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Community Based Adaptations to Climate Change: Experiences of the Mijikenda Community in Coastal Kenya

Maxie Elizabeth Groh

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Supervisor:
Ana Catarina Larcher das Neves Santos Carvalho, PhD, Professora Auxiliar Convidada,
ISCTE - Instituto Universitário de Lisboa,

Co-Supervisor:
Chemuku Wekesa, PhD Candidate, Applied Ecologist,
Kenya Forestry Research Institute (KEFRI)

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DEDICATION

This thesis is dedicated to the youth who are increasingly challenged by the geopolitical consequences of climate change.

The world cries out for global rules that respect the achievements of science.
José Mujica

Always remember that the people are neither fighting for ideas, nor for what is in men's minds. The people fight and accept the sacrifices demanded by the struggle in order to gain material advantages, to live better and in peace, to benefit from progress, and for the better future of their children. National liberation, the struggle against colonialism, the construction of peace, progress and independence are hollow words devoid of any significance unless they can be translated into a real improvement of living conditions.
Amílcar Cabral

The condition of women in a nation is the real measure of its progress.
Ngũgĩ wa Thiong'o

ABSTRACT

Small-scale farmers in Africa are among the most vulnerable to the impacts of climate change. Macro level climate change policies are having little positive impacts on their livelihoods. However, at the local level, communities are innovating and adapting to climate change. While these innovations are not enough to guarantee extensive adaptation to climate change, they are an important element for the survival of agrarian societies and botanical diversity. It is therefore important to understand what these innovations are and the factors that hinder and facilitate them. This knowledge would allow the incorporation of strategies to support the endogenous capacities of societies to innovate and adapt to climate change into climate change policy and projects.

This thesis will present the case study of agrarian societies, the Mijikenda, in Kenya's coastal areas. Kenya's coastal forests and agricultural lands, while fragmented and threatened by degradation, contribute to the resilience of coastal Mijikenda communities. They serve as territories of biocultural heritage that have traditionally unified the communities through cultural cohesion and information exchange, and are reserves of rich agro-biodiversity that improve community food security and health.

Kenya's coastal societies have developed various strategies to adapt to climate change that have emanated from the specific biological and cultural conditions of these coastal territories. This study investigates the factors that hinder and facilitate biocultural innovations - innovations that are developed locally and adapted to community needs - and which serve to boost climate resilience in three Mijikenda communities: Giriama, Rabai, and Duruma. They include technological innovations (e.g. use of a wide range of herbal plants to control increasing incidences of pests in crops and animals) and social/institutional innovations (e.g. establishment of cultural centers). It will build on work previously conducted by the Kenya Forestry Research Institute (KEFRI) within the framework of the Smallholder Innovation for Resilience (SIFOR) research project, and will focus on a specific set of aspects that have not previously be dealt with: how gender and age affect the capacity to innovate.

The study has found that gender and age play an important role in the capacity to innovate. Elders of the Mijikenda community demonstrated the highest awareness and participation in biocultural innovations, while youth are increasingly becoming isolated from the events and practices that have traditionally

reinforced capacities to innovate. Socially reinforced gender discrimination limits women's resilience to climate change by reducing access to agricultural inputs, markets, capital, leadership positions, and information.

Local strategies, though not enough to overcome the multiple challenges of climate change, need to be identified, analyzed, and included in climate change policies that aim to develop strategies to enhance local adaptation capacities. Increased participation, support and sensitization to the importance of biocultural heritage and related innovations including crop landraces and farming practices and ceremonies that engage wide audiences could complement other contemporary development strategies aimed at improving community adaptation to climate change in Kenya and elsewhere. Innovation springboards in the Mijikenda communities were found to often be centered on cultural events involving cross-generational information exchange and participation. Adaptation processes could be supported through the establishment of community climate adaptation innovation centers that could source updated weather information, job training, loan and grant opportunity information, workshops, technology transfers and exchange programs, and improved access to information technology (including WiFi).

Key terms: Climate adaptation, biocultural innovations, Mijikenda community, food security, biocultural heritage, Kenya

RESUMO

Os pequenos agricultores africanos estão extremamente vulneráveis aos impactos das mudanças climáticas. As políticas globais sobre mudanças climáticas têm tido poucos impactos positivos sobre as suas formas de vida. No entanto, a nível local, as comunidades têm demonstrado capacidade de inovar e de se adaptar às alterações climáticas. Embora essas inovações não sejam suficientes para garantir uma ampla adaptação às alterações climáticas, as capacidades endógenas de inovar são um elemento importante para a sobrevivência das sociedades agrárias. Assim, é importante compreender quais são essas inovações e os fatores que dificultam e facilitam o seu surgimento e adopção. Este conhecimento permitirá a incorporação, nas políticas sobre mudança climática e projetos, de estratégias para apoiar as capacidades endógenas de sociedades de inovar e adaptar-se às alterações climáticas.

Esta tese apresenta o estudo de caso de sociedades agrárias, os Mijikenda, que habitam áreas costeiras do Quénia. As florestas costeiras e terras agrícolas do Quénia, embora fragmentadas e ameaçadas pela degradação, contribuiem para a resiliência das comunidades Mijikenda costeiras. É nesses territórios que está ancorado o património biocultural que garante a unidade das comunidades através da coesão coesão social e das trocas de informação cultural; são também reservas de agro-biodiversidade que melhora a segurança alimentar da comunidade e saúde.

As sociedades costeiras do Quénia desenvolveram várias estratégias para se adaptar às mudanças climáticas que emanavam das condições biológicas e culturais específicas desses territórios costeiros. Este estudo investiga os fatores que dificultam e facilitam as inovações bioculturais - inovações que são desenvolvidas localmente e adaptadas às necessidades da comunidade - e que servem para aumentar a resistência ao clima em três comunidades Mijikenda: Giriama, Rabai e Duruma. Estas incluem inovações tecnológicas (por exemplo, utilização de uma vasta gama de plantas à base de plantas para controlar pragas nas culturas e animais) e as inovações institucionais / sociais (por exemplo, criação de centros culturais). Este estudo vai dar continuidade ao trabalho anteriormente realizado pelo Instituto Kenya Forestry Research (KEFRI) no âmbito do projecto de investigação, Smallholder Inovação para a Resiliência (SIFOR), e incidirá sobre um conjunto específico de aspectos que não tinham anteriormente ser tratados nomeadamente investigará como o género e a idade afetam a capacidade de inovar.

Os resultados do estudo indicam que o sexo e a idade desempenham um papel importante na capacidade de inovar. Os mais velhos da comunidade Mijikenda demonstraram uma maior sensibilização e uma maior participação na produção de inovações bioculturais, enquanto os jovens estão cada vez mais isolado dos eventos e práticas que têm demonstrado ser capazes de reforçar as capacidades de inovar. A discriminação de género limita também a capacidade das mulheres produzirem inovações para se adaptarem às mudanças climáticas, dado o seu reduzido o acesso a insumos agrícolas, mercados, capital, posições de liderança, e informação.

As estratégias locais, embora não suficientes para superar os vários desafios da mudança climática, precisam ser identificadas, analisadas e incluídas nas políticas de mudanças climáticas que visam desenvolver estratégias para melhorar a capacidade de adaptação locais. O aumento da participação, apoio e sensibilização para a importância do património biocultural e inovações relacionadas, incluindo variedades crioulas de culturas e as práticas agrícolas e cerimónias que envolvem amplas audiências poderiam complementar outras estratégias de desenvolvimento contemporânea destinadas a melhorar a adaptação da comunidade para as alterações climáticas no Quénia e em outros lugares. O estudo indica que os eventos culturais envolvendo a troca de informações entre gerações e participação são incubadores de inovação nas comunidades Mijikenda. Estes processos de inovação/adaptação poderiam ser apoiado através da criação de centros comunitários de inovação para adaptação climática que poderiam reunir informação atualizada sobre o tempo, formação, informação sobre empréstimos e oportunidades de acesso a financiamentos, workshops, transferências de tecnologia e programas de intercâmbio, acesso a tecnologia de informação (wifi).

Palavras-chave: adaptação às alterações climáticas, as inovações bioculturais, comunidade Mijikenda, segurança alimentar, herança biocultural, Quénia

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GLOSSARY OF TERMS

ADB	Asian Development Bank
CBA	Community-Based Adaptation
CIFOR	Center for International Forestry Research
CIFs	Climate Investment Funds
EBRD	European Bank for Reconstruction and Development
FAO	Food and Agriculture Organization
FPE	Free Primary Education
GHCN	Global Historical Climate Network
GPCP	Global Precipitation Climatology Project
HADCRU	Hadley-Climate Research Unit
IEA	International Energy Agency
IIED	International Institute for Environment and Development
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
KWS	Kenya Wildlife Service
LECZ	Low Elevation Coastal Zones
MDBs	Multilateral Development Banks
NASA	National Aeronautics and Space Administration
NCDC	National Climate Data Center
NCEPe	National Center for Environmental Prediction's longer ensemble version
NCEPr	National Center for Environmental Prediction's conventional version
OECD	Organisation for Economic Cooperation and Development
PPCR	Pilot Program for Climate Resilience
PRB	Population Reference Bureau
RCP	Representative Concentration Pathway
SIFOR	Smallholder Innovation for Resilience
SLP	Sea Level Pressure

SODA	Simple Ocean Data Assimilation
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Convention on Climate Change
WWF	World Wildlife Fund

INTRODUCTION

Of all the regions in the world, Sub-Saharan Africa is the least well equipped to respond to the direct and indirect effects of climate change (Justice, 2006: 172-181). A combination of stress factors add to Africa's overall high geographic, social, and economic vulnerability to climate change. Agricultural systems are highly important to local economies and livelihoods across Africa and food security is sensitive to slight changes in temperature and rainfall. Risks associated with weather changes and rising sea levels include environmental shocks (flooding and drought caused by warming temperatures and inconsistent rainfall), decreasing cultivation periods of harvestable lands, and insufficient response capacities due to limited infrastructure and capital. Response capacities are further weakened by widespread poverty, rapid urbanization, disease, internal conflict and war (Vieira, 2011: 7-8). Beyond the immediate and long term effects of climate change on crop production, financial and technological isolation, as well as increasing intolerance towards traditional practices and ceremonies, are challenging the adaptive capacities of small scale farming communities.

Climate change refers to a change in global or regional weather patterns, due to substantially increased levels of atmospheric carbon dioxide. This carbon is largely produced by the use of fossil fuels that correlate with the increased use of machinery and natural resource extraction during the Industrial Revolution. Climate change is directly and indirectly caused by human activities, such as deforestation and burning of fossil fuels. While the social and geographic impacts of climate change are diverse, the hottest years on scientific record are now occurring annually (NASA, 2016). As broad climate change mitigation and adaptation policies are debated among global leaders, agricultural-based communities that are increasingly food insecure are relying on local strategies to adapt to climate change.

Climate change mitigation and adaptation is a two-tiered process that aims to: 1) mitigate the amount of greenhouse gases that are released into the atmosphere by decreasing carbon dioxide outputs and supporting healthy forests, and 2) help communities adapt by reducing the risks and consequences of climate change. Climate change mitigation and adaptation are essential to reducing the immediate and long term risks of climate change. In addition to reducing carbon emissions, building community resilience through adaptation is an integral facet of immediate and long term global climate adaptation.

Climate change without adaptation is predicted to negatively impact the major crop production of wheat, rice, and maize in temperate and tropical regions where local temperatures increase more than 2°C above late-20th century levels (IPCC, 2014).

Following increased global attention to the need to protect the natural environment in the 1960s, the discourse regarding climate change has prioritized the idea of a globalized environment, with selectively generalized climate-related themes (Orlove, 2014: 252). Despite fifty years of organization creation and policy development addressing environmental protection, the basic climate adaptation needs (including access to improved irrigation methods and seasonal forecasts) of small scale farmers and communities whose livelihoods are directly dependent on their local environments are only growing more serious. Climate change mitigation has been increasingly prioritized in climate funding and policies. However, adaptive capacity (the potential of societies and individuals to respond to change) is less often taken into account (Levine, et al., 2011).

> People's innovation was rarely considered; interventions equated 'innovation' with the provision of standardised new technology, which recipients were supposed to simply adopt. In some villages, innovation was clearly constrained by a dominant culture which frowned upon doing things differently. This culture was not challenged by the introduction of an 'approved' innovation by external authorities or experts. Opportunities were being missed to find out where, how and by whom local innovation is happening, i.e. the forces that constrain people from innovating. These barriers included institutional issues such as culture, the ability to take financial risks, lack of confidence, and limited access to information and new ideas. Adaptive capacity could have been supported by identifying and analysing these factors and identifying measures to address them together with the people concerned.
> (Levine, et al., 2011: viii).

Due to diverse vulnerabilities, the most successful climate adaptation initiatives are instigated on multiple levels, flexible and inclusionary, and consider the societal norms, as well as the technology and institution strength of a specific community (Thompkins, 2004: 1-10). Climate adaptation strategies that emerge locally and are reinforced through community based-management and participation reveal unique community resilience capacities that band-aid development interventions often overlook (Wekesa et al., 2015, Ongugo et al., 2015). The concept of community based-adaptation (CBA) was developed to encourage the inclusion of such strategies (the decision-making processes and knowledge of communities

as they work to enhance their adaptive capacities and resistance to climate shocks through network building and by maintaining the resilience of existing resources and ecosystems) into policy making (IIED, 2009). Another key concept is that of biocultural innovation. Biocultural innovations can be defined as "the totality of all traditional based knowledge and cultural practices whether explicit or implicit practiced by the communities in adaptation to climate change and that are used in the management of socio-economic and ecological facets of life guided by the wisdom of the ancestors of the community" (Ongugo et al., 2015: 9).

The objective of this thesis is to analyze biocultural innovations using the case study of the Mijikenda communities in Kenya.

The contribution of biocultural innovations to Mijikenda community climate change resilience is evidenced through the existence of culturally and environmentally specific developed products and processes (technological innovations) and concepts and organizations (social innovations). Technological innovations include the products and processes aimed at increasing farming production, conservation farming, livestock health, economic benefit, medicinal and food security, insurance against risks posed by climate change, and conservation of landraces. Social/ institutional innovations include the concepts and organizations aimed at enhancing conservation of cultural practices and cohesion, economic benefit, conservation of landraces, preservation of traditional values, conservation of agrobiodiversity, and preservation of indigenous knowledge (Ongugo et al., 2015: 63-65).

