Climate Risks and Responses in Semi-Arid Kenya: Implications for Community-Based Adaptation

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Abstract: **- Communities in semi-arid areas face multiple climatic and non-climatic risks forcing them to subsequently adopt various response strategies. Research on risk management has typically focused on static, location-specific understanding of risk and response. However, empirical evidence suggest that risks and vulnerability vary across time and space. Increasingly, responses traverse multiple locations and dynamic e.g. people migrate away from their home areas, women move beyond their family homes for a better livelihood. To highlight this complex and dynamic nature of risks and responses, we study livelihood transitions in Kisumu, western Kenya. We unpack risk and response portfolios across scales – household, and levels – and classify them as coping, adaptive and maladaptive.**

Our findings show that present responses do not necessarily qualify as climate change adaptation strategies. While certain strategies do improve household wellbeing in the short run, there is relatively lower evidence to suggest an increase in adaptive capacity to deal with future climatic risks.

These findings point to critical gaps in understanding current risk management and will contribute to the climate policy framework especially community adaptation.

Key words: **semi-arid, livelihoods, climate adaptation, vulnerability, risk management**

I. INTRODUCTION

Livelihood vulnerability of small-scale farmers is characterized by a range of interacting social, economic, political, and environmental changes (Tucker *et al.,* 2015; Stringer *et al.,* 2017). This vulnerability is exacerbated by inherently low agricultural productivity (Thornton *et al.,* 2009), rapid and increasing natural resource degradation (Stringer *et al.,* 2017), inadequate governance responses to support diversification and adaptation responses (Tucker *et al.,* 2015), and an overall poor performance on development indicators due to economic marginalization (Tucker *et al.,* 2015).Climate change is projected to exacerbate these challenges especially in Africa, by pushing farming systems to cross biophysical thresholds with long-term implications on livelihoods and agricultural sustainability (Fraser *et al.,* 2011; Tucker *et al.,* 2015).

Characterized by low and erratic precipitation, heterogeneous soil profiles, relatively short growing seasons, and complex subsistence systems of agricultural production, the semi-arid lands of Kenya including Nyando face several climate related challenges (Ministry of Agriculture, Livestock and Fisheries (MoALF), 2017).Further, low investment in rainfed agriculture, and limited government support have undermined local survival and adaptive capacities (Raburu *et al.,* 2012). Although the farmers have responded in various ways, few documentations exist on how livelihoods have adjusted through experimentation; drawing on past experiences of variability and leveraging human and social capitals.

In Kenya and specifically Nyando, very limited studies have examined how vulnerability is changing over time. However, empirical evidence suggests that risk and response portfolios are spatio-temporally dynamic (Cutter and Finch, 2008; Kasperson, 2017). Increasingly, risk management strategies and spaces traverse multiple locations, for instance, through higher human mobility and changing social norms (Benz, 2014; Nguyen, 2014). Emerging vulnerability and adaptation literature highlight the necessity of capturing this temporality through novel methodological approaches(Fawcett *et al.,* 2017; Singh, 2018a) and adopting it to understand how adaptive capacity (a latent property) is realized as adaptation (adesirable outcome) (Mortreux and Barnett, 2017).

To understand this dynamic reality of risks and responses in the context of a changing climate, we examine livelihood responses and their outcomes at household and community scales in rural Kisumu – a county in western Kenya. We unpack household risk portfolios and assess responses and adaptation barriers for long-term implications on household wellbeing and systemic sustainability. We use the heuristics of survival, accumulation, erosion and land degradation (see Table 1) to highlight the variations in risk management across households. While reaffirming the argument that interventions to build adaptive capacity must be contextual (Adger*et al.,* 2005; Smit and Wandel, 2006), our findings push this thesis further to suggest that many responses that may not necessarily fall under 'adaptation' can help households cope with the current risks. Moreover, while certain strategies enhance household well being, little evidence exists to suggest an increase in adaptive capacity for managing future climatic risks. Our findings thus, identify critical gaps in understanding current risk management strategies, policy frameworks and relevant project implementation at subnational and community levels.

This paper is structured as follows. In the next section, we review the literature on risk and responses, with a geographical focus on semi-arid lands, and thematic focus on temporality. Section 3 describes the methodology and study sites while Section 4 presents the results. In Section 5, we

conclude by reflecting upon our findings and suggest some entry points for enabling community level adaptation.

