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IMPACT OF CLIMATE CHANGE RELATED DISASTERS ON THE RESILIENCE OF HOUSEHOLDS IN NYANDO AND LOWER NYAKACH SUB COUNTY, KISUMU COUNTY, KENYA

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ABSTRACT

Nyando and Lower Nyakach Sub-counties in Kisumu County experience both floods and drought in alternating cycles. Floods and drought have been documented as indicators of Climate Change; hence, they are considered Climate Change Related Disasters (CCRDs). The CCRDs leave trails of destruction and negates cumulative efforts at maintaining sustainable livelihoods and ecosystem health by the communities. The impact of the CCRDs on the environment (soils and water sources) is therefore likely to influence the resilience of households given the short period available for households to successfully cope with one disaster before the other one strikes, potentially compromising their resilience. This paper explores how impact of CCRDs on the environment influences resilience of households through the lens of coping mechanisms. The study adopted a descriptive survey design. Data for the study were collected through a survey of 374 households. 12 key informant interviews and direct observations in the two sub-Counties. Purposive sampling was used to select two wards from Nyando and one Ward from Lower Nyakach Sub-Counties prone to floods and drought. The target population was 64,103. Data processing and analysis was conducted using Descriptive statistics such as frequency, means, percentages, and inferential statistics (Chi Square, t-test, and regressions tested at alpha $p < 0.5\%$) were used to correlate Impact of Climate Change Related Disasters (CCRDs) to coping capacity. The Impact index (M=3.47) was higher than the coping index (M=2.84). Whereas Impact of CCRDs on environment was not significantly different across the Wards ($p = .155$), Coping of households was significantly different across wards ($p = .027$). Impact was found to significantly influence coping of households ($p = .000$) and the relationship was positive. ($r = .286$). The study recommends identification of site-specific interventions to mitigate the impacts of CCRDs, on the environment. It also recommends a communal approach to management of common resources and enhancement of extension services and resource allocation to the wards.

KEYWORDS: Resilience, Climate Change Related Disasters (Floods and Drought) & Coping, Impact

INTRODUCTION

Globally, Studies have demonstrated that about 90% of all natural disasters that afflict the world are related to severe weather and extreme climate events. (Gentle and Maraseni, 2012) reported gradual increase in both maximum and minimum temperatures and also high variability in rainfall in the remote mountainous Jumla District of Nepal over a period of 30 years as having had a significant effect on agriculture and resource degradation (deforestation and loss of pasture for livestock). Regionally in Africa, the negative effects of climate change have also been witnessed. For instance,

in Rubanda district of Southwestern Uganda, temperature was found to have increased significantly whereas a decreasing trend of rainfall had been observed over the past 40 years. Farmers here perceived climate variability as the cause of decline in agricultural productivity impacting on food security (Byamukama, Bello and Omoniyi, 2011). In Kenya, floods and droughts have been documented as indicators of climate change and they are reported as some of the major recurrent disasters that afflict Kenyans (Kenya Disaster Risk Profile, 2014). However, the flood hazards turn into disasters only in few places in the country. The most commonly affected places are the floodplains of the major rivers such as the lower Tana River, the lower Nzoia River at Budalang'i plains and the lower Nyando River at Kano Plains (Opere, 2013). The Lake Victoria Basin in western Kenya is one of the most flood-prone regions in the country (GoK, 2007)). In recent years, floods in the Nyando River basin have resulted in negative impacts, ranging from loss of human lives and livestock to widespread destruction of crops, houses, public utilities and disruption of various economic activities (Nyakundi, Stephen, Isaac and Andre, 2010). Prolonged drought due to below normal precipitation in Nyando river basin has also contributed to immense negative effects in the basin. A Study conducted in Nyando district to assess the vulnerability to climate change in Lake Victoria basin revealed that environmental resources like trees and grass cover were highly vulnerable due to fuel needs, clearing wooded areas for farming and use of these areas for building and creation of new homes due to population increase (LVBC, 2011). Grass cover could suffice for ground cover. If ground cover is vulnerable, then the soils would be equally vulnerable to climate change and its vulnerability needs to be investigated.

