3 Adaptive Capacity to Mitigate Climate Variability and Food Insecurity of Rural Communities Along River Tana Basin, Kenya

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Abstract

Climate variability is one of the leading natural threats and a root cause of food insecurity in the developing world, more so in Africa. It is a major impediment to the accomplishment of the global Sustainable Development Goals (SDGs), Vision 2030 and Big Four agenda in the Kenyan context. The rise in occurrence and brutality of extreme events resulting from variability of climate including prolonged flooding and drought has become more pronounced in the relatively

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drier areas. This chapter presents a synthesis about rural communities in Garissa and Tana River Counties, Kenya. The key environmental conditions that face the rural communities in the two counties are prolonged drought and recurrent flooding events. The two conditions have resulted in various challenges facing the communities in these regions through low agricultural production (food and pastures), poor infrastructure, human displacement, and the resultant extreme poverty, overall food insecurity, and tough livelihoods. The problems have been exacerbated by lack of capacity by most of the community members to cushion themselves against these impacts. However, as the conditions continue to manifest themselves, the community members have also identified adaptive mechanisms that are best suited in the region including planting drought-resistant crop varieties, diversifying their livelihoods, embrace sustainable land use, and made efforts to plant trees. We, therefore, conclude that integrated information sharing including early warning alongside affordable and appropriate technologies and crop insurance could be an entry point in cushioning the local communities in the arid and semiarid lands (ASALs) against the extreme weather conditions experienced in the region.

Keywords

Adaptive capacity · Africa · Climate variability · Food insecurity · Mitigation · Rural livelihoods

Introduction

Climate variability has been on the rise due to increased global atmospheric greenhouse gas emissions (GHG) comprising mainly of nitrous oxide, carbon dioxide, and methane (IPCC 2014). Carbon dioxide is the key GHG, while as much as methane and nitrous oxide are emitted in trivial quantities in reference to carbon dioxide, they play a significant role in global warming and their associated global effects. For example, N_2O, a potent gas with a high potential to deplete ozone layer, is over 265 more powerful while CH_4 is 28 more powerful in their global warming potential relative to carbon dioxide, over 100 years' time limit (IPCC 2014). These three main GHGs accounts more than 80% to the present global radiative imposing to enhanced global warming and consequently climate variability and its negative resultant effects (Myhre et al. 2013).

Climate variability characterizes one of the extreme economic, environmental, and social intimidations facing the earth presently (Nnadi et al. 2019). In emerging countries, climate variability has a substantial influence on the livelihoods and living situations of the rural communities. Sub-Saharan Africa (SSA) is a "vulnerability hot spot" of climate variability influences (Asfaw et al. 2018). SSA challenges on adaptation will raise considerably, even if the global emission gap is maintained lower than 2 °C due to limited adaptive capacity. The IPCC's Fourth Assessment (AR4) demonstrated that Africa's vulnerability to the effects of climate variability is relatively high due to low adaptive capacity and over-reliance on natural systems for their livelihoods (Mpandeli et al. 2019). Extreme occurrence of droughts is likely to become more rampant and severe in Africa (Schellnhuber et al. 2012). Consequently, climate variability is negatively affecting agricultural production, particularly in SSA where most countries rely heavily on rainfed agriculture as the mainstay of their economies (Abdul-Razak and Kruse 2017). Climate variability related to biophysical stressors is expected to worsen the existing vulnerabilities by dipping the crop yields (González-Orozco et al. 2020).

It is postulated that warming more than 3 °C worldwide will see almost all of the current crops such as maize, sorghum, and millet-cultivated regions in Africa becoming unfeasible for present cultivars. Water unavailability, lower feed quality which is inaccessible, and effects of disease and heat stress will negatively affect production in the livestock sector (Schaeffer et al. 2013). According to Huq et al. (2004), climate variability has a direct impact on how humans manage natural resources and which results in food insecurity. The risks associated with climate variability threaten the capacity of livelihoods to meet basic needs, such as food and water. These effects will be more intense in the arid and semiarid lands (ASALs) where the resources are already limited, vulnerable, and could, therefore, suffer the most.

To mitigate climate variability, community adaptive capacity must be pursued. According to Levina and Tirpak (2006), the term adaptive capacity has been defined differently by different authors. Different authors have explained the concept of adaptive capacity to simply mean the capacity of a natural system to positively respond to the impacts of climate variability. Policymaker also use the term adaptive capacity to refer to the ability of individual communities to respond and adjust their way of life based on the effects of climate variability and lead to adaptation. Therefore, whenever we use adaptive capacity, society and communities must come up with coping strategies especially when dealing with impacts of climate variability in order to minimize its adverse effects.