This study started by analyzing the impacts of climate change in Africa and the specific conditions that affect its vulnerabilities to climate change and capacity to adapt. Global climate change policies and their limitations in improving the livelihoods of agrarian societies are then analyzed; namely by not taking into account community based innovations, and how to enhance them in order to facilitate climate adaptation at local level. Specific climate change impacts and adaptation responses in Kenya were reviewed.

To study community-based adaptation using local innovations, field research was conducted in three Mijikenda communities (Giriama, Rabai, and Duruma) in coastal Kenya. The Mijikenda are comprised of nine sub-tribes of Bantu peoples who share linguistic and cultural similarities along the coast of Kenya, between Tanzania and Somalia. Central to their cultural history and practices are sacred Kaya coastal

forests (some of which are currently recognized as UNESCO World Heritage Sites[1]). In these forests, local governance systems and other traditional cultural practices exist at varying levels.

The study was conducted within the framework of the research conducted by the Kenya Forestry Research Institute (KEFRI), a semi-autonomous government agency within the Ministry of Environment and Natural Resources as a student attachment based in Kilifi County. KEFRI has been working on comparative studies of climate innovations and agricultural adaptations among the five Mijikenda community sub-tribes in the coast region, and their research was integral to the data collection and review. The case study for this thesis expanded on their research findings by examining the role of women and youth in sustaining community innovations, which previously was not well documented.

The study answered four main questions:
Q1. Which technological and social/institutional innovations have been developed or adopted in the communities?
Q2. What is the influence of gender and age on innovation development and adoption?
Q3. What other factors facilitate or constrain innovation?
Q4. How can they be strengthened?

These were further subdivided into the following questions:
Q1.1. Which technological innovations have been developed or adopted in the communities?
Q1.2. Which social and institutional innovations have been developed or adopted in the community?
Q2.1. What are the relationships between gender roles and biocultural innovations and adoption?
Q2.2. What are the relationships between age roles and biocultural innovations and adoption?
Q3.1. What is the influence of location on innovation?
Q3.2. What are the impacts of education on innovation? What is the impact of access to technology?
Q3.3. What other factors influence innovation and adoption?

[1]Mijikenda Kaya Forests designated as UNESCO World Heritage Sites and their geographic coordinates: Kaya Giriama (S3 47 55.00 E39 30 52.00), Kaya Jibana (S3 50 15.00 E39 40 10.00), Kaya Kambe (S3 51 49.00 E39 39 7.00), Kaya Kauma (S3 37 14.00 E39 44 10.00), Kaya Ribe (S3 53 49.00 E39 37 58.00), The Rabai Kayas (S3 55 55.00 E39 35 46.00), The Duruma Kayas (S3 59 54.00 E39 31 25.00), Kaya Kinondo (S4 23 36.00 E39 32 41.00) (UNESCO, 2016).

The methodology used for the case study involved application of questionnaires, semi-structured interviews and focus group discussions (FGDs). The data analysis and discussion considered how the theoretical framework applies to the case study and how better knowledge of community based strategies can lead to the development of policies that can help strengthen community-based innovations. Lastly, the conclusion contains an overview of the research results and recommendations.

CHAPTER I
CLIMATE CHANGE POLICY AND ADAPTATION STRATEGIES

1.1 Climate change and challenges to adaptation in Africa

Climate change is a global phenomenon that has diverse impacts across social and geographic strata. It is challenging the adaptive capacities of populations, institutions and stakeholders around the world. Fifteen out of the sixteen hottest years on record have occurred since 2001, last year (2015) being the hottest (NASA, 2015). Today 70% of the world's major rivers do not reach the sea and it is estimated that by 2050, four billion people could be living in water-scarce areas (WEF, 2016: 11-15). Financial, infrastructural, technological, and scientific isolation, are driving small-scale communities to become increasingly dependent upon locally developed innovations to adapt to climate change. Although they are adapting, the pressure of climate change is so great that their responses alone may not be big enough, and therefore need to be reinforced through public policy. Interventions that fail to analyze the broader macroeconomic challenges faced by small-scale farming communities, and ignore their specific adaptation challenges and response capacities, can contribute little to their long term climate resilience. On the other hand, agriculture-focused climate adaptation initiatives that incorporate community-specific strengths and needs will empower individuals and the resilience of their communities.

As climate change continues to influence global weather patterns and crop productivity, deforestation in East Africa is problematic for local populations as well as the global community. With growing population pressures and interest in developing Coastal tourism and natural gas extraction, as well as changing climates, the unique coastal ecosystems of East Africa are at risk for irreversible loss of plant

diversity and related cultural-linguistic knowledge. Locally, forests contribute to local livelihoods, nutrition, and biodiversity. Moreover, forests absorb huge quantities of atmospheric carbon. Sustainable regional management strategies are more important than ever. According to the World Wildlife Fund (2012), 10% of the original coastal forests of Eastern Africa remain fragmented into 400 patches that cover about 6,250km² in Kenya, Tanzania and Mozambique. These forests are threatened by limited alternatives to unsustainable harvesting practices, fuelwood extraction and charcoal burning, economic profitability of export markets, and limited capacity to enforce policies.

African food security is especially sensitive to climate shocks as smallholder farmers are responsible for more than 80% of Africa's agricultural production (Annan, 2015), the majority of which depend on rain-fed agriculture. Regions with high indices of poverty are disproportionately threatened by climate shocks due to livelihood losses and weak institutional infrastructure response capacities. Economic livelihoods directly dependent on small scale agriculture and local natural resources are particularly vulnerable to climate change (Sultana, 2013: 372-381; Carr 2014: 182-197; Laddey, 2011; Awuor, 2008: 231-242).

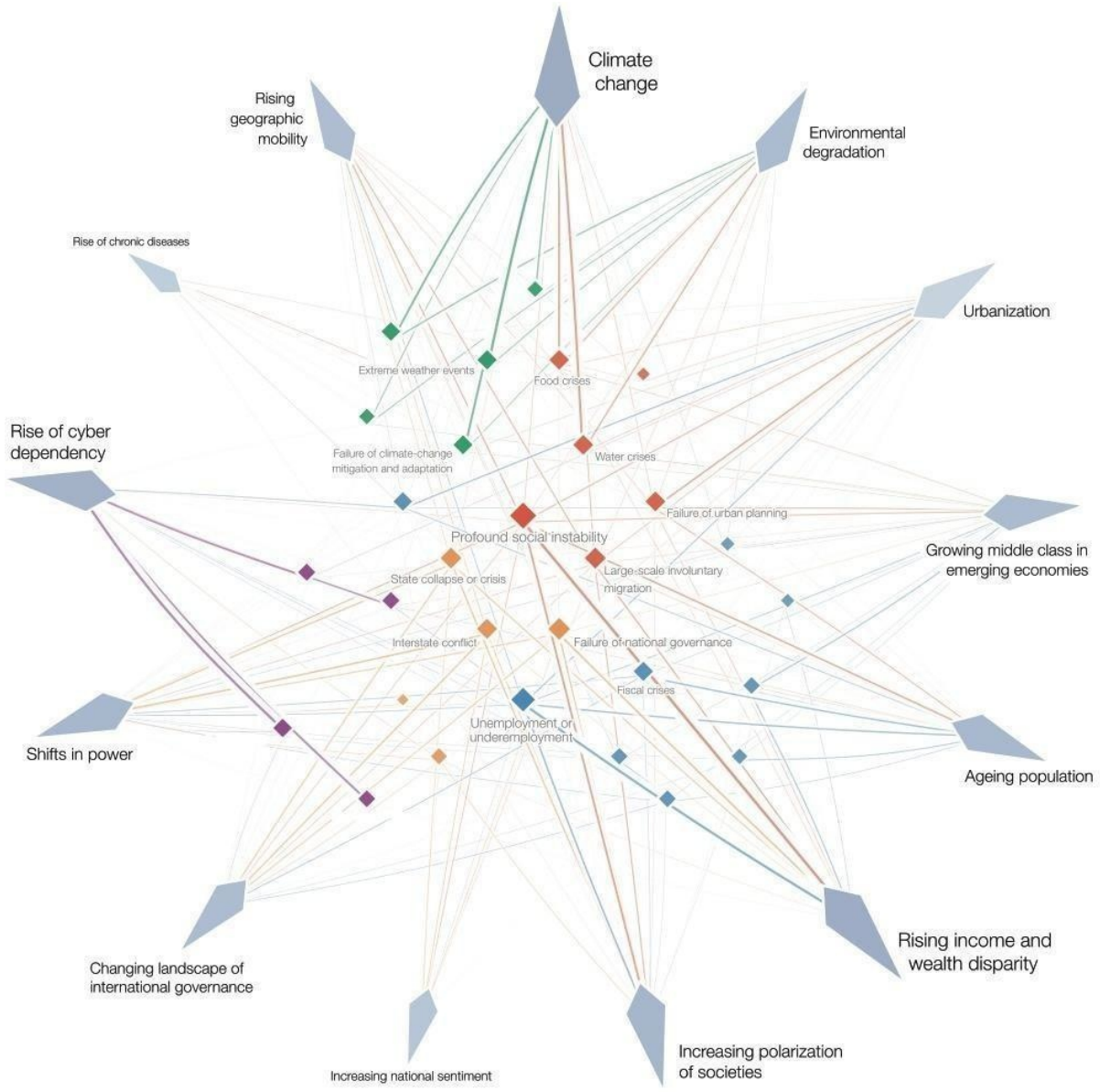
> Climate change will interact with non-climate drivers and stressors to exacerbate vulnerability of agricultural systems, particularly in semi-arid areas (high confidence). Increasing temperatures and changes in precipitation are very likely to reduce cereal crop productivity. This will have strong adverse effects on food security.
> (Niang et al., 2014: 1202)

Climate forecasts for global mean temperature rise vary, and African temperatures are forecasted to increase at a faster rate during this century as compared to the global average (IPCC, 2014:1-32; UNEP, 2015). While the climate policies of the UN and EU are based on a 2°C predicted temperature rise, others anticipate a greater temperature increase over the course of this century (Dirix, 2013; IPCC, 2014; World Bank, 2013). The World Bank estimates that average global temperatures will rise by two degrees Celsius above preindustrial levels by 2050, and four degrees before the end of the century (World Bank, 2013). Scientists argue that even a 2 degree increase is too high of a risk to coastal settlements, species diversity, and long term global resilience (Hansen, 2016: 3761-3812). Widespread drought, warming temperatures, inconsistent rainfall, and flooding are fundamentally changing societal structures within Africa through livelihood loss (especially of pastoral herders, fishermen and farmers), environmental degradation, and

loss of biocultural heritage (the legacy of a people's culture and their relationship to the natural environment). Furthermore, decreasing cultivation periods and harvestable lands, and insufficient response capacities due to limited infrastructure and capital, widespread poverty, rapid urbanization, and internal conflict and war weaken response capacities in Africa (Vieira, 2011:1-20) (Figure 1.1). Half of Africa's capital cities are located in coastal areas, increasing the continent's vulnerability to anticipated rising sea levels (Figure J.1).

> Warming projections under medium scenarios indicate that extensive areas of Africa will exceed 2°C by the last 2 decades of this century relative to the late 20th century mean annual temperature and all of Africa under high emission scenarios. Under a high Representative Concentration Pathway (RCP), that exceedance could occur by mid-century across much of Africa and reach between 3°C and 6°C by the end of the century. It is likely that land temperatures over Africa will rise faster than the global land average, particularly in the more arid regions, and that the rate of increase in minimum temperatures will exceed that of maximum temperatures.
> (Niang et al., 2014: 1202)

Figure 1.1: Global Risk-Trends Interconnections Map 2016



Source: The World Economic Forum Global Risk Report 2016

Shifting ranges of African species and ecosystems are affected by elevated levels of CO_2, in addition to land use and other non-climate stressors. Studies show significant increases in seasonal mean temperature and frequency of extreme events in the equatorial and southern parts of East Africa (including Kenya, Ethiopia, South Sudan, and Uganda) over the last 50 years (IPCC, 2014:1-32). Climate data across the

African continent is available from a variety of sources. In his research, Jury analyzed 50 years in recent climate trends across Africa, from the 1960s to the present. Recorded changes he observed in surface air temperature, sea level pressure and precipitation are well documented by over 400 national meteorological service stations, the Global Precipitation Climatology Center, the Global Precipitation Climatology Project (GPCP), the Hadley-Climate Research Unit (HADCRU), the National Climate Data Center (NCDC), the Global Historical Climate Network (GHCN), and the University of Hawaii Sea Level Center. In addition to variable precipitation trends across the continent and a general decrease in rainfall, Jury observed a general increase in the number of warm spells across the southern African continent "reaching +0.03 degrees Celsius a year in some places" (Jury, 2013:1). Jury notes that precipitation trends are more variable, especially within the Sahel, and a general decrease in rainfall in central Africa. In southern Africa rainfall variation over the annual cycle has been influenced by:

> ...changes in solar insolation and north-south displacement of the Hadley cell... Summer easterly winds draw moisture from the Southwest Indian Ocean and warm Agulhas Current, whereas in winter, westerly winds bring dry air from the South Atlantic Ocean and cool Benguela Current...The southern African region is well endowed with historical data from over 300 rainfall and more than 100 temperature stations from national meteorological services, as well as marine data sets fed by a busy shipping lane.
> (Jury, 2013: 53).

In analyzing regional impacts, adaptation, and vulnerability to climate change in Africa, the Intergovernmental Panel on Climate Change (IPCC) wrote:

> The equatorial and southern parts of eastern Africa have experienced a significant increase in temperature since the beginning of the early 1980s (Anyah and Qiu, 2012). Similarly, recent reports from the Famine Early Warning Systems Network (FEWS NET) indicate that there has been an increase in seasonal mean temperature in many areas of Ethiopia, Kenya, South Sudan, and Uganda over the last 50 years (Funk et al., 2011, 2012). In addition, warming of the near surface temperature and an increase in the frequency of extreme warm events has been observed for countries bordering the western Indian Ocean between 1961 and 2008 (Vincent et al., 2011b).
> (Niang, 2014:1206).