II. CHARACTERIZING RISKS, RESPONSES, BARRIERS AND WELLBEING OUTCOMES

Risks to livelihoods include biophysical drivers (extreme events, natural resource quality) and structural factors (inequality, poverty, infrastructure); both mutually embedded in specific socio-economic contexts (norms, rules, networks) (Otto *et al.,* 2017). These drivers are inherently dynamic, rooted in historically shaped pathways (Ribot, 2010; Tschakert *et al.,* 2013; Kasperson, 2017), and mediate individual responses (Singh et al., 2016b). Capacities to adjust livelihoods and cope oradapt to dynamic risks are heavily influenced by infrastructure, wider institutional regimes and agendas, financial capital, social norms and practices, and ability to harness and share knowledge (Berrang-Ford *et al.,* 2011; Sietz*et al.,* 2011; Patnaik and Das,2017).

Household responses can be seen as falling along a continuum from no response to coping and adapting (Singh *et al.,* 2016b).Responses can be categorized by scale (individual, household, community or regional levels), by actor (vulnerable communities, nonstateactors, government) and by response timing (autonomous, planned). Autonomous responses, can be seen as spontaneous responses to non-climatic changes such as market dynamics or ecological change, and include strategies such as livelihood and income diversification (Ellis, 2000), asset or social capital investments (Olsson *et al.,* 2014), and shifts in socio cultural practices such as regulating food intake by some household members, inclusion of child labour as a family income source (Singh *et al.,* 2016b; Choudhury and Sindhi, 2017).Planned responses, on the other hand, are the result of deliberate policy decisions which recognize or pre-empt certain risks and aim to maintain status quo or transition towards a desired state (IPCC, 2014). In Kenya, planned responses to strengthen climate adaptation are nascent and were only recently launched under the National Climate Change Response Strategy (NCCRS) of 2010. The NCCRS recognizes the impacts of climate change to Kenya´s economic and social development and set path for development of the National Climate Change Action Plan (NCCAP) of 2012, a people-centred development approach. However, the level of effectiveness, impacts and outcomes of the NCCAP and other national adaptation responses still remain untested.

Adaptation responses may be specific to climatic risks or leverage generic capacities for enhancing economic and human wellbeing (Eakin *et al.,* 2014; Lemos*et al.,* 2016). At an individual level, responses are typically autonomous and cover a range of actions that include livelihood security and management functions (e.g. diversification of livelihood, investment etc.), adoption of technological solutions(e.g. irrigation facilities), management of societal ties and knowledge (e.g. fall back options enabled by social cohesion)(Ravera*et al.,* 2016).While farmer households have responded differently in Nyando, the outcomes of these responses in the context of adaptation and future adaptive capacity remain understudied. In an attempt to address this gap, we map out responses as coping, adaptive or maladaptive and continue to differentiate between generic strategies (e.g. to improve agricultural incomes, meet daily sustenance) and specific strategies that are direct response to climatic risks (Table 1). This heuristic of generic versus specific draws from Eakin *et al.,* (2014) and distinguishes climate adaptation from ongoing development interventions that enhance household capacities. It also embeds individual responses within wider development interventions aimed at providing infrastructure, services and general poverty reduction.

Table 1: Mapping coping and adaptive responses and their outcomes. The upwards, downwards and sideways arrows represent doing better, worse and negligible change respectively (*Source:* Singh *et al.,* 2018)

Response		Directionality			Illustrated example from literature
		Ecological	Economic	Social	
Short term coping	Surviving Eroding Accumulating Moving	⇔ ⇓ ⇔ ⇔	⇓ ⇑ ⇔ ⇑	⇓ ⇓ ⇓ ⇓	• Survival strategies such as reduced food intake or distress sale of livestock (Bhatta and Aggarwal, 2016) can erode personal assets and human capitals, especially if practiced over long periods • Trade-offs and externalities associated with shared resources such as groundwater, forests can lead to conflicts as well as resource over-extraction (Lele*et al.,* 2013) • Overreliance on microfinance institutions can disenfranchise certain social groups, and eventually lead to social reproduction of poverty, and farmer distress (Taylor, 2013) • Entrenched 'powerlessness in labour/gender relations' drives inequality, undermines wellbeing and perpetrate social vulnerability (Bhagat, 2017; Jha *et al.,* 2017)
Long term adaptive	Adaptive behavioural change Institutional shifts	⇑ ⇑	⇑ ⇑	⇔ ⇔	• Changes in cropping practices such as shifting planting dates and growing less water requiring/pest resistant crops in the face of recurrent drought or water scarcity (Jain *et al.,* 2015) • Access to crop insurance is particularly effective and increases chances of farmers engaging in yield-raising adaptations(Panda *et al.,* 2013)