Communities living in SSA are facing climate variability in a very tough way due to their lack of capacity to respond. The influences include increasing temperatures, more inconsistent rainfall, and increasing incidence of floods and droughts (CARE and ALP 2013). These impacts have severe consequences especially among the rural poor whose livelihoods are directly pegged on the very vulnerable environment. These communities heavily depend on land resources for agricultural production and therefore the impacts of climate variability have a direct impact on their livelihoods. Crop yields will decline transversely in the landmass as ideal growing temperatures are surpassed and growing periods reduced. The areas and timing of cropping activities that were previously suitable for certain crop are anticipated to shift as home-grown climates varies.

In Kenya, the adverse effects of climate variability have also been witnessed particularly in the ASALs which forms ~80% of Kenyan land mass (582,646 km^2) (Macharia et al. 2020). The main effects of climate variability in Kenya have been demonstrated by prolonged and frequent droughts, floods, resurgence of diseases, pests, and environmental disasters. As a result, agricultural productivity is significantly reduced, resulting to increased food insecurity and threatened livelihoods which in most instances leads to human conflicts over scarce land and water resources (Enya et al. 2013). For instance, the *La* Nina occurring between 1999 and 2001 in SSA was the most prolonged and most severe ever, causing devastating effects especially on human livelihoods. The drought affected over four million people due to crop failure and the resultant reduced yields. Droughts have caused starvation, loss of life, and degradation of the environment as a result of deforestation.

Variability in climate poses major threats to environmental sustenance, commercial, and sustainable development in rural areas of the arid regions of Kenya. In particular, the ASAL region of Garissa and Tana River County has been experiencing severe prolonged drought and flooding despite having River Tana traversing the region. This has led to loss of vegetation cover, drying of water catchment areas, rivers, and seasonal streams. This is then followed by heavy lack of pastures and shortage of drinking water resulting to livestock deaths. Recently, in short rains of 2018/2019, Garissa and Tana River counties experienced floods which caused severe havoc resulting to over 50 fatalities, over 15,000 people displaced, and thousands of livestock killed as a result of bursting of River Tana's banks. In addition, extreme weather events such as flooding has spoiled or destroyed transport and communication networks and affected other nonagricultural portions of the food system badly. This has led the communities to seek alternative ways of meeting their livelihoods such as charcoal burning hence environmental degradation resulting to double tragedy from the loss of their only source of livelihood and land degradation. Against this backdrop, this study aimed to close the gap by identifying possible adaptive capacity of the vulnerable communities in the region for the purpose of coping mechanism. This study was conceived to explore the existing adaptive capacity which is sustainable and viable and which the communities would easily embrace to act as adoptive buffer towards the impacts of climate variability in Garissa and Tana River Counties.

Impacts of Climate Variability

Key among the impacts of climate variability includes the following.

(a) **Drought**

Drought is a major threat globally and more so in Africa due to low adaptation capacity resulting from limited resources. Drought results in decreased moisture emanating from inadequate and erratic rainfall and high extreme temperatures. As observed by Keya (1997), moisture storage is largely dependent on rainfall received prior to the onset of drought conditions and the permeability of the soil (micro edaphic conditions). Drought has led to loss of pasture for the livestock as well as wildlife, vegetation loss, and food insecurity. This threatens the source of livelihoods of local communities in the arid lands.

(b) **Loss of biodiversity**

Ecosystem varieties will hypothetically change rapidly as heating increases with reduced precipitation, and will result to biodiversity loss. Some species may be impotent to adapt to the varying climatic conditions (Schaeffer et al. 2013).

High temperatures and lack of precipitation affects distribution and abundance of fauna and flora species. Substantial shifts in climatic situations could result to loss of some standing biomes and the general aesthetic appeal of our environment (Williams et al. 2007). In some instances, the changes in climate may favor the growth of invasive plant species hindering the alien species such as *Prosopis Juliflora* "Mathenge" a common plant in the northern Kenya.