Adaptation costs have multiple factors to predict, including the costs of sea-level rise, flooding, drought, and disease-transmission on African economies. A 4°C increase by 2100 could cause sea-level rise along African coasts to exceed more than one metre. While sea level rise across the continent will vary, African sea-level rise is predicted to be 10% higher than the global mean (UNEP, 2015; Schaeffer, 2013: 6). African countries with greater than 20% of their urban population located in urban low elevation coastal zones (LECZ) include: Egypt, Tunisia, Mauritania, Senegal, The Gambia, Guinea-Bissau, Guinea, Liberia, Benin, Equatorial Guinea, and Mozambique. Among the most endangered cities to sea-level rise due to their populations and proximity to the coast are: Alexandria, Tunis, Dakar, Freetown, Libreville, Porto Novo, and Maputo (UN-Habitat, 2008) (Figure J.1). In addition to coastal productivity, coastal flooding would threaten urban economies and population health. Water availability across Africa varies widely, and while some regions are predicted to experience increased levels of rainfall, these rains often correlate with existing rainy seasons, creating alternating conditions of flash flooding and drought. A 4°C increase in temperature by the end of the century is predicted to cause annual precipitation rates to decrease by up to 30 percent in southern Africa, and groundwater supplies in west and southern Africa to decrease their resupply rates by 50-70 percent (World Bank, 2013). Drought, which reduces erosion control by decreasing the topsoil and plant life, threatens the ability of farms to absorb torrential rainfall, often resulting in a net loss of produce and flooding. An FAO study (2014) comparing the African countries with the greatest water resources per capita in 2010 (14,300 to 205,788 m3/yr/cap) versus the countries with the lowest water per capita (100 to 1,030 m3/yr/cap) demonstrated that cameroon, Central African Republic, Congo, Democratic Republic of the Congo, Gabon, and Madagascar received the greatest amount of water while Burkina Faso, Ethiopia, Kenya, Nigeria, Somalia, South Africa and Zimbabwe experienced the lowest (FAO, 2014: 10).

Climate change is predicted to exacerbate disease transmission throughout sub-Saharan Africa, including increasing incidences of vector born diseases (which are especially sensitive to climate). In highland areas, notably in East Africa, research demonstrates that climate change will increase malaria epidemics. Other diseases projected to increase with climate change include meningococcal meningitis, leishmaniasis, and malnutrition (IPCC, 2014). Response capacities will be further weakened by infrastructural challenges, including limited access to emergency transport, nutritional impacts of flooding on crops, and property damage.

Due to financial, infrastructural, technological, and scientific isolation, small-scale communities are increasingly dependent upon locally developed innovations to adapt to climate change. Challenges to adaptation in Africa include unclear land tenure, weak institutions, lack of access to inputs, isolation from markets and absence of suitable roads, informational barriers, social barriers and constraints on women, institutions that restrict indigenous adaptive mechanisms, financial barriers including poverty and lack of credit, land degradation, high rates of diseases, corruption, neglect of specific social and cultural contexts, and the undermining of local resilience capacities (IPCC, 2014: 1202-1213).

Climate change presents particular socio-demographic challenges to in Africa. Africa is home to the world's youngest workforce (around 70% of the population is under 25). Youth are two times more likely to be unemployed as compared to their elders (Amare, 2014). In Kenya (whose population over the last 40 years has more than tripled, and 43% are under the age of fifteen) two thirds of rural farmers do not think their land will be sufficient for their children to work and live (PRB, 2011: 1-2). Matin et al. (2014) highlight the social implications of climate change, noting that ethnic identity has large implications in environmental impacts, especially in areas with distinct inequalities, conflict, and weak democratic institutions. In their article, "Group Inequality and Environmental Sustainability: Insights from Bangladesh and Kenya Forest Commons", they state:

> Majoritarian democracy as practiced in many African and Asian countries has often failed the minority ethnic groups in their quest for equal citizenship… social and environmental dimensions of sustainability cannot be treated separately and the issue of equity among groups, ethnic or otherwise, needs to be recognised in policies for sustainable development.
> (Matin et al., 2014)

Another challenge to adaptation is the intra- and inter-state conflict and economic inequality that are exacerbated by climate change. Climate change, poverty, and violence amplify each other (Parenti, 2011). Syria's ongoing Civil War was preceded by a drought that lasted from 2006-2010 and destroyed 80% of livestock and 60% of Syrian farmlands, causing 1.5 million displaced climate-related refugees to migrate to Syrian cities (Gore, 2016). In Africa, research demonstrates that warming temperatures and decreasing precipitation increases the chance of civil wars due to shocks that disrupt economic productivity, livelihoods, and resource availability widely influenced by agricultural yields (Burke, 2009: 20672-

20673). As agricultural systems (and their extended economies) are sensitive to slight temperature and precipitation changes, food security across Africa is challenged by the effects of climate change on food availability (including production and trade), access to food, stability of food supplies, and food utilization (Schmidhuber, 2007: 19703-19708). Scarce access to water and food, economic uncertainty, population growth, and weak institutions are inevitably ingredients for conflict as people struggle to reclaim balance in rapidly changing, and overcrowded, environments. Instability related to climate-induced conflicts in Kenya have made it easier for terrorist organizations to take advantage of vulnerable regions weakened by drought, loss of land, and joblessness. Additionally, ongoing land and water resource-access conflicts have been heightened by rising temperatures, increased drought, erratic rain and flooding (Parenti, 2011; Ongugo, 2014). Climate-induced migration, urbanization, and other movements past previously inhabited spaces or boundaries, is increasing pressures on ecosystem resource availability. The World Bank estimates that urbanization rates in Africa will rise from 36% (in 2010) to 56% in 2050 (World Bank, 2013). As climate change pushes people into new geographic and social spaces, semi-nomadic pastoralists, small scale farmers, fishermen, and communities who rely directly on local environmental resources for their food and economy will become increasingly vulnerable to the shocks associated with forced environmental migration.

Estimated climate adaptation costs for Africa vary widely, demonstrating inconsistent predictions of global and regional temperature changes and related legislation. For example, in their article discussing climate adaptation funds for Africa by way of the African Union's African Risk Capacity agency and the Extreme Climate Facility, climate change adaptation investments costs for Sub-Saharan Africa are predicted to reach $14-17 billion USD every year from 2010-2050 (Syroka, 2014). Other estimates have included $10-20 annually to prepare for a 2°C increase by 2050 (Okonjo-Iweala, 2014), while the UNEP predicts that even if temperatures remain below a 2°C increase, climate adaptation costs could reach $50 billion annually (UNEP, 2015). Adaptation costs could be reduced by interventions that incorporate existing community-based adaptation techniques and knowledge, complemented with the prioritization of clean energy investments across the continent. Sustainable energy policies across Africa are necessary for decreasing climate adaptation costs, improving environmental conditions, the development of climate adaptation innovations, economic independence, and job growth. Africa and the Middle East have been identified as having big potential for clean energy, and the regions saw a combined investment increase of 54% in 2015, reaching $13.4bn. Although foreign direct investments in Sub-Saharan Africa exceed

Official Development Aid and is three-quarters higher as compared to 2007, investments continue to prioritize natural resource exploration and extraction (ILO, 2016).

> The assertion by the fossil fuel industry and the people who support them, that it would be expensive to solve the problem, is absolutely wrong. There have been economic studies that show if you add a gradually rising fee to fossil fuels, by collecting a fee on fossil fuel companies at the source, the domestic mine, or port of entry, and if you distribute the money to the public, an equal amount to all legal residents, it would actually spur the economy. It would increase the gross domestic product and add millions of jobs. We need to have such a common sense solution, which is revenue neutral, so it doesn't make the government bigger. Instead of proposing taxes or regulations that conservatives will fight tooth and nail, we should find an approach that both liberals and conservatives would be willing to support. That's what needs to be understood, that it's not painful to solve this problem if we are smart, but we have to think this through. Climate Scientist James Hansen (Bagley, 2016)

The incorporation of climate adaptation into existing frameworks of international development would require adaptation costs to climate change in Africa to be much higher than other regions, due to much needed infrastructural and technological development that would need to precede the implementation of regional adaptation plans. Considering that Africa's overall regional warming is predicted to be higher than the global average, Anderson (2006) argues that economic development projects which incorporate adequate environmental protection measures can save money and resources if they incorporate diplomacy, domestic regulatory innovation, domestic industries, consulting, recognition strategies that encourage sustained funding, technology development, corporate leadership, and streamlining government for cooperation on climate protection (Andersen, 2006).

1.2 Global policy responses to climate change

1.2.1 The incorporation of climate change into frameworks for sustainable development

"Issues of climate change go beyond environmental management" (CIFOR, 2014). The incorporation of climate change into frameworks for sustainable development initiatives is increasingly common (CIFOR, 2014; Orlove, 2014; Schipper, 2007) as climate change will continue to intensify the political, economic, and institutional obstacles to sustainable development. However, despite the wealth of scientific research that policymakers have been presented with over the past four decades, lack of political prioritization and

will has caused climate mitigation and adaptation measures to be introduced into legislation at an alarmingly slow rate. This has been aggravated by the integration of climate adaptation schemes into historically unsuccessful development models in Africa and elsewhere (Ireland, 2013: 158-166). Top-down climate policy, though increasingly decentralized, continues to concentrate on climate mitigation and short-term climate variability (IPCC, 2014:1-32).

The notion of a globalized environment, and an interrelated world system constrained by similar factors, was promoted in mainstream international discourse in the 1970s (Sachs, 2010: 26-36). Since then, the roles and risks of humans in rapidly changing global weather patterns has been widely publicized. The heightening of global environmental awareness in the 1960s and 1970s saw the establishment of numerous global sustainability initiatives. The first Earth Day was celebrated in 1970. In 1972, the United Nations Environmental Programme (UNEP) was established in Nairobi. The same year, the UN Conference on the Human Environment in Stockholm integrated the global environment into the international agenda (Sachs, 2010: 26-36).[2]

> When it became obvious, around 1970, that the pursuit of development actually intensified poverty, the notion of 'equitable development' was invented so as to reconcile the irreconcilable: the creation of poverty with the abolition of poverty. In the same vein, the Brundtland Report incorporated concern for the environment into the concept of development by erecting 'sustainable development' as the conceptual roof for both violating and healing the environment.
> (Sachs, 2010: 29)

In the 1980's climate change discourse focused on greenhouse gasses and socio-environmental systems as they related to sustainable development policy frameworks (Orlove, 2014: 252). In The Development Dictionary: A Guide to Knowledge as Power, Sachs discusses how converged development themes, including population growth, migration, water availability, technology, and energy have since been promoted in the name of climate change through UN and multilateral agency meetings (Sachs, 2010). Strategies for sustainable development have been reinforced at the local, national, and international level,

[2] Meanwhile, the same year the UNEP was established, twelve African nations were still under the control of colonial administrations focused on natural resource extraction and export.

through diplomacy, domestic regulation technological cooperation, financing, and corporate leadership (Andersen, 2006).

The term "sustainable development" was introduced to international discourse in 1987 at the World Commission on Environment and Development Brundtland Report, "Our Common Future". The Brundtland Report of 1987 encouraged the adoption of the environment by the development industry by discussing poverty as anti-environmental and non-sustainable (Sachs, 2010). That year, the World Commission on Environment and Development was established, followed by the Intergovernmental Panel on Climate Change (IPCC) in 1988 by the World Meteorological Organization and the UNEP. Sustainable development as a central policy framework continued to be promoted at the 1992 Rio Summit with the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol in 1997. The Millennium Summit and the Millennium Declaration of the United Nations in 2000 saw the establishment of the eight Millennium Goals. Goal 7 of the Millennium Development Goals seeks to "Ensure Environmental Sustainability". To achieve Millennium Goals, the World Bank approved Climate Investment Funds (CIFs) (The Clean Technology Fund and the Strategic Climate Fund) in 2008 (Orlove, 2014). Later, the 2012 2nd Rio Summit United Nations Conference on Sustainable Development and the 2015 United Nations Climate Change Conference negotiated the Paris Agreement (at the 2015 UN Climate Change Conference). There, governments agreed to limit global temperature increase to below 2^{o}C above pre-industrial levels, with efforts to limit temperature increase to 1.5^{o}C. In addition to capping emissions, this agreement encourages a growing trend in climate focused business and investment

1.2.2 Failures of global policy responses to climate change

The World Economic Forum's Global Risk Report 2016 states the failure of climate mitigation and adaptation to be the greatest global risk of 2016. This risk was stated to be more serious than the threat of weapons of mass destruction, water crises, involuntary migration, and energy price shocks (WEF, 2016: 11-15) (Figure 1.1). This is intensified by the geopolitical risks of climate-related disasters, which can lead to humanitarian emergencies and instability (Gore, 2016). Varying infrastructure capacities, food systems, socio-cultural relationships, local environmental knowledge, access to finance and technology around the world demand diverse community-based management strategies.

> In all regions of the [African] continent, national governments are initiating governance systems for adaptation and responding to climate change, but evolving institutional frameworks cannot yet effectively coordinate the range of adaptation initiatives being implemented (high confidence). Progress on national and subnational policies and strategies has initiated the mainstreaming of adaptation into sectoral planning. However, incomplete, under-resourced, and fragmented institutional frameworks and overall low levels of adaptive capacity, especially competency at local government levels, to manage complex socio-ecological change translate into a largely ad hoc and project-level approach, which is often donor driven. Overall adaptive capacity is considered to be low. Disaster risk reduction, social protection, technological and infrastructural adaptation, ecosystem-based approaches, and livelihood diversification are reducing vulnerability, but largely in isolated initiatives. Most adaptations remain autonomous and reactive to short-term motivations.
> (Niang et al., 2014:1206)

The Center for International Forestry Research (CIFOR), which conducts research on climate change and forest management in emerging economies, stresses the need to consider the climate variations and climate-sensitive sectors that are unique to each community's adaptation needs (CIFOR 2015). The unpredictable and non-uniform nature of changing weather patterns as well as the specific adaptation response capabilities and challenges of particular communities should be included in data collection and policy analysis. Development activities that include local adaptation strategies have the potential to increase community resilience to climate change by reducing the vulnerability of climate-sensitive sectors, including water, agriculture and energy (CIFOR, 2015). Foreign-directed research within African institutions may overlook national and community specificities and variances (IPCC, 2014).