THE PROBLEM

This study focuses on the assessment of Impacts of CCRDs on the Resilience of Households in Nyando and Lower Nyakach Sub Counties, Kisumu County, Kenya**.** It is claimed that in lower Nyando river basin, droughts and floods, which are the indicators of climate change, have affected soils and water sources, the natural capital base for the communities' livelihoods and ecosystem health. This community mainly draws their livelihoods from agricultural practices such as small scale farming in crops such as maize, sorghum, millet, cowpeas, cassava, rice and traditional livestock keeping for their own household consumption. The frequencies of floods and drought have increased in the recent past with consequent deterioration of the natural capital. There is relatively little research and lack of documentation on the relationship between Impact of CCRDs and coping with a view to building resilience in the livelihoods of the communities. Little attention has been paid to the soils and the water sources damaged by floods and drought. The key challenge this study hopes to address is how Impact of CCRDs on the environment influences resilience of households through the lens of coping mechanisms.

OBJECTIVES

The broad objective of this study is to examine the how Impact of Climate Change related disasters namely floods and drought on the environment influences the resilience of households in Lower Nyando river basin, Kisumu County, Kenya.

The Specific objectives were:

- To determine the Impact of Climate Change related Disasters on the environment (soil and water sources) in Nyando and Lower Nyakach Sub Counties, Kisumu County, Kenya
- To examine coping of households in Nyando and Lower Nyakach Sub Counties, Kisumu County, Kenya.
- To explain how Impact of CCRDs on environment influences Coping in Nyando and Lower Nyakach Sub Counties, Kisumu County, Kenya

LITERATURE REVIEW

Climate change is a global phenomenon that results in global warming, droughts, flooding and depletion of natural resources (Adger, Huq, Brown, Conway & Hulme, 2003). Climate change refers to a change in the climate that persists for decades or longer, arising from either natural causes or human activity (adapted from IPCC, 2007). The observed change in climatic conditions over the past 30 years is clear on every continent. All the key indicators of climate change, including sea-level rise, temperature and drought days, are expanding outside the normal ranges of frequency, intensity and location (Nolan, Michael & Smith, 2015). Recent extreme weather events such as hurricanes in the United States, floods and storms in Europe, typhoons in Asia, droughts in Africa, and bushfires in Australia have served to remind us of the impacts of climate change and in many cases, highlighted shortcomings in preparedness and disaster response (Nolan *et al.,* 2015).

Climate Change Related Disasters (CCRDs)

Of all the relevant factors in climate, precipitation is the main cause of disasters in the water resources sector. Abundant precipitation can lead to disasters such as flooding, water pollution, soil erosion, dam breaks, and water-related disease outbreaks and famine. On the other hand, scarcity of precipitation in areas, which ordinarily receive it, can lead to drought, water scarcity, loss of vegetation, loss of livestock and wildlife, famine and general suffering of people living in the affected areas (Opere, 2013). Markers of climate change include floods, drought and temperature (Ajuang, Abuom, Bosire, Dida & Anyona, 2016) and rainfall variability (Thorlakson, 2011). Floods and drought are therefore climate change related hazards (Krishnamurthy, Lewis & Choularton, 2014).

Impacts of CCRDs on the Environment

Effects of CCRDs range from socio-economic, environmental, physical and ecological. In 1997/1998, the El Nin o associated floods affected many parts of Kenya, causing destruction to property, loss of lives, famine and waterborne disease epidemics. Obiayo, Stanley and Charles (2016) investigated the influence of floods on community livelihood sustainability and development in Nyando River Basin, Nyando Sub-County and established that floods wreck havoc on the maize and bean crops leading to food insecurity, school children stayed out of schools longer, more people accessed water from open sources posing health risks and inadequacy of sanitation facilities, shelters were also destroyed. Floods may lead to intense soil erosion with consequent decreased soil fertility (Thorlakson, 2011). Soil erosion causes reduced yields because of nutrient loss, reduced water retention and infiltration, reduced soil organic matter and restricting plants' root depth (Mbaria, 2006; Mutegi*et al.*, 2008; Sanchez *et al.,* 1997 in Thorlakson, 2011). Water logging also makes ploughing difficult and results in loss of nutrients from the soil through leaching. Floods can also render farms uncultivable, for the time, it is submerged and even deposit sediments on farms that will make cultivation expensive and difficult for some time. Floods therefore have a large potential of reducing food production (Armah, Yawson, Genesis, Justice, and Ernest, 2010). Floods leading to soil erosion may cause siltation of wetlands (Masese, 2012). Drought may result in reduction in soil quality. Soil moisture essential for microbial activities, is reduced in drought conditions and consequently, there is minimized organic activity and continued dry spell which kills soil organisms. The end result is dry and cracked soil and it even becomes easier for desertification to set in. Drought also makes it unsuitable for plants and vegetation cover to survive leading to bare soils susceptible to both wind and water erosion. Badly eroded soils have lost all topsoil and some subsoil and are no longer productive farmland (Smith, 2000). In Northern Ghana, changing climatic conditions are affecting soil moisture with a consequent possibility of affecting crop production (Mabe, Sarpong & Osei-Asare, 2012) thereby