Long term generic	Development interventions Livelihood security and management	⬇ ⬆	⬆ ⟺ ⬆	⟺ ⟺	• Green Revolution trajectoriese.g.Vision 2030,canincrease incomes and food security but undermine ecological systems and heightened regional inequality (Pingali, 2012; Gajjar *et al.,* 2018) • Co-benefits of employment generation (e.gkazikwavijana) that has helped livelihood diversification, drought proofing, natural resource management, soil reclamation, reclamation of commons (such as tanks, wells etc.) and in some cases, stemmed migration (Adam, 2015; Esteves *et al.,* 2013)
Potentially maladaptive	Ecological Institutional	⬇ ⬇	⬇ ⬇ ⟺	⬇ ⬇	• Well-intentioned interventions e.g. farm ponds for rainwater harvesting have shown to potentially produce maladaptive outcomes such as high initial investment and maintenance costs (Rao *et al.,* 2017) and negative externalities such as higher groundwater abstraction (Kale, 2017) • Negative externalities of subsidies and reduced taxes (on agricultural equipment such as heavy-duty diesel water pumps) on groundwater abstraction (Kumar *et al.,* 2013) • Investment inefficiencies in drip irrigation subsidies are widening economic disparities (Fishman *et al.,* 2015

The possible outcomes of the response strategies on household wellbeing are discussed from a perspective of the three pillars that underpin sustainability (social, ecological, and economic). Literature informs the direction of these outcomes, with examples from India and Kenya.

Table 1 above highlights that while some autonomous responses thrive within local social-ecological limits (e.g. leaving land fallow), others may over a longer timescale, erode people's capacity to cope and thus lead to maladaptive outcomes (e.g. reduced food intake, increasing school dropouts). Further, practices like reduced food consumption might entrench some people into poverty cycles and differentiated vulnerability (Sen, 1981; Krishna, 2006), with serious implications for inter-generational wellbeing (Pande, 2003). However, studies that chart such inter-generational aspects of response behavior, especially in climate related vulnerability studies still remain few (Singh *et al.,* 2017a).

III. STUDY AREA AND RESEARCH DESIGN

The research adopted mixed methods such as structured household survey, participatory focused groups discussions (FGDs) (Singh *et al.,* 2016), multi-stakeholder key informant interviews, and in-depth life histories (Singh, 2018a) for data collection. The methods enabled a detailed understanding of local livelihood trajectories and the risk and response portfolios at community, household, and intra-household levels. Since rural urban migration is an important livelihood strategy, interviews were targeted to understand migration related dynamics. Mixed multi-scalar approaches highlighted how households negotiated their fast-changing environmental, social, and institutional landscape with some coping, others adapting, and several others undertaking potentially maladaptive strategies. Similar to studies on social vulnerability (e.g. Burnham and Ma, 2017), we deliberate on the circumstantial drivers of vulnerability at the local scale, going beyond immediate, and observable impacts to more structural drivers and barriers of vulnerability(Ayers and Dodman, 2010; Ribot, 2010).

The semi-arid area under study is located on the plains of Lake Victoria in Kisumu, Kenya. (Refer to map in Figure 1). The area also known as Katuk Odeyo, is experiencing food insecurity, complex socio economic, environmental challenges (Raburu*et al.,* 2012; Odada*et al.,* 2004) and low farm labour productivity (Förch*et al.,* 2013). Further, population pressure has created land fragmentation and reduction in cultivation area (Recha*et al.,* 2017).

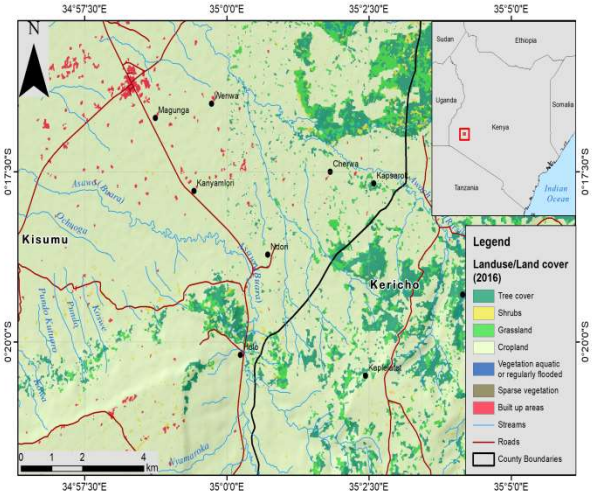

Fig 1: A map of the study area

Astratified random sampling approach (Abdul-Razak and Kruse, 2017) focusing on equal distribution of households within 5 clans targeted 315 households (Lemma, 2016). The village `population` register complimented with transect walks, focus group discussions, key informant interviews, and participatory resource mapping, was used for familiarization with basic socio-economic profiles. Qualitative research tools were adopted for capturing broad risk perceptions, response strategies, adaptation barriers, life histories and information networks. Temperature and rainfall data for Kisumu was obtained from the World Bank knowledge portal for development practioneers and policy makers (Fig. 2).