> An early example of this is found in one of the world's first and largest climate change programs: the Pilot Program for Climate Resilience (PPCR). The PPCR was established during 2008 by several multi-lateral development banks (MDBs), including the World Bank, Asian Development Bank (ADB) and the European Bank for Reconstruction and Development (EBRD), in coordination with a range of governments. The stated purpose of the PPCR is to pilot and demonstrate ways in which climate risk and resilience can be integrated into development in addition to producing knowledge and experience for scaling-up adaptation measures… In seeking to respond to climate change the World Bank seems to have found ways to reaffirm what they were already certain of: that economic growth is central and a top-down, 'think big' approach (akin to the Green Revolution) is the best way forward… The most urgent changes are

> not needed in the developing world but among the policymakers of donor nations. It is here that new kinds of donor subjectivities must be found, and new ways of funding climate change programs, bedded not in familiar certainties but in a new effort to move uneasily, supporting the diverse practices of local communities as they respond in their own particular ways to the universal threat of climate change. (Ireland & McKinnon, 2013: 161)

Communities labeled as "agrarian" often have complex local economies with diversified income sources. Compared to the globalized, growth-driven development agenda that directs most large-scale multilateral adaptation projects, project designs that allow innovation targets to emerge locally incorporate unique community strengths and vulnerabilities into the process. "Strategies that integrate land and water management, and disaster risk reduction, within a framework of emerging climate change risks would bolster resilient development in the face of projected impacts of climate change" (Niang et al., 2014: 1202). Post and alternative development approaches have applied this approach through participatory community engagement and gender empowerment at the local scale (Ireland, 2013).

> As mitigating climate change is a multi-level governance problem, bottom-up approaches should be further developed so as to build up domestic support for future global action on climate change, empower citizens to take responsibility, and motivate leaders to approach the problem according to the complexity that characterizes it. Furthermore, ancillary benefits can be an extra driver for such policies. (Dirix, 2013)

1.3 Community adaptation strategies to climate change and biocultural innovations

The adaptive capacity of communities describes the potential of societies and individuals to respond to change. The concept of community-based adaptation (CBA) can be defined as the decision-making processes and knowledge of communities as they work to enhance their adaptive capacities and resistance to climate shocks through network building and by maintaining the resilience of existing resources and ecosystems (IIED, 2009). Recognition of the effectiveness of community-based adaptation and participatory innovation development in sustainable adaptation to environmental change, assessed together with socio-economic, environmental, and policy changes, is as "an entry point to strengthen the resilience of local people to climate change" (Gebre Michael et al., 2009:2).

Developed locally and adapted to community needs, biocultural innovations are more accessible to small-scale farmers due to cost-efficiency and local availability. Biocultural innovations have traditionally been used to manage socio-environmental and economic consequences of climate change in the community (Ongugo et al., 2015:9) (Levine, 2009). Innovations such as conservation of landrace crops contain a wealth of genetic diversity and are often better adapted to withstand a range of local soil and weather conditions and pests and diseases, as compared to introduced crops. Geographical pockets of edible biodiversity are more valuable than ever as the FAO estimates that 75% of genetic plant diversity has been lost since the 1900s (FAO, 2015). This genetic erosion of edible food crops and plant species (and increased dependence on imported food) is largely attributed to economic and historical factors, which have been aggravated by climate change. Globalized resource production, encouraged dependence on "improved" crop species and monocultures, habitat loss, and removed legal frameworks have challenged the conservation of landrace crops and other biocultural innovations.

Studies show that conservation of biocultural heritage knowledge, including local natural resource management practices and innovations, improves community adaptation and resilience against climate change (CIFOR, 2015; Mutta, 2011; Ongugo et al., 2014). Thompkins and Adger (2004) argue that community based-management enhances adaptive capacity and adds resistance to climate shocks through network building and by maintaining the resilience of existing resources and ecosystems. In their article titled "Does adaptive management of natural resources enhance resilience to climate change?", they note that the most successful climate adaptation initiatives will be instigated on multiple levels, be flexible and inclusionary, and consider the societal norms, technology availability and institution strength of the specific area (Thompkins, 2004: 1-10). Supporting local adaptive capacities can not be separated from larger development initiatives, argue Levine et al. (2009), as adaptation is driven by numerous pressures and "vulnerability to the impacts of climate change often comes from vulnerability in a general sense-from poverty and marginalisation" (Levine et al., 2009).

1.4 Conclusion

Overwhelming dependence on small-scale, rainfed agriculture across sub-saharan Africa presents particular climate adaptation challenges to the region. Despite increased global attention and legislation from the 1960s onwards aimed at promoting environmental conservation and sustaining population

growth through sustainable development policies, basic climate adaptation needs have yet to be successfully incorporated into frameworks of international development. Economic vulnerability is exacerbated by unpredictable agricultural yields as well as financial, technological, and geographic isolation. Limited institutions and infrastructure are challenging the diverse adaptive capacities of small scale farming communities and failing to create alternative employment opportunities for youth who are increasingly looking to diversify their income opportunities beyond their rural home areas in urban centers.

As Africa's predicted climate adaptation costs are estimated to be much higher than the global average, climate funds directed towards infrastructural, financial and technical inputs and training would be better utilized if complemented with localized strategies incorporating biocultural heritage (including understandings of how biocultural innovations have been developed and could be strengthened) into community resilience interventions. Furthermore, climate adaptation policies should address poverty, discrimination based on gender and ethnicity, and other socially created vulnerabilities including trade policies that undermine efforts at climate mitigation and adaptation in Africa.

CHAPTER II
CLIMATE ADAPTATION STRATEGIES IN KENYA

2.1 Kenya's biocultural legacy and national adaptation initiatives

Coastal Kenya is home to diverse range of ecosystems rich in plant and animal species diversity. Catalysts of social change in Kenya's coast result from interactions between various cultural, economic, and social groups (Shipton, 2013) as well as environmental changes. The five major African language groups represented on the Swahili coast today are a testimony of the region's rich linguistic and cultural heritage, influenced by internal migration and Indian Ocean waterways, cultural exchange, trade, slavery, religion (the growth of Islam in Kenya in the 8th century and Christianity in the 17th century), colonialism and globalization. The extensive trade networks that spanned across the Indian Ocean and East Africa contributed to changing subsistence and environmental management practices, architecture, and cultural interactions on varying scales. Ivory, shells, and other archeological findings document the expansive

trade that existed between the Arabian Peninsula and East Africa, extending back to the fifth century. Coastal upland and low plain communities engaged in intricate trading arrangements along the Indian Ocean, bringing inland products to the coast and beyond, as evidenced by certain imported goods including glass beads, eighth-century AD Sasanian pottery, and Chinese pottery dating back to the ninth to twelfth-century (Shipton, 2013).

Today about 75% of Kenya's national labour force is employed in the agricultural sector, which contributes to 25% of the nation's GDP (KEFRI, 2013). High dependence on climate-sensitive natural resources for subsistence threatens the economic livelihoods of millions of people, especially the small scale farmers (Government of Kenya, 2013). As Kenya's growing population and economic growth will likely increase carbon emissions, the government is combining climate resilience and mitigation to reduce vulnerability in the a number of national planning sectors, including: agriculture, environment, water and sanitation, tourism, infrastructure for transport and energy, manufacturing, population urbanization and housing, health, and disaster preparedness (Government of Kenya, 2013).

Current studies, local observations, and more than 30 years of meteorological climatology records demonstrate an increasing frequency and magnitude of extreme climate events on Kenya's coast, including extended periods of reduced rainfall and crop production, high incidences of crop and livestock diseases, and decreased soil fertility (Wekesa et al., 2015). Climate change mitigation and adaptation interventions in Kenya have been undertaken by a number of cross-sectoral government agencies, donors, private stakeholders, and academics, including: the National Climate Change Response Strategy in 2010, the National Climate Change Action Plan (NCCAP) in 2013 and Vision 2030. The NCCAP has identified a low carbon climate resilient development pathway for Kenya, emphasising sustainable development, adaptation, and mitigation (Government of Kenya 2013).

2.2 Smallholder Innovation for Resilience (SIFOR) Project

The global implications of the climate resilience of small scale farming communities is evidenced in a number of foreign funded research projects that incorporate climate adaptation. Currently, the enhanced resilience capacity of the Mijikenda community to climate change in coastal Kenya is the topic of research for a five year study: the Smallholder Innovation for Resilience (SIFOR) Project. The goal of the

five-year project (2012-2017) is to strengthen biocultural innovation for food security in the face of climate change, in a comparative study that is being conducted in China, India, Kenya and Peru. With funding from the European Union's Agriculture Research for Development Program, and UK aid, and other donors, the project aims to improve the adaptive capacity of coastal communities to climate change impacts by identifying and disseminating traditional knowledge-based innovations which enhance productivity in the face of climate change. In Kenya, the SIFOR project is led by the Kenya Forestry Research Institute (KEFRI) at their Coast Eco-Regional Research Programme headquarters.

The KEFRI Coast Eco-Regional Research Programme is located about 100 kilometers north of Mombasa, in Gede, Kilifi County, in the Arabuko-Sokoke Forest Reserve. At 420 km2, the Arabuko Sokoke Forest is the largest coastal forest in East Africa. It is the largest remnant of the coastal forests that used to span across much of East Africa, from Mozambique to Somalia. A biodiversity hotspot, the Arabuko-Sokoke Forest has a number of rare and endemic bird and butterfly species, and is characterised by three distinct forest types: Cynometra-dominated forests and thickets, Brachystegia-dominated (Miombo) woodlands, and Mixed Forests. In addition to KEFRI, the Kenya Wildlife Service (KWS) and the Kenya Forest Service (KFS) manage the forest and facilitate participatory community forest management with the surrounding Mijikenda (Giriama) community.

KEFRI's SIFOR study analyzed the impacts of climate change on farming systems, livelihoods, crop varieties, forest use and indigenous knowledge and practices of diverse Mijikenda communities in Kilifi and Kwale counties over the last 30 years (Ongugo et al., 2014). The most serious impacts of climate change were found to include: reduced crop production (related to a reduced rainfall), increased incidences of plant and animal pests and diseases, reduced soil fertility, and increased incidences of extreme weather (Ongugo et al., 2015). While farmers are being encouraged to intercrop slower growing local varieties of plants with faster growing starches, "frequent incidences of hunger and drought have necessitated a switch from maize to cassava as a major crop in all the Mijikenda communities" (Ongugo et al., 2015). Results from their study demonstrated that crop production has been declining over the last 17 years, rates of urban labor and migration have been increasing. It was found that food insufficiency was not uncommon, and the decrease in crop and livestock productivity is increasing community dependence on purchased food and relief.

For their report, KEFRI selected 155 respondents based on age, agricultural or cultural knowledge, and gender, to participate in a qualitative, open ended questionnaire survey, and 375 households responded to a quantitative interview. Their study focused on middle aged and elderly members of the community, due to their specialized knowledge regarding agricultural and cultural practices. Trends in crop diversification over the last 30 years were examined, and it was argued that global crop diversity is sustained by small-scale and indigenous farmers (Ongugo et al., 2015; Wekesa et al., 2015).

A variety of climate adaptation strategies have been adopted, revitalized, or encouraged in the Mijikenda communities due to widespread food insecurity and weather unpredictability. These technological, market, social, and institutional community-based innovations include: planting diversified varieties of the same crop in the same piece of land in a single season, combination of modern and traditional tilling practices, change in farming practices, planting large areas of resilient crops, domestication of wild plants, and formation of a cultural village to showcase culture. In addition, KEFRI has actively encouraged increased access to landrace seed banks and local markets, improved irrigation, and revival of cultural exchange within the communities (Wekesa et al., 2015: 5).

The study shed light on the social and institutional implications of climate adaptations in Kenya. Practices surrounding seed exchange demonstrate gender disparities within the Mijikenda community. While higher rates of women select landrace seeds (70.62%), "65.86% of men make most decisions regarding the selection of hybrid seeds as compared to only 34.14% of women. Similarly, men's participation in selection of improved seed varieties was higher at 77.25% as compared to women at 22.78%." The gender disparities in seed selection are related to social roles in which it is easier for men to frequent the markets that exist within towns and city centers. Women are expected to care for domestic chores and children, and this limits their ability to engage in market trade (Ongugo et al., 2015). Despite these challenges, it was found that women are more involved than men in their participation of certain social innovations, including traditional seeds exchanges and group gatherings incorporating music. Native language attainment, strong governance system, and cultural values were found to strengthen the resilience of living biocultural heritage within the community. Heads of households (often men, unless a women is a window) are most likely to participate in traditional ceremonies. The low participation of children in traditional cultural events has been attributed to religious misinterpretation and westernized education systems that contribute little to understandings of environmental and cultural history.

2.2.1 Limits to climate adaptation

The most frequently reported extreme weather event over the last ten years in coastal Kenya has been drought. Significant loss of traditional crop varieties is attributed to a reduction of cultural attachment and community governance structures, and more recently due to climate related causes including frequent droughts, hybrid input requirements, pests, and diseases. Despite the presence of Mijikenda biocultural innovations to increase community resilience to climate change, economic insecurity aggravated by climate shocks are causing community members to adopt a number of coping strategies. These were reported to include diversification of eating and work habits, eating less preferred foods, financial loans, and combining traditional crop varieties with introduced and hybrid crops (which when available are purchased at most the local market or exchanged with other farmers) (Ongugo et al., 2015).

The SIFOR study findings demonstrate the need for sensitisation and collaboration in understanding the economic and environmental value of landrace crops, while addressing the need to safeguard traditional knowledge and local innovations as they contribute to climate adaptation. Legally recognised community ownership of genetic variants, is imperative. The study recommended the potential benefits of enhanced economic value of traditional products that contribute to the ecosystem management and a revitalisation a traditional cultural identity that engages and empowers Mijikenda youth to participate in climate adaptation initiatives (Ongugo et al., 2015; Wekesa et al., 2015: 5).

2.3 Case for thesis research

The case study for this thesis was conducted within the Mijikenda community in collaboration with KEFRI, and expanded on their research findings. The perspective of women and youth were largely excluded from the data collection for the SIFOR study, and the role of women and youth in sustaining the community innovations was not well documented. Women were less represented than men during the interviews, due to cultural constraints which favored male participation in household interviews and focus group discussions that aimed to gather information from community members with specialized knowledge. The study concentrated on the middle aged and elderly males (who are nearly always the head of household among the Mijikenda), and only 4% of the total interviewees were youth.