necessitating high adaptive capacities by farmers. Recha, Gachene & Lieven (2017) projections (2030-2050) indicate that there will be an increase in soil moisture stress in Nyando due to high evaporation as a result of increase in daytime temperatures. This is likely to exacerbate the impacts of drought in Nyando river basin. Prolonged drought due to below normal precipitation in Nyando river basin has also contributed to immense negative effects in the basin such as loss of decreased water volume in rivers, dry wells, death of livestock and loss of livelihoods dependent on water (Nyakundi, Stephen, Isaac and Andre, 2010). Access and quality issues have remained a thorn in the flesh to residents of Nyando district especially during the long spells of drought Nyakundi *et al.,* (2010). If these impacts are not addressed adequately, they could compromise the productivity and health of the productive assets with subsequent impacts on the users. The degree of impact depends on the ways in which the natural triggering event interacts with particular ecosystems and with the specific characteristics of the society affected, including its level of economic development; the types of livelihoods of its members; education levels; and other factors that generally determine both how resilient the affected population is as well as what resources are available for adaptation (Malone, 2009).

Concept Resilience

Mayunga (2007) defines disaster resilience as the capacity or ability of a community to anticipate, prepare for, respond to, and recover quickly from impacts of disaster. Interestingly, Folke, Colding and Berkes (2002), describes resilience as "the capacity to change in order to maintain the same identity". It is apparent that resilience is a very dynamic term and which can be operationalized by various disciplines. It is also apparent that resilience is not just about systems bouncing back to their normal state, but is also about systems finding stability in the new changed states. Since the ancient application of resilience to ecological studies, works from various authors have shown the linkage of resilience to explain socio-ecological systems (Aldunce, Ruth, Mark & John, 2015; Parsons *et al.*, 2016; Ranjan & Abenayake, 2014) in which communities respond to disturbances or disasters within a natural environment. Broadly, resilience when applied to human systems is best conceptualized as a capacity and process rather than as an outcome (Imperiale and Vanclay, 2016). Resilience has many dimensions such as physical/technical (Joerin, Rajib, Yukiko & Ramasamy, 2012), Social (Joerin *et al.,* 2012), Economic (Khalili, Sanaz, Michael, Philip, 2015), community (Kusumastuti, Viverita, Zaafri, Lenny & Dwi, 2014), and institutional (Khalili *et al.*, 2015). Kotzee and Reyes (2016), included the ecological dimension as a measure of resilience. Mayunga, (2007) emphasizes that resilience is a function of the five capitals namely: social, economic, human, natural and physical. Daniel, (2011) in his efforts to formalize the theory of resilience, ascertains that resilience is dependent on a coping strategy.

