes with land preparation (clearing and ploughing), harvesting and planting time and influenced the cost of farm inputs. On average, the amount of rainfall received in Kwale County is not adequate to effectively support crop and livestock production and has led to decline in livestock and crop yields. In particular, AEZ L5-6 can no longer support rain-fed crop farming during the MAM season, calling for appropriate adaptation strategies to reduce the effects or reverse the situation. Smallholder farmers have been subjected to frequent crop failure and loss of livestock forcing others to poverty or engage in non-farm activities.
- Due to rainfall variability, smallholder farmers in Kwale County have designed and implemented several adaptation strategies to respond to rainfall variability. The most adaptive approaches include: planting high yielding, early maturing and drought, disease and pest tolerant crops; rainwater harvesting; and agricultural

diversification and change of herd structure. The main hindrances to implementation of the adaptation mechanisms include: inadequate financial capital; lack of improved seeds, information on weather incidences and seasonal rainfall variability; and frequent attack by pests and diseases.

6 Recommendations

Rainfall received in Kwale County is highly variable and has negatively affected agricultural production. It is therefore imperative to formulate specific recommendations that can help improve the smallholder farmers' adaptability to rainfall variability. The study makes the recommendation given below:

The Ministry of Agriculture should ensure that dissemination of weather forecasts is effective and efficient and reach smallholder farmers in real-time in order to enable them make right decisions regarding agricultural activities. More so, the Government through the Ministry of Environment and Mineral Resources should ensure that the number of functional meteorological stations in Kwale County is increased because the two functional stations do not fully represent the County.

The Government through the Ministries of Special Programmes, Agriculture and Livestock Development, NGOs and CBOs should organize trainings for smallholder farmers to educate them on rainfall variability, its effects and appropriate adaptation techniques. Such trainings will empower the smallholder farmers and therefore reduce their vulnerability to effects of rainfall variability.

Due to lack of financial resources to acquire improved seeds of high yielding, early maturing and drought, disease and pest tolerant crops, the Government, NGOs and private sector should assist the smallholder farmers access the seeds at the right time, in adequate quantity and be used for the intended purpose. Farmers need training to make them embrace the new seeds. There is also need to establish policy framework that can easily facilitate the use of the improved seeds among the poor smallholder farmers.

References

Adejuwon, J.O. (2005). Food Crop Production in Nigeria: Present Effects of Climate Variability. *Climate Research*, Inter-Research, Germany.

Admassie, A., Adnew, B. and Tegene, A. (2006). Stakeholders Perception to Climate Change, Ethiopian Economics Association, Economic Focus, Vol.11, No. 1.

Agbaje, G.L. and Akinlosotu, T.A. (2004). Influence of NPK Fertilizer on Tuber Yield of Early and Late-Planted Cassava in a Forest Alfsoil of Southwestern Nigeria. African Journal of Biotechnology, 3(10): 547-551

Allamano, P., Seckler, D. and Makin, I.I. (2010). Estimating the Potential of Rain-fed Agriculture: Working Paper 20. Colombo, Sri Lanka: International Water Management Institute.

Alvaro, C., Tingju, Z., Katrina, R., Richard, S.J. and Claudia, R. (2009). Economy-Wide Impact of Climate Change on Agriculture in Sub-Saharan Africa International Food Policy Research Institute (IFPRI). *Discussion Paper* 00873:1.

Ati, O.F., Stigter, C.J. and Oladipo, E.O. (2002). A Comparison of Methods to Determine the Onset of the Growing Season in Northern Nigeria. *International Journal of Climatology*, 22: 731–742.

Ayanlade, A., Odekunle, T.O., Orinmogunje, O.I. and Adeoye, N.O. (2009). Inter-annual Climate Variability and Crop Yields Anomalies in Middle Belt of Nigeria. *Adv. In Nat. Appl. Sci, 3(3): 452-465*.

Deressa, T., Hassan, R.M., Ringler, C. (2008). Measuring Ethiopian Farmers' Vulnerability to Climate Change across Regional States. International Food Policy Research Institute. IFPRI Discussion Paper 00806.

Dessai, S. and Hulme, M. (2003). Does Climate Policy Need Probabilities: Tyndall Centre for Climate Change Research Working Paper 34. UEA, Norwich.

Fakorede, M.A.B. and Akinyemiju, O.A. (2003). Climate Change: Effects on Maize Production in a Tropical Rainforest Location. Maize Revolution in West and Central Africa. IITA, Ibadan.

FAO. (2001). Climate Variability and Change: A Challenge for Sustainable Agricultural Production. Committee on Agriculture. htpp://www.fao.org (Accessed on 20/12/2012).

Field, C.R. (2005). Where There is No Development Agency. A Manual for Pastoralists and their Promoters. NR International, Aylesford, Kent, UK.

Galvin, K.A., Thornton, P.K., Boone, R.B., Sunderland, J. (2004). Climate Variability and Impacts on East African Livestock Herders: The Maasai of Ngorongoro Conservation Area, Tanzania. African Journal of Range and Forage Science, 21(3), 183-189.

Hatibu, N. and Mahoo, H.F., 2000. Rainwater Harvesting for Natural Resources Management: A Planning Guide for Tanzania. Regional Land Management Unit Technical Handbook No. 22, Nairobi, Kenya.