(c) **Food insecurity**

Extreme temperatures above the ideal may have harmful consequences on crop productivity (Wheeler et al. 2000). These changes have a significant effect on the facets of food security since they negatively affect food availability, access, and utilization resulting to unstable and unreliable food systems. Kenya may experience reduced yields with the changing climate (Herrero et al. 2010). Crop yields are drastically reducing in SSA as the optimal temperature increases altering cropping and seasonal calendars (Schaeffer et al. 2013). In Africa and to a large extent, the ASALs region of East African such as Sudan, Ethiopia, and Kenya have in the past experienced hostile climate change. This has hampered crop production leading to acute shortage of food, pastures, and fibers, hence food insecurity. According to Lobell et al. (2011), yields are likely to diminish by ~1% daily for maize crops if such high-temperature regimes are consistent similar with other crops such as cotton and soybeans (Schlenker and Roberts 2009). Similarly, livestock production will be severely affected through quality feed and water availability (Schaeffer et al. 2013).

(d) **Human health and diseases outbreak**

Water availability and increased rates of disease outbreak are transformed by climate change (Schaeffer et al. 2013). The impacts of climate variability will be felt through increased infectious diseases which are relatively high in SSA. Extreme weather events may lead to illness and mortality. The level of malfunction may also be on the rise up to between 35% and 80% due to a rise of between 1.2 °C and 1.9 °C (Lloyd et al. 2011). As reported by Patz et al. (2008), flooding results to disease outbreaks including diarrhea, cholera, trachoma, and conjunctivitis. Other diseases like malaria may shift and be felt to areas where they were not felt before due to changes in temperature suitability responsible for pathogen growth.

(e) **Water resources**

Change in the hydrological sequence due to climate variability has a direct impact on water timing and circulation (Goulden et al. 2009). With most of the countries in SSA facing challenges with provision and supply of clean usable water, climate change will exacerbate this and lead to more water shortages in the coming years (Schellnhuber et al. 2012). The resultant effect will be increased disease outbreaks due to poor sanitation, low agricultural production, food insecurity, and general influence on livelihoods. Rise in temperature due to global warming would lead to a complex rate of evapotranspiration leading to increased loss from water bodies (Ogolla et al. 1997).

(f) **Land degradation**

Population increase combined climate variability impedes good resource management leading to environmental degradation (UNEP 2002b). Climate variability is slowly encroaching and engulfing countries thus rendering their land unproductive due to variations in weather patterns and global warming. As human population grows further, the natural distribution of vegetation on earth will be altered. This leads to opening new land for agriculture and cultivation of marginal areas (UNEP 2002a). This has led to loss of natural habitats, reducing vegetation cover and exposing soils to wind and water erosion in many parts of Africa. Soil erosion has increased the rate of siltation in dams and rivers and at the same time reducing the productivity of the land.

Adaptive Capacity to Mitigate Climate Variability Impacts

Adaptive capacity calls for strategies to help the communities to adapt to these extreme events such as drought and flooding. Adaptation simply means adjustments made in the existing systems as a response mechanism toward countering the effects of climate variability by the communities and individuals involved. These adjustments are mainly meant to act as a buffer and to assure proper exploitation of the new opportunities that minimize harm and as they present themselves. Therefore understanding the adaptive capacity by farmers is crucial to effective adaptation planning since it assures continuous production crucial to effective planning and guarantees human survival (Chepkoech et al. 2020). With the projected increase in global temperature, likely to result to increase in global warming, it's thus inevitable for individuals and communities to find adaptive ways which guarantees their survival. Adaptive measures toward climate change are no longer regarded as second measured but should be taken as primary consideration especially by farmers. However, the adaptation capacity in most African countries is low mainly due to lack of capacity to invest in the recent technologies which have been studied and found to promote better survival and livelihoods. Majority of agriculture in SSA is rainfed with only a very small percentage of farmers with a capacity to carry out irrigation which makes it difficult to predict due to climate variability. Further, the challenges are associated with lack of reliable weather data to inform on policy, and therefore most of the countries lack early warning systems that can be used early enough to caution the governments of possible climate-related calamities.

Impacts and Adaptation Strategies to Climate Variability in Arid and Semiarid Lands: A Case of Garissa and Tana River Counties in Kenya

Rainfall and Temperature Impacts on Food Security

From a data synthesis on annual rainfall and temperature over a period of 20 years for Garissa and Tana River counties indicate that rainfall was characterized with extended dry season occurring between January and February. The long rainy season occurs between March and May (MAM) while prolonged dry season occurs from

Fig. 1 Reduced River Tana flow during the month of October. (Courtesy of D. Karienye)

mid-May to mid-October, while short rainy season begins in mid-October to end of December of each year. There are fewer days of more intense rainfall with the rains often starting late but intense which are described as "very unreliable" (that is seasonal failures are common).