IV. FINDINGS

Using risk narratives from the FGDs, KIIs and village profiles, we first describe community-level responses and adaptation barriers. We discuss how risks to agricultural and non-agricultural livelihoods and associated responses have been shaped by wider policy imperatives, institutional arrangements, and donor funded projects. To unpack the variabilities associated with these risks and responses across various households, we then discuss risks observed at the household-level, and then broadly from multi-scalar planned and autonomous responses.

4.1. Overview of risks

The small-scale farmers are experiencingboth erratic rainfall patterns, and variability in temperature (see Fig 2). With compromisedgroundwater levels, and degraded soil and poor soil quality (Odada*et al.,* 2004), the suitabilityof the area for rainfed agriculture is undermined. To understand risk perceptions, the respondentswere asked to rank the major risks that are threating their livelihoods (Table 2). Soil erosion, poor soil productivity, HIV/AIDS, business opportunities were prominently mentioned during the FGDs (Table 3).Overall, both men andwomen identified soil degradation, untimely rainfall and water scarcity as significant risks to agriculture. This corroborates the meteorological trendsof more erratic but torrential rainfall. Key issues mentioned relate to agriculture and markets such as poor soil quality, lack of climate smart seeds, lack of irrigation facilities, poor road infrastructure, inadequate storage facilities, and food price fluctuations. Further, risks associated with uncertain timing for planting and harvesting, physically strenuous labour due to heat and poor health, inadequate young people interested in farming, and limited land for cultivation were prominently mentioned as issues threatening livelihoods. Similarly, risks associated with alternative livelihoods mainly running petty shops and small businesses, exploitative middlemen, lack of credit facilities and access to finances at crucial times in the agricultural calendar were mentioned as critical constraints. Despite the extensive existence of several NGO's, availability of credit or subsidies for key agricultural inputs, was still a major challenge.

Respondents also alluded to cognitive risks, which were mental barriers in undertaking certain strategies. For examples, several respondents noted seeing 'no alternative' to youngsters' disinterest in farming as undermining family agricultural enterprises and food security. While these risks are often not tangible, they manifest as concrete risks with implications for future response decisions.

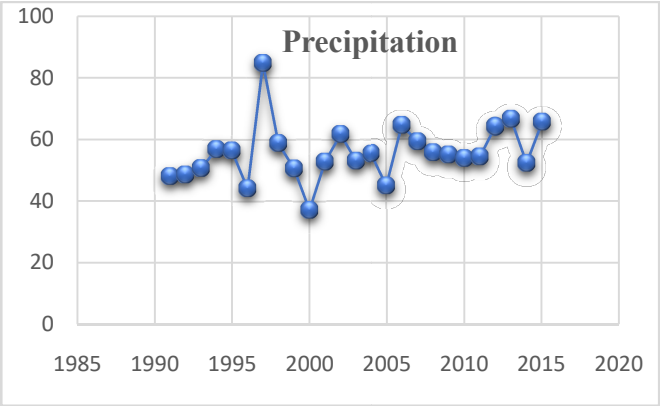

Figure 2a: Precipitation variation in Kisumu between 1985 and 2015 *(Source:* World Bank knowledge portal for development practioneers and policy makers)

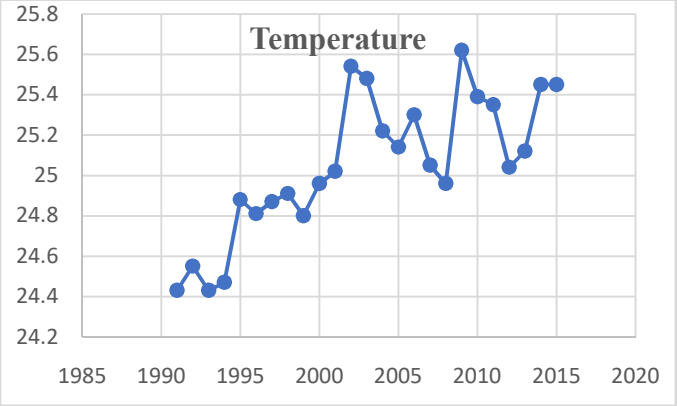

Figure 2b: Temperature variation in Kisumu between 1985 and 2015 *(Source:* World Bank knowledge portal for development practioneers and policy makers)

4.2 Perceptions of risk through adaptation drivers and responses

Overall, respondents reported increasing environmental change: longer dry spells, falling groundwater levels, decreasing crop diversity, and higher youth out-migration. Further, water resources have declined while flood associated damages are on the rise culminating into a huge gulley which runs for several kilometers. Vegetative and tree cover still remains low although agroforestry is slowly catching up through support from various NGO's. Similarly, the shift in farming landscape has manifested through decreased soil fertility, drying up of traditional open wells, and water shortages in man-made ponds. Farmers reported cases of water related conflicts, despite this, water harvesting, and other water conservation measures such as drip irrigation are still nascent. The respondents perceived decreasing rainfall amounts, increasing rainfall variability (becoming more erratic and torrential) and seasonal shifts as key climate related risks. The cumulative effects of soil erosion, land degradation and growing water scarcity have impacted farming (reduced crop variety), social cohesion (increased conflicts over water resources and land degradation), and

livelihoods (out-migration and over dependence on remittances from family members).