The SIFOR study led me to ask the questions: Which technological innovations have been developed or adopted in the communities? What is the influence of gender and age on innovation development and adoption? What other factors facilitate or constrain innovation? How can innovations be strengthened?

CHAPTER III
METHODOLOGY

Data collection for this research was conducted in Kwale and Kilifi counties, in the Kenyan Coast, from October to December 2015. Three Mijikenda communities were targeted for the purpose of the study were Giriama, Rabai, and Duruma. The communities were chosen based on existing baseline studies (Smallholder Innovation for Resilience, 2014), diverse livelihood practices, traditional cultural relevance, community relationships with the government institution (KEFRI) to which I was attached, accessibility, and the available resources. Access was granted and supported by community leaders (Kaya elders) and government officials.

The study was conducted in collaboration with the Kenya Forestry Research Institute (KEFRI), a semi-autonomous government agency within the Ministry of Environment and Natural Resources. KEFRI has been conducting climate adaptation research in the coastal region for about 10 years, and is a leading research institution on social and technological innovations developed by farmers to adapt to climate change in Kenya. Their mission is "To conduct research and provide information and technologies for sustainable development of forestry and allied natural resources for socio-economic development" (KEFRI Strategic Plan 2013).

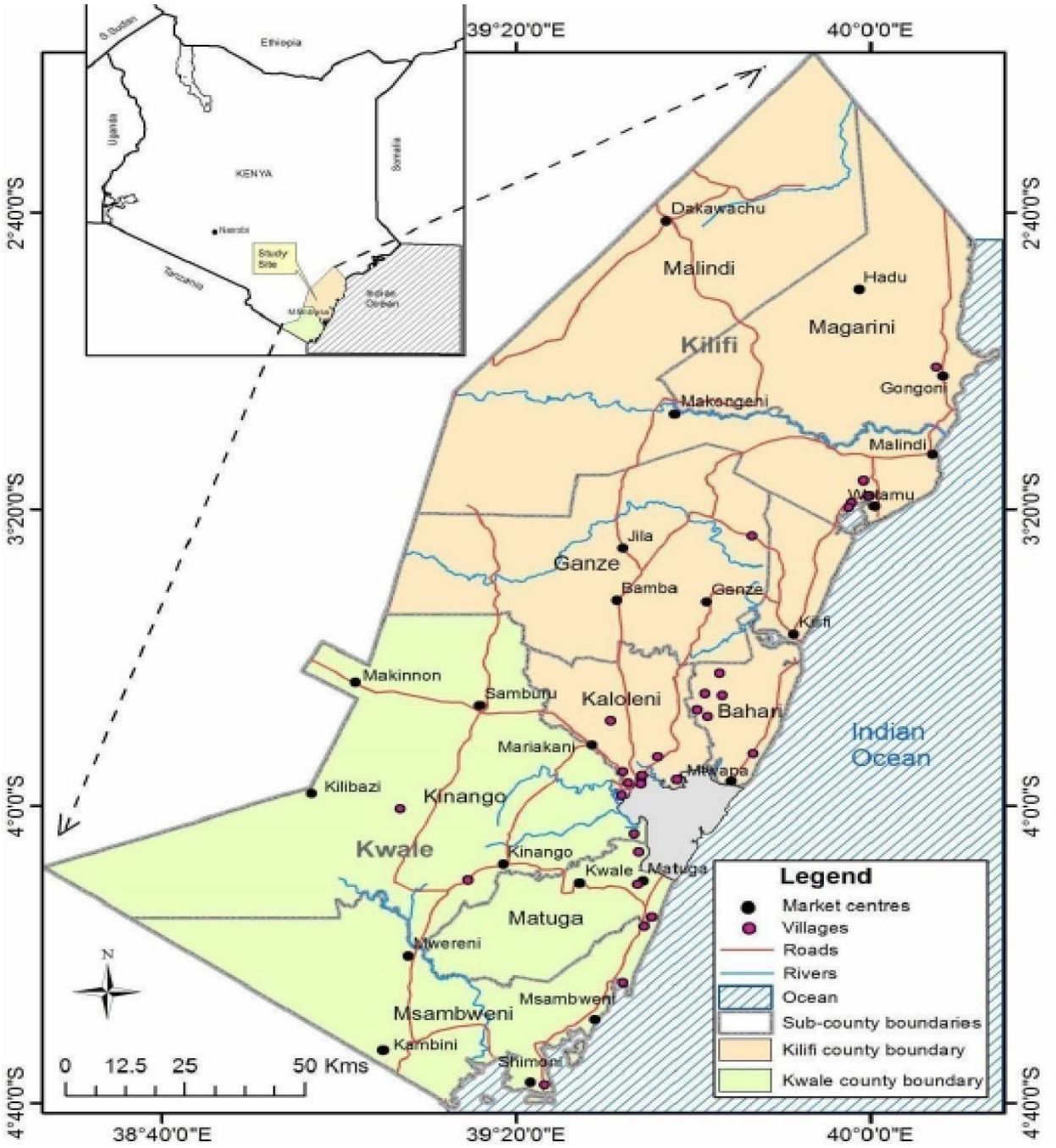


Figure 3.1: Location of the study sites in Kwale and Kilifi Counties, Kenya

Source: (Wekesa et al., 2015)

A review of existing literature on regional climate adaptation studies within agricultural based economies was conducted in order to develop an understanding of processes of innovation development in response to changing environmental conditions, to identify methodologies applied to previous studies, and to ascertain gaps within the information that had been collected regarding climate adaptation within the area. Women and youth from Mijikenda community were highlighted as previously untargeted subjects of past studies, and became a focus in this investigation.

The data collection occurred in four Rabai villages, five Giriama villages, and four Duruma villages. The number of villages was determined based on population density, location of community leaders or experts, and presence of underrepresented targets of previous studies (women and youth). Household questionnaires, key informant interviews, focus group discussions, and participant observation were methods used in this study. When designing the questionnaires, each question aimed to understand the study objectives (Appendix A). Additionally, a statistical analysis plan was developed to organize data in excel before the collection commenced. Analysis of coded data was objective as most of the categories were already established, while others emerged from open ended questions.

A total of 141 household interviews were conducted. About 65% of the interviewees were women and 35% were under the age of 35. Giriama and Rabai both had 15 males represented, while Duruma had 20 males represented in the interview. Within each of the three targeted Mijikenda communities, an average of 40 household questionnaires (43 in the case of Giriama) were used to collect information about community social and technological innovations and information sharing processes. Three local field coordinators assisted in data collection, due to their knowledge of respective Mijikenda dialects and customs. Additionally, six key informant interviews were conducted within each of the three communities with elders or members who have specialized knowledge regarding agro-biodiversity, conservation, traditional practices, and innovations. These people were Kaya elders, innovative or experienced farmers, and or traditional herbalists. They were selected based on their experience by the KEFRI researchers active in the areas or by the local field coordinator.

The household questionnaires were consisted of six sections: A) Administrative; B) General geographic information; C) General characteristics of the respondent; D) Community based innovations; E) Gender

participation in innovations; F) Gender roles in sustaining biocultural innovations; G) Factors promoting or hindering biocultural innovations (Appendix A).

The name, residence status, duration of time lived in the area, age, gender, household size, main occupation of household head, other household occupations, and marital status were recorded. Ethnicity was identified based on the respondent's last name. Education status was recorded, ranging between no formal education to postgraduate education.

To determine which technological innovations have been developed or adopted in the communities, respondents were asked to tick from the following list: re-introduction of traditional farming methods, planting large areas of resilient crop varieties, combination of herbal plants to treat livestock diseases, domestication of wild plants, planting diversified varieties of the same crop on the same piece of land in one season, preservation of land races in communal seed bank, and value addition of traditional crops and products.

To determine the extent to which social and institutional innovations have been developed or adopted in the community, respondents were asked to identify and explain the practices in which they participate, including: free seed exchange, formation of communal farming and marketing groups, formation of cultural centers, revival and or preservation of customary laws and practices, preservation of community registers, free primary school education, and others. Some of these innovations (e.g. formation of cultural centers and free seed exchange) were pre-identified by KEFRI and included in their SIFOR study, while others were investigated for the first time in this study (e.g. free primary school education).

Gender participation in innovation development and sharing was studied. In addition to listing innovations that they apply to their agricultural or socio-cultural practices, respondents were asked to identify who taught them the innovation and their gender, the number of years that they have been practicing the innovation and the number of males and females with whom they have shared the innovation. Respondents were also asked to identify the location where men and women learn about the innovation, and the role of men and women in promoting the innovation.

The gender and age roles associated with sustaining biocultural innovations were studied by examining the trends in information sharing and roles in promoting innovations. The respondents were asked how many innovations were developed by men, women, Kaya elders, and youth in their community. To understand which structures and practices promote or hinder the development of local innovations, the influence of school, ceremonies, festivals, and rituals were questioned and analysed with regard to gender and age. Participants were asked to list innovations in which their children are knowledgeable and or participate, noting the percentage of boy and girl children in the family with knowledge, and the application to farming, networking, and cultural practices.

Respondents were asked to list their opinions on the practices and factors that promote and hinder local innovations. The responses were analyzed to compare differences in gender perspectives. Respondents were asked how to improve men, women, youth, and elder participation in strengthening and sustaining local innovations.

The availability and usefulness of technology in accessing information about agricultural adaptations and strengthening biocultural innovations, mainly access to cell phones and internet) was determined. Namely, the number of people in each household who access internet, how they access internet, which kinds of information they seek, and which gender or age group has the most or least access to technology.

Following a review of completed questionnaires and interviews, focus group discussions were held in each of the three communities. The community field coordinators, KEFRI research scientists, key informants, and other community leaders attended each of the focus group discussions. The purpose was to discuss the questionnaire responses that had been gathered within the community, to cross-check responses, and to gather new information by having focus group participants expand upon certain listed innovations and innovation adaptation processes. In the focus group discussions, social networks, livelihoods, observed environmental changes, infrastructure, technology availability, and the disassociation of youth from traditional cultural practices were discussed. Specifically, key informants were asked about the process by which and extent to which community based innovations are practiced and developed, and the biggest environmental challenges faced within their communities. Lists of innovation “hot-spots” were constructed from the findings. Key informants shared perspectives on

infrastructure and technology availability and impediments, including access to electricity, running water, reliable transportation systems, cell phones, radio, and internet access.

Excel was used to compile and analyze collected data from the household and key informant interviews. The data was processed to analyze trends in influences of community, gender, age, occupation, and education on social and technological innovations.

CHAPTER IV
MIJIKENDA COMMUNITY BASED ADAPTATIONS

In this section I analyze and discuss the household interviews, key informant interviews, focus group discussions, and participant observation that were used to study the biocultural innovations that strengthen Mijikenda resilience to climate change. These methods of data collection helped to determine the technological and social/institutional innovations that have been developed or adopted in the communities, the influence of gender and age on innovation development and adoption, the extent to which location, education, technology and other factors facilitate or constrain innovation development, and Mijikenda opinions on ways to strengthen innovation development in their respective communities.

The agricultural innovation development process among small scale farmers in coastal Kenya is largely driven by local (individual, family, and community level) reactions to climate change for food security. Such innovations are challenged by limited resource availability and a cultural net loss of traditional values that previously enhanced ecological awareness and community cohesion. Most innovations are developed locally and not commercialized, due to lack of investments and institutional support. Innovations are generally shared among family members and interested neighbors, with gender selectivity. Social recognition is the main form of compensation for innovations developed by an individual or group, as tangible incentives and monetary compensation are extremely rare for locally developed innovations, and reciprocity in the form of work exchange is widely practiced. Successful innovations continue to be validated through the community's observation of a family's bountiful harvest or health.

The main occupation among the Giriama, Rabai, and Duruma is farming. Farming was stated to be a significant occupation in 79% of Mijikenda households (Figure 4.1). Small businesses and casual labor are also widely practiced in each of the three communities. Other household occupations within the communities include: security, commercial driving, mechanic, teacher, herbalist, weaver, police officer, construction, carpentry, tourism, restaurant staff, and oxen ploughing. Cultural, geographic, and infrastructural differences among the communities have led to varying livelihood practices among the Mijikenda. In the Duruma community, livestock keeping, charcoal production, and fishing are especially important to household incomes. Palm wine tapping, practiced at various levels throughout all the Mijikenda communities, serves as a main source of income for the Rabai.