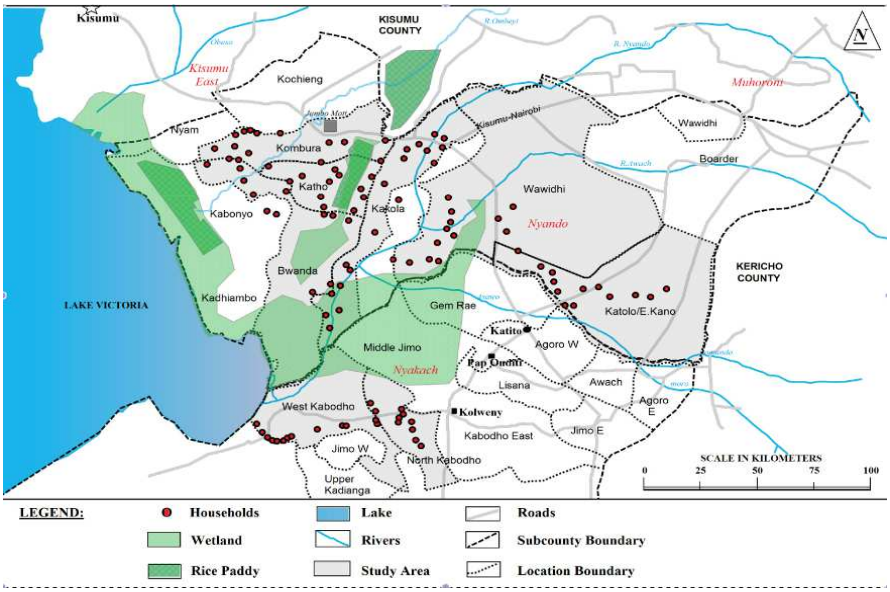
Coping as an Attribute of Resilience

Capacities assess the potential for disaster resilience within the system of interest, rather than the actual realization of disaster resilience in relation to a particular natural hazard event (Norris, Stevens, Pfefferbaum, Wyche and Pfefferbaum, 2008 in Parsons *et al.,* 2016). The Australian National Disaster Resilience Index (ANDRI) identifies coping capacities as one of the attributes of resilience. In a practical sense, coping capacity relates to the factors influencing the ability of a community to prepare for, absorb and recover from a natural hazard event (Parsons *et al.*, 2016). It focuses on the capacities of communities to anticipate and respond to hazards. Even though much work has been done on effects and coping with floods in the study area, little has been done to address effects of floods and drought on soils and water sources and the impact of CCRDs on resilience of households.

The Context of Livelihoods and Climate Change in the Research Area

The study area is located in lower Nyando river basin that traverses both Nyando and lower Nyakach sub-counties of Kisumu County. The Nyando River Basin covers an area of 3,500 square kilometers in Kisumu County. The Nyando River catchment straddles the equator bound by longitudes 34°45' 0"E and 35° 21"E. (Otiende, 2009).

It borders the Winam Gulf, a protruding part of Lake Victoria, at the end of which is Kisumu Town. The plain is, however, characterized by broken low ridges and river valleys (Ocholla, 2010). The Nyando river catchment empties its water into Lake Victoria. The Nyando River traverses the Kano Plains and covers a large area of the lower plains. It is notorious for frequent flooding. Available data suggest that progressively greater flooding is being caused by smaller flow in the rivers concerned (Opere, 2013). Nyando Sub-County is classified as semi-humid (Ocholla, 2010). The Nyando river basin experiences a bimodal rainfall pattern with long rains in March-May and short rains in September-October. The annual rainfall varies from more than 1,100 mm to 1600 mm with a minimum and maximum mean monthly rainfall of 72mm and 243 mm respectively (JICA, 1992 in Raburu, Okeyo-Owuor & Kwena 2012). Vertisols are the dominant soil types (Ocholla, 2011). Households display a high degree of poverty and low incomes as reflected in the employment types where the majority of the people were in the informal sector. The main occupation of a majority is subsistence farming (Nyakundi *et al.*, 2010). A map of the study area is as shown in figure 1.



Source: Author

Figure 1: Map of the Study Area.

METHODOLOGY

The study adopted a descriptive survey research design, targeting a population of 64,031 and an accessible population of 14,675 household heads with a sample size of 374 (HHH) drawn from 3 divisions with 8 locations in the two Sub-Counties. Two divisions that are prone to both floods and drought were purposively selected from Nyando sub-county and one division that experiences floods only was selected from Nyakach sub-county for comparison purposes. Stratified, purposive, proportionate and systematic random sampling was used to select households and key informants. A household questionnaire was administered to sample size of 374 household heads (HHHs). Thirteen (13) key Informant Interviews lasting 30 minutes to one hour were conducted. Direct observations were made and where applicable, photographs were taken. The data was collected during both the dry and the wet seasons.

Data Analysis

The data collected was coded, screened and cleaned. Data processing and analysis was done using Social Sciences (SPSS version 20) computer system. Descriptive statistics such as frequency, means, percentages, and inferential statistics (Chi Square, t-test, ANOVA, and Multiple regressions tested at alpha $p < 0.5\%$) was used to regress the coping capacities of households to impact of CCRDs.

RESULTS

The effects of floods and drought (CCRDs) on soils and water sources (environment) were first determined and expressed as an index denoting the impact of CCRDs on the environment. The next step involved determining the frequency of engaging different strategies to cope with the effects of CCRDs on the environment and this was expressed as an index denoting coping capacity. The coping index was then regressed against the Impact index to determine the influence of impact of CCRDs on the environment on the households coping ability.