In the last 20-25 years, there have been some efforts towards climate adaptation at both on and off farm levels (Table 5). However, response has been slow due to various reasons among them inadequate financial and technical support. To understand the significance of the responses mentioned in Table 5, the community did a PRA based risk ranking (Table 2).

Table 2: Risk ranking profile from PRA and FGD's

No.	Risk	PRA ranking
1	Drying borehole	6
2	No farm implements	3
3	Children disinterested in farming	8
4	Gender hierarchy (engaging women in keyfarming decisions)	5
5	Lack of storage facilities	11
6	Poor credit facilities	5
7	Issues around marketing	5
8	Low capital for investing in farming	4
9	Pest attack	9
10	Lack of technical know how	7
11	Poor availability of farm inputs	7
12	Lack of quality seeds	8
13	High temperature	2
14	Untimely rains	2
15	Soil quality	1
16	Water scarcity	1

The ranking identified water scarcity and soil quality as the biggest risk to livelihoods. Climate variability, experienced as untimely rains and extreme temperatures, lack of farm implements, low capital investment, lack of credit facilities, and markets, followed in that order respectively. Deteriorating soil quality and drying boreholes corroborate reports of land degradation (Recha*et al.,* 2017, Mango *et al.,* 2011) and dire groundwater situation (Förch*et al.,*2013).Inadequate agricultural extension services were mentioned as a critical issue, with farmers reporting minimal government support in securing agricultural inputs and relevant technical services. High incidence of pest attacks was also identified as a key riskwhich was exacerbated by unavailability of pesticides at the right place and time.

4.3 Perceptions of climate variability and change

Household perceptions of climate variability were captured for rainfall, temperature and extreme climatic events by asking about perceptible change and climate associated impacts over the last twenty years. Regarding climatic variability, 99.6% households reported being impacted by risks associated with lack of sufficient rainfall, increasingly erratic frequency and intensity over the years (Table 4). Similarly, 99.3% of households reported being affected by annual temperature changes. A further 98.3% reported being impacted by more than 6 flood incidences while 96.3% reported climate change affecting their food production chain. Water availability was reported as a recurrent risk, despite this, only 0.6% reported to have adopted any form of irrigation. Perceptions of climatic risks were complex and tended to be experienced and perceived through how livelihoods are impacted i.e. how agricultural yields or food prices have been affected (Table 3).To sum up, lack of water due to erratic rainfall, land degradation, and smaller land holdings were the most significant risks. These risk perceptions square well with the overall narrative of rainfall deficit, reduced crop production, and poor soil productivity with in the area. (Mango *et al.,* 2011).

Table3: Perceptions regarding climate impacts on food production

S. No	Impacts	Percentage
1.	Reduced or no crop production	39.9
2.	Late and unpredictable rains	18.8
3.	Heavy rains sweep away crops	16.2
4.	Crops and seedlings dry	14.0
5.	Unpredictable planting patterns	5.5
6.	Food prices have gone higher	3.3
7.	Impending droughts due to high temperatures	1.8
8.	No changes	0.4

4.4 Household response strategies

Livelihood risk response strategies fall along a 'response continuum' ranging from no response to coping, adaptive, or potentially maladaptive responses (Singh *et al.,* 2016b). Within adaptive strategies, we distinguish between those that build generic capacity (to meet human development goals such as access to food, improved health) and those that build specific capacity (to deal with climatic risks) (Eakin *et al.,* 2014). We categorized household responses as on-farm (agricultural practices, land management, water management) and off-farm practices (livelihood practices) (Table 4).On-farm adaptation responses entail changing agronomic practices in order to manage reduced precipitation with a view of enhancing crop production. Key response strategies include changing the timing of planting, planting early maturing varieties and drought tolerant crops, crop diversification/staggered cropping, agroforestry, crop rotation/inter cropping, drip irrigation, using green houses, organic farming, water harvesting, fodder conservation and zero grazing, drought tolerant feeds, pest control (crush pens, vaccination), and climate resilient breeds. Off-farm responses included livelihood diversification, relying on family, friends and church, selling livestock and fish, charcoal production, changing diets, temporary migration, sand harvesting, government/NGO assistance, and early warning