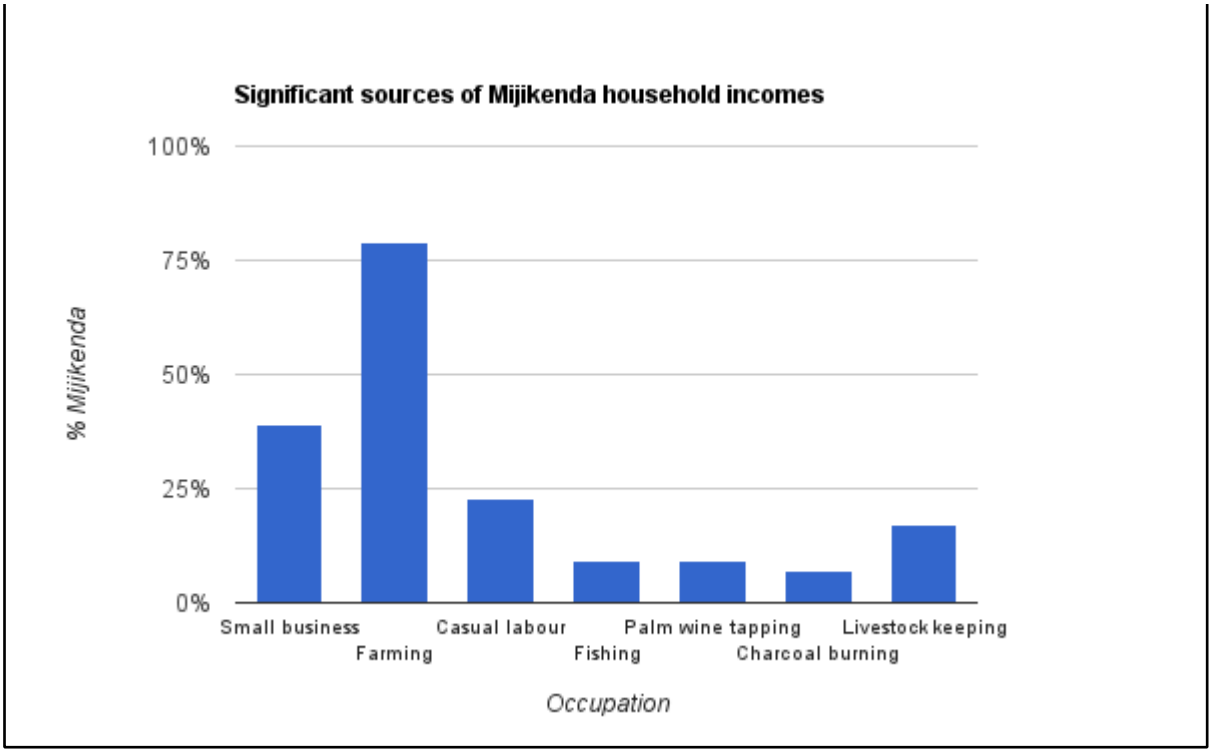


Figure 4.1: Significant sources of Mijikenda household incomes

In the focus group discussions, key informants summarized the greatest environment related challenges within their sites. Climate change and related reductions in crop productivity, as well as the over-

exploitation of the Kaya forests, were stated to be the biggest challenges faced by the Rabai community. Environmental degradation has been accelerated by the current education system coupled with declining traditional values (including traditional resource governance systems), according to Rabai leaders. Additionally, Rabai leaders discussed how changes in climatic patterns are making weather much less predictable, changing the duration and occurrence of rainy seasons, and resulting in an overall decline in crop production. In the Giriama community, leaders stated the destruction of terrestrial and mangrove forests through overharvesting to be the greatest environmental challenge they face. A high market demand for dye is driving the over extraction of certain plant species used in the dye making process. Food security is the greatest challenge in the Duruma community. Duruma leaders highlighted the extinction of a number of plant species of economic and cultural importance which previously bolstered food security within the community (Appendix F). They attributed this loss of plant diversity to climate change, over harvesting, loss of traditional values, and land mismanagement. Duruma community resilience to climate change is further reduced by land ownership conflicts, climate related pests and diseases, limited access to infrastructure and funding, modern education, and gender inequality.

4.1 Technological and social/institutional innovations developed by Mijikenda communities

The extent to which technological, social, and institutional innovations have been developed within the communities was analyzed. The household questionnaire surveyed community awareness levels of the following technological innovations: re-introduction of traditional farming methods, planting large areas of resilient crop varieties, combination of herbal plants to treat livestock diseases, domestication of wild plants, planting of diversified varieties of the same crop on the same piece of land in one season, preservation of land races in communal seed banks, and value addition of traditional crops and products. The surveyed social/ institutional innovations were: free seed exchange, formation of communal farming and marketing groups, formation of cultural centers, revival/preservation of customary laws and practices, preservation of community registers, free primary school education, and tree nursery establishment by community groups. In addition, participation in twenty five unique technological and social/institutional innovations were identified through the survey and confirmed through the focus group discussions and observation (Appendix B). While the Giriama community had the greatest number of people claiming to participate in innovations, the Duruma community had the greatest variety in the number of innovations listed.

4.1.1 Technological innovations developed or adopted by Mijikenda communities

In the household interviews, the following technological innovations were listed by interviewees as innovations in which they participate: digging terraces in a swampy areas in order to control water for early planting, use of herbal treatment, use of organic manure, early tilling of land before the rains, fish farming, tree nursery establishment and management, planting of coconuts, intercropping, planting crops in zay pits, use of fresh milk to treat chicken diseases, wild plant domestication, wild bird keeping on a tree to predict farm season conditions (Figure C.5), oxen plough (Figure C.4), utilizing local rocks as building materials, goats and poultry upgrading, homestead water pan or *Zaypit* (sunken waterbed), indigenous poultry hatching using maize husks, tree planting, maintaining and exchanging indigenous vegetable seeds (Figure C.7) (Appendix B & C).

In the focus group discussions, Mijikenda leaders further discussed the main biocultural innovations developed or adopted in their communities. Rabai leaders highlighted certain technological innovations as important adaptations to climate change within their communities, though they estimated that only 5% of their community practices these biocultural innovations. They included: use of a wide range of herbal plants (such as neem tree leaves) to control pests in crops and animals; use of wood ash from specific tree species to control pests on farms and to preserve seeds for planting during the next season; digging of gabions in swampy areas to conserve water; early tilling of land and planting before the onset of rains; and conservation tillage.

Similar to Rabai, Giriama key informants agreed that while biocultural innovations are useful in improving individual adaptation to climate change, innovations are practiced by very few members of their community and are not well shared. Key informants emphasized the practice of the following technological innovations in their community: planting of maize seeds face-up to facilitate faster germination, especially during dry periods; use of burnt ash from either *Mbanje*, *Mnyangakitswa* or *Mkuro* tree to enhance sense of smell; use of firewood ash to prevent pests and preserve seeds; use of firewood ash and animal manure as fertilizer to enhance farm fertility; sprinkling of burnt cow dung and

ash in tree and crop nurseries to prevent pests; and use of various herbal plants to treat a range of plant and animal diseases. Some of the herbal treatments listed by Giriama leaders included: pounded *mjaji*[3] roots mixed with *mboho* roots to treat snake bite wounds; *Jatropha curcus* leaves mixed with water used to prevent pests on plants; *Azadirachta indica* (neem) tree soup used to spray crops against pests and diseases; *mtupa* soup used to treat jiggers in human beings and on pests and diseases in crops; *Mbirandu* bark mixed with water to ease constipation in livestock (cows, goats and sheep); *Aloe vera* soup to treat diarrhoea, worms and constipation in livestock; *Mtsatsa* used to treat pregnancy related complications in human beings; and a donkey manure and pepper mixture that is pounded together and fed to poultry as a vaccine against poultry diseases (Appendix H).

Duruma key informants identified the following community-based technological innovations: tree planting; wild bird keeping to predict weather forecasts; *dungu* (a method of local seed preservation that involves hanging landrace maize seeds in a tree or cowpeas in coconut fiber in a tree) (Figure C.7); *Zaypits* for household and farm use; medicinal tree domestication; use of improved oxen-ploughs (Figure C.4); fish ponds; intercropping; livestock improvement breeding; indigenous poultry hatching using corn husks; use of livestock manure in fertilizer; and using locally available rocks as building alternatives to wood. Some of the innovations were locally introduced (medicinal tree domestication, rock walls, wild bird keeping, dungu, poultry hatching and livestock improvements), while others were introduced by NGOs, the government and private entities (including zay pits, the oxen plough, and fish ponds).

4.1.2 Social and institutional innovations developed or adopted by Mijikenda communities

In the household interviews, the following social and institutional innovations were listed by interviewees as innovations in which they participate: free seed exchange, establishment of cultural centers, microfinance, traditional birth attendant, weaving, and women's groups (silk) (Appendix B & C). In the focus group discussions, Mijikenda leaders highlighted the following social and institutional innovations as important adaptations to climate change within their communities. Rabai key informants emphasized: the formation of community groups including village microfinance, farmer's groups, women's groups, development of cultural centers (Figure C.2); free seed exchange, and a 'work for food' program

[3] Vernacular Mijikenda plant names

introduced by World Vision. While loss of cultural values challenges the transmission of the traditional innovations, externally introduced innovations (including group formation aimed at improving socio-economic conditions) are gaining popularity in the Rabai community. Giriama key informants emphasized the practice of the following social/ institutional innovation in their community: performance of rituals by Kaya elders (Figure C.1 & C.8) to avert conflicts, promote peace, and conduct rainmaking ceremonies during prolonged periods of drought.

4.2 The influence of gender and age on innovation development and adoption

4.2.1 Relationships between gender roles and biocultural innovations

Mijikenda males and females had similar awareness levels with regard to existing technological and social/institutional biocultural innovations in their communities. However, participation levels in community based innovations were significantly higher among males (Table 4.1). Socio-economic exclusion resulting from gender discrimination decreases women's exposure to centers of innovation, including educational centers (fewer Mijikenda females are enrolled in primary, secondary school, and university), urban centers (men are more likely to access urban markets), leadership roles (traditional leadership roles throughout the Mijikenda community, such as Kaya elder positions, are almost exclusively held by men), and workshops (family obligations and household head roles favor men's chances of attending workshops and other community events, especially those including travel distance).

Mijikenda men are active participants in an average of 3 community based innovations, while Mijikenda women are on average active participants in only 1 community based innovation. Mijikenda males were on average aware of 4 listed technological innovations (56%), and 3 social innovations (54%), while Mijikenda females were on average aware of 3 listed technological innovations (53%) and 3 social innovations (51%). Rabai females had the highest percentage of innovation awareness among the Mijikenda. Giriama females, meanwhile, demonstrated the lowest levels of innovation awareness. Female participation in the Rabai Cultural Village activities and leadership, as well as the proximity of the Rabai community to Mombasa increases market access and information exchange among women. Of the fifty men and ninety-one women interviewed, men listed 125 total innovations and women listed 93 total innovations.

Innovation Participation	Response (%)					
	Rabai Men	**Rabai Women**	**Giriama Men**	**Giriama Women**	**Duruma Men**	**Duruma Women**
Technological innovations	77	86	50	43	42	33
Social/Institutional innovations	77	77	37	31	50	47

Table 4.1: Technological and social/institutional innovation participation among Rabai, Giriama, and Duruma males and females

The gender and age roles associated with sustaining biocultural innovations were studied by examining information exchange processes, roles in promoting innovations, and innovation adoption levels in the Mijikenda communities. Mijikenda males and females both reported that with respect to information sharing, family and friends were prioritized as beneficiaries of useful biocultural innovations. Mijikenda women were more than twice as likely to state that they obtained innovation knowledge from other women, as compared to men. Women were more likely to share information with family members, as compared to friends. Men were equally as likely to share with friends and family. To a much lesser extent, community members stated that they also share innovation information with neighbors, other community members, and group members. Few community events which youth attend are gender specific. For example, girls are more likely to attend birth ceremonies while circumcisions ceremonies are exclusively attended by boys.

In the Giriama community innovations are shared with family members, neighbours and group members, and often amongst members of the same gender (except in groups where information is shared with all members). Social recognition is the main incentive available to encourage innovations. Similarly, among the Duruma most innovations are taught within a family, where teaching innovations is gender selective. Boys are often taught by their fathers, and girls are taught by their mothers. The elder sons are prioritized in knowledge teaching, due to the Duruma system of land transfer that favors the eldest born male's

position. Beyond families, biocultural innovations in the Duruma community are shared with neighbors (of the same gender) and group members.

Mijikenda women are far more likely to participate in small savings groups (such as table banking and microfinance groups), as compared to men. Women's groups who undertake income generating activities for enhanced livelihood encourage social cohesion among members of the community and provide safety nets for members and their families during disasters (including death of a family member or failed crop). These meeting spaces are useful in providing a platform for information sharing and is a means of increasing capital among members. Engaging in savings and credit schemes allows members to access financial capital to initiate businesses, buy tools or materials, and meet other financial obligations. The female dominated groups are attempts to gain financial footholds and small business opportunities in male-dominated societies, as existing social obligations and expectations essentially limit women's movement, access to markets and financial independence. While their reasons for the formation of women's groups in the Giriama community are essentially the same as in the wider Mijikenda community (desire to participate in savings and credit schemes, initiation of income generating activities and socialization), Giriama leaders pointed out that these groups have also contributed to social disintegration due to prevalent cases of theft of money coupled with lack of accountability by group officials entrusted as custodians of group savings.

Men's groups in the Rabai community are limited to the Rabai Council of Kaya Elders. In the Rabai focus group discussion, it was stated that the absence of men's groups can be attributed to the fact that men are less cohesive as compared to women, and are therefore unable to form and sustain interest in groups. Among the Duruma, most groups are comprised of women. However, some notable groups, including the mixed male/ female Kaya elders group and the all-male Duruma fishing groups don't follow this trend. Giriama leaders recognized that cultural factors, which often distinguish roles based on gender, are cause for the gender disparities in finance groups in their community.

4.2.2 Relationships between age and biocultural innovations

There was a positive correlation between technological and social/institutional innovations and age, as Mijikenda elders demonstrated having the greatest knowledge of biocultural innovations (Figure 4.2).

Innovation participation varied widely, and is related to age range and speciality, and in the case of certain introduced innovations- date of introduction from outside source. Mijikenda elders aged 56 and higher participated in the highest number of various innovations, with over 76% of participants listing innovations in which they have actively participated. In fact, everybody who reported participating in 3 or more innovations was over 56 or older. On the other hand, Mijikenda youth aged 25 and below had the lowest percentage of innovation participation, with less than 16% of those interviewed claiming they participate in innovations. The reduction in knowledge-transfer to Mijikenda youth was found to be related to decreasing adherence to traditional values within the Mijikenda community structure, increasing enrollment in primary and secondary schools, deforestation and related disappearance of culturally significant plant species, unclear land titles, and lack of job opportunities for rural youth resulting in an urban migration. The disengagement of youth from participating in agriculture-related biocultural innovations and traditional knowledge systems surrounding natural resource management was observed in all of the studied Mijikenda communities.

Knowledge of community based social and technological innovations was analyzed with respect to age group. For technological innovations, interviewed participants younger than 15 had an average awareness of 14% of the listed innovations. Meanwhile, participants aged 16-25 had a 41% awareness, ages 26-35 had a 51% awareness, ages 36-45 had a 56% awareness, ages 46-55 had a 61% awareness, ages 56-65 had a 63% awareness, and those aged older than 65 were on average aware of 83% of the listed technological innovations. With regard to awareness of listed social innovations, those younger than 15 had an average awareness of 17% of the listed innovations, ages 16-25 had an average awareness of 45%, ages 26-35 had a 50% awareness, ages 36-45 had a 52% awareness, ages 46-55 had a 63% awareness, ages 56-65 had a 55% awareness and those aged older than 65 had an 65% awareness of listed social innovations within their communities. Every respondent who reported participating in more than three innovations was over the age of 65.