Objective 1: sought to determine the impact of CCRDs on the environment (soil and water sources) in Nyando and Lower Nyakach Sub Counties, Kisumu County, Kenya. In summary, the impacts of floods on soils are many and can be lumped together in order of prevalence as follows: Surface soil and sediment contamination, reduced fertility, and introduction of invasive species and erosion of vegetation cover. The impacts of floods on water sources are also many and can be lumped together in order of prevalence as follows: Physical, Chemical and Biological contamination by effluents from farms, industries and sewage and last but not least, siltation. The impacts of drought on soils in order of prevalence range from: Poor soil texture and consistency, loss of soil moisture, loss of soil fertility, soil erosion to emergence of invasive species that thrive in degraded soils. Lastly, the impacts of drought on water sources in decreasing order of prevalence rank from reduced water volumes and hence water scarcity, water pollution by dust, and debris and loss of water quality leading to turbidity and foul smells. All these render the water not fit for human consumption. An illustration of the impacts of CCRDs on the environment is captured in plate 1.

Plate 1: Impacts of Floods and drought on Soils and Water sources.

In terms of severity, the impact of floods on soil recorded a mean of 3.52, that of floods on water sources, a mean of 3.16, that of drought on soils, a mean of 4.07 and that of drought on water sources, a mean of 3.47. These four means were computed to give a composite index (M = 3.47) table 1.

Table 1: Impact of CCRDs on the Environment Index

Scale	n	Mean	SD
Impact of floods on soil	343	3.52	0.75
Impact of floods on water sources	333	3.16	0.73
Impact of drought on soil	342	4.03	0.60
Impact of drought on water sources	334	3.47	0.74
Impact of CCRDs on the Environment Index	**346**	**3.47**	**0.60**

From the results, it can be concluded that the impact of floods on soils is more severe compared to the impact of floods on water sources. Similarly, the impact of drought on soils is also more severe compared to the impact of drought on water sources. The implication of these results is that soils in the study area are as vulnerable as water sources to the impacts of floods and drought, yet more prominence has always been given to floods compared to drought. The floods and drought also seem to be common phenomena whose management need to be factored in routine natural resource management decisions. The effects of this would be felt in the agriculture sector, livelihoods and social setups, which are largely dependent on the environment for survival. The Impact of CCRDs on environment was not significantly different across the Wards (p = .155) or by sub-county (p = .180), suggesting that any interventions taken should be uniform across the study area. The interventions may take a landscape approach starting from the highlands whose activities set the tempo of CCRDs experienced in the Nyando river basin. In order to assure food security, environmental health and human well being, policy and interventions need to be alive to the impacts of CCRDs on the environment. Efforts need to be channeled towards reducing the effects of floods and drought on soils and water sources.

Objective 2: sought to establish the coping capacity of households in Nyando and Lower Nyakach Sub Counties, Kisumu County, Kenya. Households were found to engage in a number of coping mechanisms to deal with impacts of CCRDs on soils and water sources. The mechanisms range from simple day to day activities like treating drinking water, draining waterlogged soils, mulching, paddocking, moving to wetlands to graze, deep ploughing, planting cover crops, planting drought resistant varieties to more complex and long term initiatives like construction of check dams, agro forestry, protecting water sources, rehabilitating damaged river banks and building gabions. All the initiatives are applied at different levels dependent on resource availability and prior experience of their success levels. The means for coping with impact of floods on soils, floods on water sources, drought on soils and drought on water sources were 2.98, 3.01, 2.87, 3.07 respectively. These means were then compounded to form a coping index which was found to be M=2.84 (table 2).

Table 2: Coping with Impact of CCRDs on the Environment Index

Scale	N	Mean	SD
Coping with effect of floods on soils index	327	2.98	0.94
Coping with effect of floods on water sources index	323	3.01	0.81
Coping with effect of drought on soils index	326	2.87	1.01
Coping with effect of drought on water sources index	326	3.07	1.00
Coping with impact of CCRDs on the Environment Index	**342**	**2.84**	**0.90**