systems.Across the community, some response strategies that have been honed over generations, such as adjusting cropping practices and risk spreading through selling livestock and fish are still being practiced. Similarly, distress selling of was mentioned as a key adaptation response as compared to selling crops especially for raising quick money. This finding is consistent with that of Hesselberg and Yaro (2006) who affirmed that in most agriculture-dependent rural African households, the availability of livestock represents wealth and serves as an important insurance mechanism for meeting pressing family obligations such as buying farm inputs, food during drought and paying school fees (Maconachie, 2011). Further, some new strategies have emerged such as diversifying into new livelihoods(e.g. petty trading in Ahero and Sondu, sand harvesting and motorbike taxis commonly known as *bodaboda*). However, overall, we found out that there has been a shift in the nature of responses over time depending on physical factors such as proximity to water source, size of cultivatable land and socio-economic factors such as age of the household's head, land tenure system, education level of the household head, wealth status, and social network etc. While migration emerged as a common response among the younger respondents', we noted more women are engaging in business signaling a change in gendered norms of work. Younger men as compared to younger ladies increasingly reported moving out to fulfil aspirations beyond agrarian livelihoods albeit temporarily during the drier periods. On the contrary, women often required "permission" to migrate. Finally, migrants tended to do manual labour in farms in the neighboring sugar growing areas of Muhoroni, Kibos, Miwani and Migori. However, with changing aspirations, several respondents noted migrating to Kisumuin order to avoid the prevailing harsh climatic conditions that is under mining rain fed agriculture. During the in-depth interviews, respondents (typically well-educated and wealthy) spoke of more opportunities being available such as setting up greenhouses or growing plantation crops such as bananas and tomatoes after intervention by some NGO's. However, this expansion of opportunities was not uniform with several poorly-connected households reporting being 'stuck' in situations.

Table 4: Types of responsestrategies adopted by the households

Adaptation strategies	Specific activities	Gender cluster
On farm adaptation and coping mechanisms	Changing the timing of planting	Both
	Planting early maturing varieties	Both
	Crop diversification/staggered cropping	Both
	Practicing agroforestry	Male
	Crop rotation/inter cropping	Male
	Planting drought tolerant crops	Both
	Using drip irrigation facilities	Men
	Using green houses	Both
	Composting	Both
	Water harvesting and storage	Both
	Fodder conservation	Both
	Zero grazing	Both
	Drought tolerant feeds	
	Pest control (crush pens, vaccination)	
	Climate resilient breeds	
Off farm adaptation and coping mechanisms	Livelihood diversification	Both
	Rely on family, friends and church	Both
	Selling livestock	Male
	Selling fish	Female
	Charcoal production	Male
	Changing diets	Male
	Temporary migration	Male
	Sand harvesting	Male
	Government/NGO assistance	Both
	Early warning systems	Both

It is important to note that while these adaptive interventions focused mainly on natural resource management, there was lesser evidence on capacity building, and incentivizing behavioural changes such as reducing water demand, sustainable sand harvesting, soil and land conservation, and shifting away from chemical fertilizers' or towards climate resilient crops. This echoes warnings by other scholars for more emphasis on supply augmentation (more water, more sand, more fertilizer) rather than demand management (Singh, 2018b).Long-term generic strategies are a function of wider dynamics of rural transformation (of livelihoods, practices, ecologies, and social structures). Overall, farming within the study area has seen a shift away from indigenous varieties to high-yielding crops. While this shift has led to resource degradation and exploitation of common resources (Recha*et al.,* 2017), some farmers, especially those educated and connected to extension officers, demonstrated a sophisticated understanding of implications of the cultivated crop varieties. On the other hand, potentially maladaptive strategies were also observed. The first kind involved practices undermining ecological bases, especially in response to successive drought years and frequent floods. Strategies such as illegal sand mining, growing Eucalyptus on farmland, and extracting soil for brick making were reported as affecting local water sources and land.

4.5 Barriers and constraints to climate adaption

The barriers and constraints can bejointly coined under limited access to climate information, inadequate institutional support, loss of productive labour and knowledge, inadequate financial support, acomplex land tenure system, small land holding and gender hierarchy. In general, Gender hierarchy meant that women still lacked the "political capital" that is often crucial in migration or access and control of family assets for profitable investments in non-farm activities". For instance, most of them were not allowed to sell cows in order to raise seed capital for engaging in other livelihood opportunities. They could only access land but had difficulties in using it as collateral to access credit facilities because these assets are usually either registered jointly or in their husband's name. Social roles are well defined, with men acting as protectors and providers while, women perform all household chores. Women often required consent from their husband to

mortgage a particular land parcel for loan purposes. This often resulted in unequal power relations and imbalances that favour men. Although women are central to environmental management and sustainable development, limiting their access to resources, restricting their rights and muting their voices and or representation in decision-making processes within climate change space is a major constraint for effective adaptation (Denton, 2002).