IPCC. (2007). Climate Change 2007: Synthesis Report IPCC Plenary XXVII. Valencia, Spain.

Jerie, S. and Ndabaningi, T. (2011).The Impact of Rainfall Variability on Rain-Fed Tobacco in Manicaland Province of Zimbabwe. *Journal of Sustainable Development in Africa*, 13(1).

Kori, E., Gondo, T. and Madilonga, R. (2012). The Influence of Rainfall Variability on Arable Land Use at Local Level: Realities from Nzhelele Valley, South Africa. International Conference on Future Environment and Energy IPCBEEvol.28 (2012). Singapore: IACSIT Press.

Mureithi, S.M. and Opiyo, F.E.O. (2010). Resource Use Planning under Climate Change: Experience from Turkana and Pokot Pastoralists of North-Western Kenya. Proceedings, 2nd International Conference on Climate Change, Development and Sustainability in Semi-Arid Areas. 16-20th August 2010. Fortaleaza, Ceara, Brazil.

Musimba, N.K.R. and Nyariki, D.M. (2004). Dryland Husbandry for Sustainable Development in the Southern Rangelands of Kenya. Organization for Social Science Research in Eastern and Southern Africa (OSSREA), Addis Ababa, Ethiopia.

Mwang'ombe, A.W., Ekaya, W.N., Muiru, W.M., Wasonga, V.O., Mnene, W.M., Mongare, P.N. and Chege, S.W. (2011). Livelihoods under Climate Variability and Change: An Analysis of the Adaptive Capacity of Rural Poor to Water Scarcity in Kenya's Drylands. *Journal of Environment Science and Technology*, 4(4): 403-410.

Mwangi, M.N. and Desanker, P.V. (2007). Changing Climate, Disrupted Livelihoods: The Case of Vulnerability of Nomadic Maasai Pastoralism to Recurrent Droughts in Kajiado District, Kenya. Eos Trans. Am. Geophys. Union 88: Fall Meet. Suppl.

Mworia, J.K. and Kinyamario, J.I. (2008). Traditional Strategies used by Pastoralists to Cope with La Nina Induced Drought in Kajiado, Kenya. AJEST 2(1): 010-014.

Nyariki, D.M., Kitalyi, A., Wasonga, V.O., Isae, I., Kyagaba, E. and Lugenja, M. (2005). Indigenous Techniques for Assessing and Monitoring Range Resources in East Africa. ICRAF, Nairobi.

Ogen, O. (2007). The Agricultural Sector and Nigeria's Development: Comparative Perspectives from the Brazilian Agro-Industry Economy 1960-1995. *Nebula*, 4(10): 184-194.

Okpara, E.E. (2003). Complementarily Between Densification and Climate Change Conventions Responses to Unpredictable Rainfall Patterns in Nigeria, *Dry Belt*. NEST forum: No. 19: 7-8.

Orindi, V.A. and Eriksen, S. (2005). Mainstreaming Adaptation to Climate Change in the Development Process in Uganda. Ecopolicy Series No. 15. Nairobi: Acts Press.

Orindi, V.A., Nyong, A. and Herrero, M. (2008). Pastoral Livelihood Adaptation to Drought and Institutional Interventions in Kenya-Human Development Report Office Occasional Paper. UNDP, Nairobi, Kenya.

Parry, A., Evans, A, Rosegrant, M.W. and Wheeler, T. (2009). Climate Change and Hunger: Responding to the Challenge. Italy: WFP.

Republic of Kenya. (2005). Kwale District Strategic Plan 2005-2010 for Implementation of the National Population Policy for Sustainable Development. Nairobi: Government Printers.

Republic of Kenya. (2009). Kwale District Development Plan 2008-2012. Nairobi: Government Printers.

Republic of Kenya (2010a). Kenya National Bureau of Statistics: 2009 Kenya Population and Housing Census, Volume 1A. Nairobi: Government Printers.

Republic of Kenya. (2010b). National Climate Change Response Strategy. Nairobi: Government Printers.

Republic of Kenya. (2010c). Arid Lands Resource Management Project II Kwale District Annual Progress Report – 2008/2009. Nairobi: Government Printers.

Saber, M. (2009). Environment in Jeopardy: Consequences of Climate Change in Egypt. *Journal of Ecology and the Natural Environment,* 1(5), 191-195.

Thornton, P.K., Kruska, R.L., Henninger, N., Kristjanson, P.M., Reid, R.S., Atieno, F. and Odero, A. (2002). Mapping Poverty and Livestock in the Developing World. ILRI, Nairobi, Kenya.

Wekesa, E., Mwangi, W., Verkuijl, H., Danda, K. and De Groote, H. (2003). Adoption of Maize Production Technologies in the Coastal Lowlands of Kenya. A KARI/CIMMYT/EU Publication, P11.

World Wide Fund for Nature (WWF). 2006. Climate Change Impacts on East Africa: A Review of Scientific Literature. Switzerland: Gland.

Bio Data

Richard Ochieng' is a Lecturer at The University of Eldoret, Department of Social Sciences (Geography). He hold a Masters of Science Degree in Geography and currently a PhD student in Geography at Egerton University. His research interest is in Climate Change adaptation with keen focus on Arid and Semi-Arid Lands.