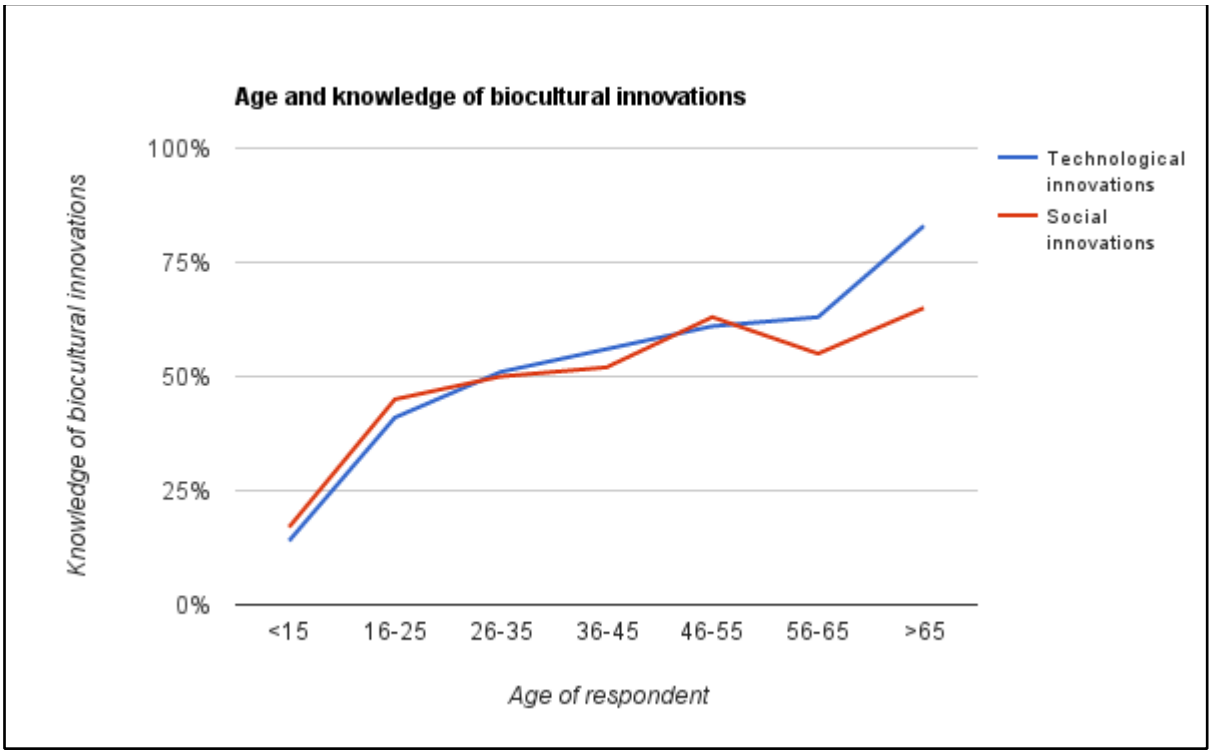


Figure 4.2: Age and knowledge of biocultural innovations

Rabai youth were found to have the greatest innovation awareness, followed by Giriama, and then Duruma youth. Elders and cultural festivals (including the annual Rabai community peace walk and the Rabai New Year festivals) were stated to be significant sources of biocultural innovation knowledge transfer for Rabai youth. Among the Giriama, both men and women currently teach youth about biocultural heritage, mainly through day-to-day mentoring. However, the level of guidance is very low.

About half of the interviewed households reported that their children are knowledgeable of biocultural innovations, though they "rarely" apply it to their cultural or agricultural practices. Participants were asked to list innovations in which their children are knowledgeable, and their application of such awareness to farming, networking, and cultural practices. It was found that 53% of boys and 51% of girls in the interviewed households know about local innovations. Youth were found to be knowledgeable of the following innovations: community cultural centers, specific agricultural adaptations such as use of ash to treat pests, tree nursery establishment, early planting, early weeding, planting in lines, collection and

preservation of local vegetable seeds, maize seed preservation, use of cow dung manure to improve fertility of the soil, planting of medicinal plants for use in treating human and livestock diseases, zay pits construction, utilization local building stones for construction, microfinance, and *Boda Boda* (motorcycle taxi) service, rearing of improved goat and poultry breeds, use of oxen plough, and fish farming. Elders were reported to be the main source of innovation information for youth in all three of the communities. Less significant sources of innovation information were stated to be peers, schools, and cultural festivals. The frequency by which youth apply learned innovation knowledge was low in all of the communities. 81% of respondents claimed that youth do not apply their innovation awareness to cultural practices. 86% of respondents reported that their children only occasionally or rarely apply their innovation knowledge to networking practices. 79% reported that their children only occasionally or rarely apply such knowledge to their farming practices (Figure 4.3).

Rabai youth access innovations through involvement in communal events, including traditional ceremonies. Both women and men teach Rabai youth about biocultural innovations through oral narration and day to day mentoring. The youth however view traditional knowledge as retrogressive and are not receptive. A suggestion was made that parents should be closer to their children in order to create a conducive environment for their children to learn. A new trend has emerged as youth form groups that provide farm labour, masonry and other forms of labour for economic gain. Youth centers exist in the community with the main purposes of sex education, socialization and income generation. These centres, however, do not focus on biocultural innovations or climate adaptation.

Giriama youth access innovation information from elders, mainly through mentoring. The youth rarely develop their own biocultural innovations, to which Giriama key informants blamed “the influence of modernity”. In the focus group discussion, it was mentioned that children and youth spend longer hours in school hence there is limited time for interaction with elders, making it difficult to mentor them. Youth centers exist in form of youth polytechnics but most of these institutions teach technical skills to the youth with little or no emphasis on biocultural innovations or indigenous knowledge. Duruma key informants stated that youth are generally uninterested in learning about biocultural innovations from their parents or grandparents.

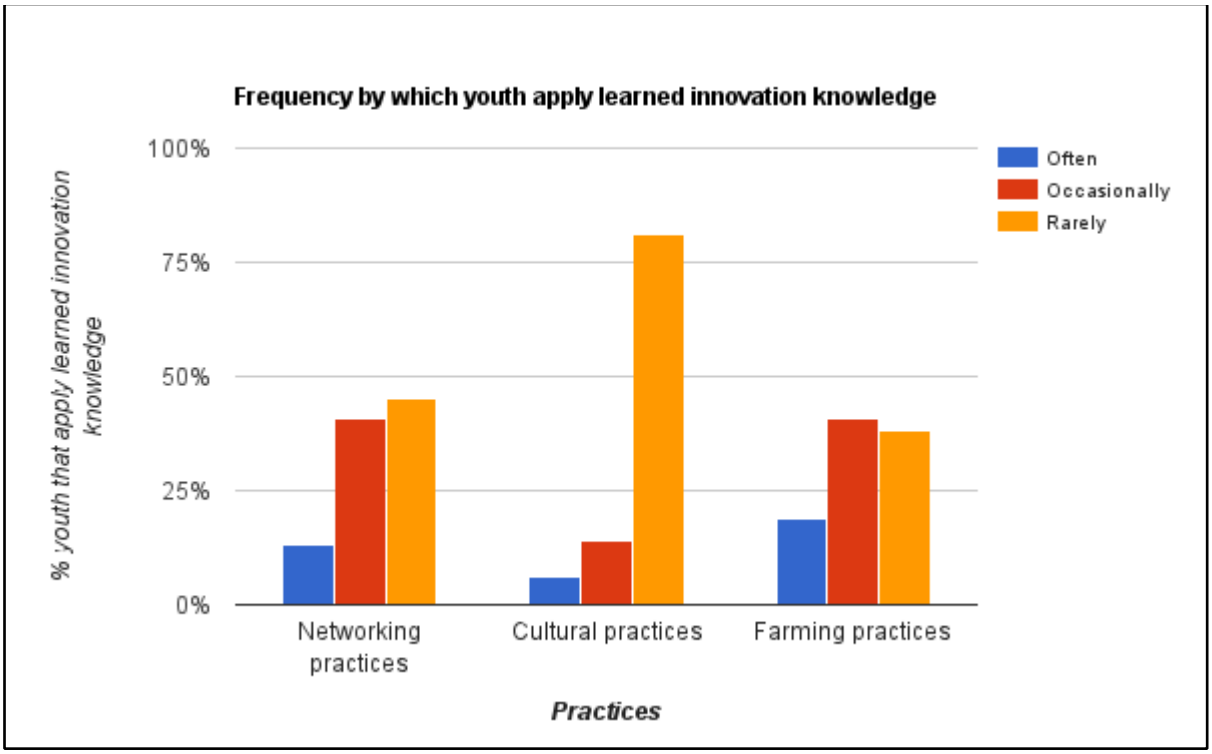


Figure 4.3: Frequency by which youth apply learned innovation knowledge to their networking, cultural, and farming practices

Many Mijikenda cultural ceremonies include youth but few specifically target them. Only 6% of Giriama reported that their community has festivals and rituals targeting youth. These included: circumcision and youth day. 0% of Duruma respondents reported knowledge of community festivals and rituals targeting youth. On the other hand, 96% of respondents in Rabai stated that there are certain festivals and rituals in their community that target youth. These included: weddings, birth ceremonies, circumcisions, funerals, youth days, dowry ceremonies, cultural dances, drama festivals, and the Rabai New Year Festival. While Rabai youth were found to be more involved in cultural ceremonies as compared to Giriama and Duruma youth, the overall cultural involvement of youth in all the communities is decreasing. Today, local institutions such as the Rabai Cultural Village or the Giriama community cultural centers play an important role in biocultural innovation knowledge sharing. These social spaces bring together the community, and aim to increase local appreciation of cultural history and values and strengths. Through performance art, local history, traditional events, ceremonies, and information about the community's

cultural values and needs are showcased. Community members and outsides are generally invited to such events in order to enhance Mijikenda recognition and appreciation.

Through active participation and mentoring, youth learn about community values. Music, dance, and drama have traditionally been used to share biocultural information within the Mijikenda community. Giriama music, for example, contains "wise words" or messages that address social ills and methods of self-improvement. Weddings and funerals were found to be the most common ceremonies that community members (including youth) attend. While children were found to be excluded from many other ceremonies, they do (to a much lesser extent) attend birth ceremonies, circumcisions, dowry payments, peer education events, *Makayamba* (traditional dances), ancestor sacrifices, and other cultural events at the discretion of their parents or community. On average, 70% of the targeted Mijikenda youth attend ritual events and ceremonies. Specifically, 82% of Rabai, 73% of Giriama, and 55% of Duruma children attend ceremonies or cultural events within their communities.

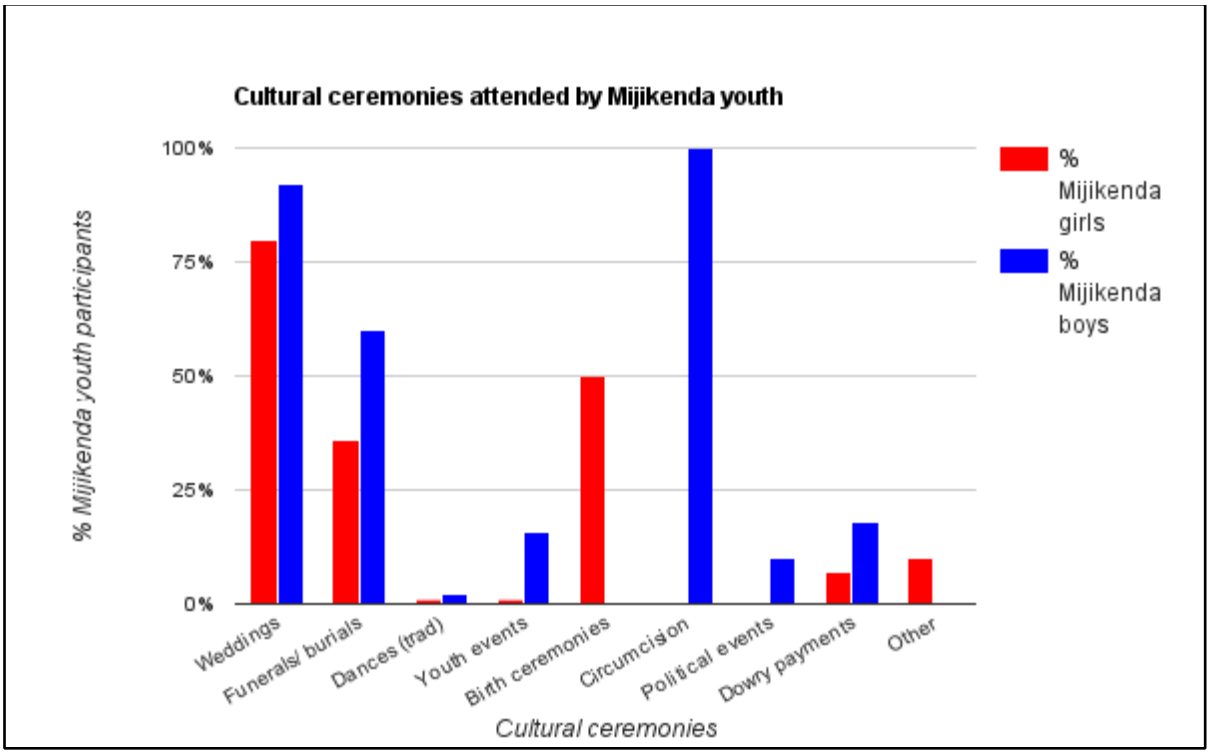


Figure 4.4: Cultural ceremonies attended by Mijikenda youth

In the Rabai community, the most common rituals and festivals involving Rabai boys and girls are traditional songs and dances. The main natural environments utilized for these ceremonies are the Kaya forests. These ceremonies are associated with various plants, some of which are now extinct or difficult to find (see Appendix I). Cowpeas and green grams (mung beans) are feasted on in most Rabai traditional ceremonies. Custard oil (no longer present in the community), *Mranze*, and *Vifuvu* plants were used to decorate and perform rituals on the bride and groom during traditional Rabai weddings. Rainmaking ceremonies (still practiced in the Rabai community) are usually led by Kaya elders in the Kaya forests. At these ceremonies, seven grains and pulses, (including maize, sorghum, cowpeas, rice, millet, finger millet, and mung beans) are eaten by the entire community, and the leftovers are sacrificed to the their ancestors as an offering to encourage rainfall. The Rabai Kaya Elders Council shared information regarding cultural ceremonies that previously targeted youth, but which are rarely practiced in actuality. Anniversaries of the deceased, for example, used to be commemorated by feeding grandchildren a meal on the grave of their ancestor so that the crumbs of the spilled food could nourish the grave. Traditional wedding ceremonies and preparations involving girls have largely been lost, as most weddings conducted in the Rabai community are now influenced by religion and westernization.