Results further indicate that access to affordable credit facilities and technical support are serious constraints to some adaptation responses. For instance, some farmers explained that they could not access seed capital for purchasing green houses and irrigation equipment for planting tomatoes. Similarly, inadequate technical expertise compromised the scope for enhancing soil productivity, post-harvest loses and climate smart agriculture. Government agencies are often poorly resourced relative to the demands placed upon them; they therefore, often tend to prioritize other poverty reduction strategies over climate adaptation (Cradock-Henry, 2012). Other impediments for government support to adaptation include ineffective or weak administration, inadequate accountability, and corruption (Techoro, 2013).

Further, shortage of productive farm labour was mentioned severally as a serious impeding factor. This factor had not only forced some famers to reduce the size of land under cultivation, and also the quantity and quality of adaptation responses had been compromised. For instance, labour constraints associated with youth migration, had concomitantly hindered implementation of various labour intensive adaptation responses related to soil and water conservation such as mulching, intercropping, composting and water harvesting etc. Illnesses and diseases were also mentioned as constraining factors. Some stated that they were too weak from hunger and could only work a few hours a day. This is further complicated by the relatively high incidence of HIV/Aids pandemic (Obiero, 2017), and high levels of vulnerability associated with caring for orphans and extended family members. Other constraints which were mentioned include poor access to climate information, and inadequate awareness and knowledge on best adaptation responses, low levels of education. According to Mougou*et al.* (2007), farmers with little or no education, are often reluctant to adopt new adaptation techniques.

Table 5: Key barriers to climate adaptation within the study area

Specific barrier to adaptation	Example of adaptation strategies influenced
Inadequate financial resources	• Development of nurseries and planting trees • Engaging in climate smart agriculture • Diversification of livelihood activities • Changing diets
Loss of productive labour and knowledge	• Soil and water conservation i.e. mulching, terracing, composting, water harvesting etc. • Livelihood diversification • Practicing traditional and inherited knowledge i.e. early warning systems
Poor access to climate information and institutional support	• Changing the time for planting • Planting early maturing varieties
Complex land tenure system and gender issues	• Planting trees • Engaging in climate smart agriculture • Crop rotation/inter cropping • Water harvesting
Socio-cultural barriers	• Temporary migration • Livelihood diversification • Changing the timing for planting • Integrated animal husbandry
Inadequate ready markets	• Planting drought tolerant crops • Diversification of livelihoods • Crops diversification
High cost of and limited access to improved crop varieties	• Planting early maturing varieties • Planting drought tolerant crops
Lack of farm implements and machinery	• Planting early maturing varieties • Changing the timing for planting

V. DISCUSSION AND CONCLUSION

Located at the crossroads of rapid development, high climate sensitivity, and an ever-expanding demographic situation, Kenya developed the NCCAP in 2012. However, the interaction of this policy intervention with structural vulnerabilities and local adaptation processes is still untested. Our research examined how local risks, and response behavior have been affected by multi-scalar adaptation interventions. Drawing on empirical evidence from a community in Nyando, we used household perceptions of risk and subsequent responses and constraints to provide insights for adaptation policies that influence climate change in rural development context. We used a typology of coping, adapting and maladapting to categorize reported response strategies and assessed them for their implications on economic, ecological, and social sustainability (Table 1).We found out that while people are responding to multiple risks, of which environmental changes are a significant part, not all responses are necessarily climate change adaptation strategies. Many intervention senhance generic capacity to deal with non-climatic risks. The responses also alleviate development deficits; however, they may be short of buildingspecific adaptive capacity to climate change. Local adaptation responses are often dynamic and complex, and in some cases, interventions could be classified as maladaptive in nature. While climate-specific interventions have recently gained momentum; the predominantly remain divorced from contextual realities (Singh *et al.,* 2016c). For instance, we are still not very certain how climate-specific interventions build adaptive capacities but more so, we lack a comprehensive understanding of assessing various synergies and trade-offs in the context of long-term structural response to locally experienced challenges, within the larger narrative of long-term environmental changes. Thus, we do see significant gaps in programme design, and implementation which have implications for sustainable risk management. Thus, while efforts to build generic capacities, in the context of improving household economic conditions and access to services, are

successful, we call for a comprehensive risk-response framework that recognizes the contextual reality of daily risks, with a view of assessing scale implications of interventions. Moreover, these responses should explicitly regard climate adaptation as a central component of risk management.

5.1. Risk and response are spatio-temporally differentiated

Overall, environmental, climate change, and increased climate variability risks are influenced by the existing structural conditions such as poor market linkages, inadequate credit, low asset bases, and gender-based differences. The participatory timelines demonstrated how risk accumulates over time with recurrent drought, natural resource degradation, and deteriorating common pool resources being significant drivers of biophysical vulnerability. The nature of risks also changes over time with increasing reports of floods, drought incidences and dry spells. When seen through a livelihoods lens, these environmental risks interacted with institutional risks (e.g. pervasive agricultural policies favoring large scale farmers), financial risks (e.g. reliance on middlemen in the absence of adequate credit facilities), and social risks (women unable to own land due to cultural reasons) to shape household vulnerability.