From the results, the coping index (M = 2.84) is much lower than the Impact index generated in objective one (M = 3.47). The study also revealed that interventions that stand to benefit individual households by virtue of ownership or proximity to the water source and where failure to take action would render them more vulnerable and were more popular

as opposed to interventions that would potentially benefit communal interests e.g., rehabilitating damaged river banks, restricted abstraction restricted grazing in wetland. A possible explanation to this is that individual interests supersedes communal interests and therefore individuals perceive common property as collective responsibility, hence, few people would be moved to protect an asset for the common good. From the findings, households engage a portfolio of responses in the face of CCRDs, similar to the findings of Béné *et al,* (2016). The availability and capacity to engage a variety of coping options in the face of disturbances, is a positive indicator of resilience. This has been proven to be true from other studies (Masese *et al*, 2016). There is a need to examine the contribution of each individual impact to the overall coping of household to enable prioritization of interventions. According to key informants, extension services are weak and so is law enforcement especially on riparian land. Coping capacity of households was significantly different across wards (p = .027). This means that there is disparity in the ability to apply interventions across the wards. Efforts therefore need to be made to ensure that location specific interventions are adopted based on the perceptions and ability of the targets to adopt them. Extension services need to be strengthened and riparian law enforced.

Objective 3 sought to explain how impact of CCRDs on the environment influences Coping Capacity in Nyando and Lower Nyakach Sub Counties, Kisumu County, Kenya. Compared with the impact index M = 3.47 (table 1), the coping index (M = 2.84) is lower. The findings may imply that impact of CCRDs on the environment is higher than the coping capacity of households. Simple linear regression was used to determine the influence of impact of CCRDs on the environment on the coping capacity of households. Impact of CCRDs on the environment index was regressed on coping with impact of CCRDs on the environment index (table 3).

Table 3: Regression table for Impact of Climate Change Related Disasters on Environment with Coping Capacity

Model	Unstandardized Coefficients		Standardized Coefficients	t-value	p-value
	B	Std. Error	Beta		
(Constant)	1.316	.281		4.683	.000
Impact of CCRDs on the environment	.439	.080	.286	5.498	.000

r =.286, R^2 = .082, F(1,340) = 30.225, p = .000

Impact was found to significantly influence coping capacity of households (p =.000) and the relationship was positive (r =.286). The explanatory variable accounts for 8.2% (R^2 =.082) variation in coping with impact of CCRDs on the environment. The effect of impact of CCRDs on the environment on the outcome was statistically significant at the.05 level, F (1,340) = 30.225, p =.000 hence rejecting the null hypothesis Ho1 and affirming that Impact of CCRDs on the environment, significantly influences the coping capacity of households.

The Linear equation for this relationship is as follows:

Coping with impact of CCRDs on the environment = 1.316 +.439 Impact of CCRDs on the environment.

The positive (r =.286) implies that there is a positive relationship between the two variables in that as the impact increases, so do the households' coping capacity increase. This points to the ability of households to adjust to perturbations in the system. The variation of 8.2% can be accounted for by the fact that human beings are naturally resilient and when faced with a challenge, they will find a way of circumventing it. This is consistent with other studies, which pointed to the ability of households to adjust to perturbations in the system (Opondo, 2013).

CONCLUSIONS

The Impact of CCRDs on environment was not significantly different across the Wards, suggesting that the impact is not dependent on the location. However, coping was significant, implying that it could be pegged on the active use or failure to use location specific interventions. Whereas, the impact of CCRDs on the environment is immense, the level at which households engage active interventions to mitigate the impact is relatively low in the study area. This probably explains the low poverty index reported in this area that is heavily dependent on rain fed and soil agriculture. If this trend continues, the natural capital might lose its capacity to support sustainable livelihoods and healthy ecosystems. To avert this situation, concerted efforts from all the stakeholders ranging from the resource users, extension officers, policy makers and educators need to be consolidated to tilt the equation to low Impact and high coping capacity (typical resilient communities).

RECOMMENDATION AND AREAS FOR FURTHER STUDY

- Efforts need to be channeled towards reducing the effects of floods and drought on soils and water sources. A landscape approach to management of land use, which is the source of rivers and also controls runoff that cascades downstream to the basin is recommended to control the impact.
- Policy recommendations should ensure that location specific interventions are proposed based on the perceptions and ability of the targets to adopt them.
- There is need to shift focus from structural and behavioral interventions, which are widespread and considered the easier option, to critical examination and management of soil and water resources.
- It also recommends a communal approach to management of common resources.
- Further studies into perceptions of the community that determines the uptake of interventions on soils and water sources needs be done.
- In-depth analyses, monitoring of soil nutrients and land use practices with changing climate needs to inform decision making in the study area.

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