Similarly, for temperatures, the highest temperature amounts were observed between February and March, which coincides with the same time when rainfall is lowest in the study area. Around September–October, the temperatures are also at highest. Temperature increase has an important impact on water availability, thus aggravating drought conditions. Decreases in rainfall have profound repercussions on river flows leading to declining river discharge (Fig. 1). The months that saw an increased rise in temperature also experienced drought. This can be explained by the high evapotranspiration making the vegetation deficient of moisture leading to crop and pasture failure.

However, in trying to escape the droughts, the few well-endowed farmers practiced drip irrigation and greenhouse farming as indicated in Fig. 2. This ensured a reduction in the impact of droughts. This low number of farmers adopting new farming mechanisms, and which is a shift from rainfed agricultural production can be explained by the high cost of the greenhouses' infrastructures. This represents an innovative technology in response to the changing weather patterns though the adoption rates remain relatively low due to high cost.

Community Perception on Climate Variability and Its Impacts

From the interaction with the community, majority of the households were extremely worried about climate variability and identified rainfall to be very unpredictable

Fig. 2 Farmers practicing greenhouses and drip irrigation. (Courtesy of D. Karienye)

Fig. 3 Land degradation through charcoal burning. (Courtesy of D. Karienye)

stating that there exists a consistently prolonged dry period every now and then. Nevertheless, farmers believe that temperatures have already increased and precipitation has declined or is unpredictable (Karienye et al. 2019).

The impact of climate variability has been felt mainly by reduced crop production, extreme cases of flooding, and land degradation as evident by charcoal burning (Fig. 3) and reduced biodiversity. The reduced precipitation coupled with flooding leads to crop failure which destroys the crops that are grown along River Tana. Floods have in the past been responsible for causing disruption in transport systems and displaced residents living in the low-land areas which are prone to flooding (CARE and ALP 2013).

Fig. 4 Community-based agro forestry programs. (Courtesy of J. Macharia)

Adaptations Strategies to Climate Variability in Arid and Semiarid Land

Based on their own experiences and from sharing information among themselves, most of the households in these ASALS of Kenya have identified several adaptive strategies to cushion them against the extreme conditions. The communities preferred livelihood diversification (business, cropping, and livestock) as an alternative livelihood option, sustainable use of the land including conservation agriculture, mulching, building trenches and ditches around the homesteads and watering crops using cans during dry spell. They have also adopted drought-tolerant and early maturing crop species, changing eating behaviors and afforestation (Fig. 4).

Conclusions

From our synthesis, the rainy seasons are no longer predictable thereby prohibiting any farming activities. The impacts of climate variability in the ASALs are mainly through extreme conditions of drought and flooding. The two conditions have resulted to various challenges facing the communities in these regions through low agricultural production (food and pastures), poor infrastructure, population displacement resulting to extreme poverty, overall food insecurity, and tough livelihoods. These challenges are exacerbated further by the inability of the majority of the communities to cushion themselves against the impacts of climate variability and this becomes a cyclic problem year in year out. The better-endowed community members have invested in greenhouses and drip irrigations to ensure continuous supply of food particularly for their domestic consumptions. However, efforts by the local communities have been identified where they have, through experience over time, resulted to planting drought-resistant crop varieties, diversified their livelihoods, embraced sustainable land use, and made efforts to plant trees. It's imperative to note that well-informed, adaptive, and forward-looking decision making is central to adaptive capacity of the host communities. In order for community to respond to expected changes and to participate in adaptive decision-making, they require precise information, knowledge and skills that enable them to actively address climate risks to their livelihoods. Therefore, adaptation energies must aim to ease access to information and the development of the skills and knowledge needed for accurate adaptation targeting. Institutions and agencies responsible for policy formulation should ensure an enabling atmosphere for local adaptation efforts.

Recommendations

In order to embrace the adaptive capacity as long-term practical solutions, the following are recommended:

- Monitoring daily weather patterns and improving scientific understanding of climate.
- The community needs to be trained on affordable and appropriate technologies such as sustainable agriculture.
- Promotion of climate-smart crops farming.
- Promotion of insurance services against the consequences of catastrophic weather events to mitigate against climate variability.
- Provision of early warning systems to the communities.
- There is a need to build community-based capacities in planning, coordination, and implementation of climate change adaptation activities and programs.
- Intensification of tree planting through community-owned nurseries, establish green zones, and invest in reforestation programs.

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