Our findings on response strategies highlighted that most households undertake a suite of activities to reduce and manage risks. These activities are predominantly coping strategies (whether negative or positive) with fewer examples of longer-term adaptive actions (see Table 1). Many households reported not undertaking any response, echoing findings of **'**the fatalistic farmer**'**. Crucially, NGO and CBO funded planned interventions tended to effectively build generic capacities with lower clarity on their efficacy in building specific capacities for reducing or managing climatic risks. This is not to undermine the positive interventions on agroforestry, soil and water conservation, livelihood strengthening, food security, and natural resource management that have been undertaken, but highlights that to meet challenges posed by climate change, existing responses will need reorientation to enhance flexible moving forward. Across time, some responses (e.g. digging farm ponds, sand harvesting, making soil bricks) are highlighted as having potentially maladaptive outcomes. This calls for growing awareness about trade-offs that a particular intervention entails, and careful pre-project examination of potential maladaptive outcomes. Finally, some responses are changing either in type (shifting away from farm livelihoods) or in nature (migrating farther away, into non-agriculture activities), demonstrating how livelihood portfolios are increasingly being dynamic and complex. Critically, these changes also signal changing aspirations, especially among rural youth. While the role of aspirational change in climate adaptation is beyond the scope of this paper, we highlight it as an important field for further research.

5.2. Assessing response outcomes in a sustainability context

Our findings underscore the importance of exploring response outcomes (conceptualized as falling across a response continuum) using a sustainability lens. This provides insights on how planned and autonomous responses impact ecological systems, social equity, and household material wellbeing (Table 1). Such approaches should build on the growing recognition that effective climate responses should integrate development, adaptation and disaster risk reduction interventions, (Taylor, 2013; Gajjar*et al.,* 2018). We used this framing to diagnose community response outcomes (Table 3, 4 and 5).We found out that outcomes of planned and autonomous responses differ between households. Responses were multi-scalar and heterogeneity masked due to identity, gender, education background, social capital, and economic status. For example, larger landholders were able to intensify crop production by introducing new varieties and diversify by adding horticultural crops and agroforestry, on the contrary, marginal landholders tended to migrate or take up informal wage labour. At a finer scale, response outcomes such as migration tended to have differential impacts at the household and family levels. More significantly, response outcomes had implications at wider spatio-temporal scales. Thus, a watershed development project making a check dam upstream could negatively impact downstream water availability while shorter-term interventions aimed at improving agricultural incomes(e.g. shifting from drought-tolerant millets to water-intensive tomatoes) could have wider sustainability outcomes on ground water extraction. Further, changes in risks and consequently responses can impact household wellbeing and overall capacities for managing future risks.

5.3. Way forward: Entry points for enabling climate adaptation

Overall, an enabling institutional environment is key to strengthening autonomous household responses. Based on our findings, we identify specific entry points for enabling community adaptation. First, risks are perceived and acted upon in an integrated manner. While climatic risks are important and increasingly perceived as crucial for rural livelihoods, they are experienced in conjunction with non-climatic risks. Thus, emphasis on perceived risks, in addition to observed risks, is a critical starting point for sustainable adaptation interventions. Additionally, risks change over time and space. Current vulnerability assessments – the basis on which adaptation interventions are designed – and adaptation interventions, tend to overlook or inadequately account for the nature of risk dynamism. Second, current development and adaptation interventions are building a robust base of generic capacity in rural areas, such as better infrastructure and services, stronger assets, and higher incomes. Although these positive impacts are differentiated between households, there is an overall perception of improved life quality (Singh *et al.,* 2016a). However, in order to prepare for climatic risks, building specific capacity to adapt is essential and currently rather ambiguous, as observed in this study. While we acknowledge that the connections between generic and specific capacities are loose, we argue that building both

capacities and considering patio-temporal scales can result in better management of risks. Interventions to build specific capacity should involve forward-looking actions such as adopting climate information to shape appropriate cropping regimes, incentivizing mixed crop-livestock systems to spread risks (as opposed to mono-cultivation of crops), institutional reform where local governance structures are flexible in the face of increasing climate vulnerability, and provision of safety nets for responses spanning rural and urban migration.

Thus, a greater emphasis on building specific capacities is recommended, moreover, the importance of establishing an explicit understanding of the linkages between generic and specific capacities; with emphasis on synergies and trade-offs, should not be undermined. It is argued that an approach guided by building specific adaptive capacities would result in positive spill-overs in the generic capacity domain. We believe that such forward-looking adaptation focused plans will pre-empt potentially maladaptive outcomes of current response strategies.

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