In the Giriama community the main youth-focused ceremonies are pre-marital classes and circumcision. Though practiced less often today, pre-marital classes (*Somo* and *Zhalusa*) traditionally targeted girls who were preparing for marriage. Circumcision is widely practiced on young boys, although today it is generally performed in the hospitals without the accompaniment of a traditional ceremony. Giriama youth are included in other rituals and festivals such as burials, weddings and traditional songs and dances. During such ceremonies, youth learn about some aspects of biocultural heritage and innovations although the majority of the youth do not view biocultural heritage and innovations as important, according to the Giriama elders in the focus group discussion. Similar to Rabai, traditional Giriama brides and grooms are decorated in custard oil. Palm wine is presented as a gift to the parents of the bride and the two families drink together as a symbol of unity. Animals, normally goats and cows are slaughtered and feasted on, and maize is ground and used to prepare maize meal during traditional ceremonies. During rain making ceremonies, different grains are also cooked and shared by all members of the community while the rest is offered as sacrifices to the ancestors. Natural environments, such as Kaya forests and communal shrines,

are accessed for some of these ceremonies- especially rainmaking and cleansing or healing ceremonies. Most of the other social ceremonies (burials, weddings and traditional festivals) are conducted within the homesteads (see Appendix H).

Duruma youth are included in a number of rituals and festivals, including traditional healing dances (*Makayamba*), burials, ceremonies, weddings, funerals, and ancestor sacrifices. Such ceremonies occur in the villages, with the exception of *Kilomba mvula*, the prayer for rainfall, which is conducted in the Kaya forest. Some of the plants involved in Duruma ceremonies or rituals are currently endangered, due to medicinal demand and mismanagement of forests (see Appendix G).

4.3 Other factors that facilitate or constrain innovation

Mijikenda men and women shared similar views on factors that hinder the development of innovations in their communities. 54% of women and 60% of men stated that lack of information is the leading cause of innovation hindrance. In addition, infrastructural, social, and technological barriers were stated to deter innovation development and expansion. About 34% of Mijikenda females and males agreed that general information sharing was one of the most important ways to promote and improve innovations in their community. 36% of females thought that training sessions would help to promote the innovation, compared to 20% of males. In addition to general information sharing and training sessions, community members stated that the following would help to boost biocultural innovation development and adoption within their communities by enhancing information and technology exchange and community awareness: cultural activities (including traditional festivals), availability of landrace crops, visibility (demonstrating proof of a good harvest and benefits to the innovator and their family), infrastructure that decreases production time and eases access to markets, access to financial capital, establishment of community groups, incorporating the innovation into economic activities, proof of a good harvest, visible benefits for the innovators and their families, practice, and increased interest in innovation development.

4.3.1 The influence of location on innovation

Information exchange among the Mijikenda is encouraged by social networks. Important sources of biocultural innovations, in order of importance, were stated to be: women (women groups, relatives,

neighbors), meetings, friends, relatives, community based organizations, site visits, cultural festivities, agricultural extension services, neighbors, observation, youth centers, internet and elders (Figure 4.5). The focus group discussions gave community leaders an opportunity to expand on the implications and importance of innovation "hot spots". Rabai and Giriama key informants highlighted the Kaya forests as an essential "hot spot" for biocultural exchange and innovation. In the Kaya forests a number of key traditional rituals and ceremonies are conducted. Some events, like the annual Rabai New Years festival, welcome the participation of the entire community. Certain areas within the Kaya forests are designated for traditional songs and dances throughout the year, and some of these ceremonies target specific members of the community. Kaya elders in Rabai were of the opinion that the vitality of their community has traditionally been linked to the health of the kaya forests. Intricate belief systems and practices surrounding forest access and resource extraction served to protect a vast amount of culturally significant plant and animal species, as well as to maintain a fortress that could be accessed in times of danger. Despite some community forest governance systems involving the Kaya forests being incorporated into greater national forestry management strategies, and the designation of certain Kaya forests as UNESCO world heritage sites, the Kaya forests and associated biocultural heritage are endangered. Two Mijikenda community centers, the Rabai Cultural Village and the Giriama Mekatilili Wa Menza, were also recognized as being important social institutions that bring together the extended community for information and seed exchanges, and annual festivals. Giriama key informants pointed out that farming innovations are more likely to be developed in the drier parts of their community- often in deforested areas, as the challenges associated with reduced rainfall and drier soils have more seriously threatened crop productivity in those villages.

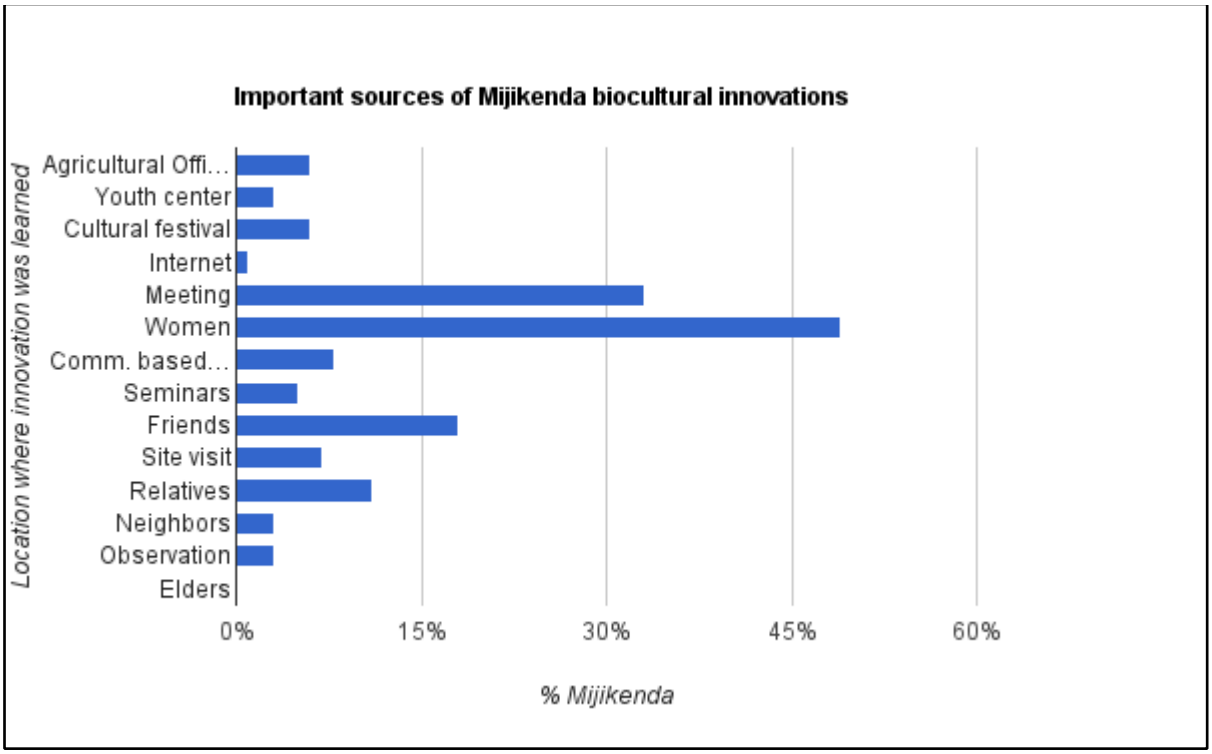


Figure 4.5: Important sources of Mijikenda biocultural innovations

Rabai key informants discussed the practices and groups in their community that actively encourage innovation exchange. Networking activities exist to a large extent with the main activities and platforms being farmers groups, SILC (Savings and Internal Lending Communities), microfinance groups, and traditional festivals. Such community group meetings and cultural ceremonies serve to support and motivate the development of innovations. Farmer's groups in particular play an important role in information exchange through oral and practical demonstrations. In such groups, members provide farm labour on other members' farms on a rotating basis. Occasionally the Ministry of Agriculture occasionally collaborates with farmers groups by hosting farm field days and training workshops. Individuals and community groups record successful and unsuccessful biocultural innovations through regular practice and the subsequent realization of their importance. Advertisements for such events generally reach community members by word of mouth, printed banners, and radio advertisements. Information about weather and market forecasts are shared via word of mouth and during local chief *Barazas* (community assemblies). The annual Rabai New Year Festival, which is marked by a week of cultural festivities

aimed at reviving and encouraging preservation of Mijikenda heritage, is open to the public and usually announced at annual peace walks preceding the festival.

In the Giriama focus group discussion, group meetings and community meetings were stated to boost information exchange and innovation development. Support and motivation for the development of innovations was stated to be strongest amongst community group members and rare at the individual level. Networking activities that promote local community innovations reportedly include: social networks, community meetings and public *Barazas* that are normally presided over by local administrative leaders (area chiefs and/or assistant chiefs). The main advertisements that promote or teach biocultural innovations in the Giriama community are found within designated cultural sites, such as the Mekatilili Cultural Centre. Local radio stations in local languages (Giriama and other Mijikenda dialects in addition to Swahili) have large audiences and also were stated to promote biocultural innovations. Information about weather and market forecasts is often shared amongst members during group meetings and community meetings or through phone conversations to neighbouring villages. Individuals and groups mark successful and unsuccessful biocultural innovations through testimonies made by neighbors or other members of the community who have visible benefits or losses.

Innovations are ways of managing household and community challenges. Most of the technological innovations found in the Duruma community have developed as reactions to the immediate needs of community members due drought and food insecurity. Factors that affect information exchange within the Duruma community are influenced by the type of innovation and the innovator's reputation. An individual's reputation precedes the community's reception of their innovation. Some of the practices that reportedly promote the development and participation in local innovations among the Duruma include *barazas*, inter village visits, good partnerships with NGOs, visible production benefits, and the time-saving benefits of certain innovations (including the household water pans). Presence of pests and diseases and declining medicinal plant availability have encouraged innovation development and sharing. Despite drought, traditional varieties of maize and cowpeas continue to exist through the innovative preservation techniques that are being utilised within the communities. Innovations that extend beyond an individual were said to promote good relationships with neighbors.

4.3.2 The impacts of education and access to technology on innovation

The education system in Kenya consists of eight years of primary school (standard 1-8), four years of secondary school, and four years of university. Universal primary school education was introduced in Kenya with the Free Primary Education (FPE) programme in 2003, making primary school compulsory and free for all Kenyans. Since its inception, the number of young Kenyans attending primary school has increased substantially. In the household interviews, young adults aged 26-35 demonstrated higher levels of education than their parents or grandparents generation. About 33% of those interviewed had no formal level of education, while 44% only completed primary school. The education levels of Mijikenda women were considerably lower than those men, in all three of the communities. While Rabai had the highest overall levels of education, (30% had completed tertiary or a higher level of education), the Duruma community had the lowest reported levels of education (30% of males and 50% of females reported having no formal education) (Figure 4.6).

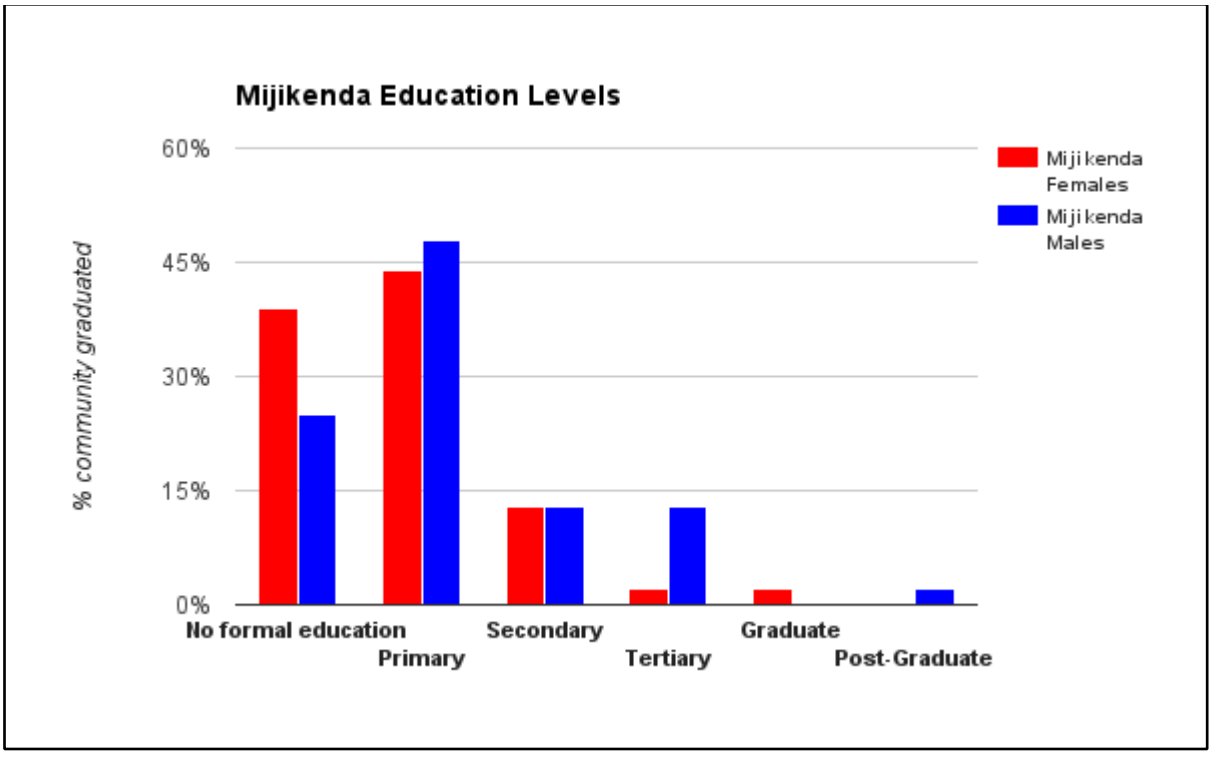


Figure 4.6: Mijikenda Education Levels

In the focus group discussions, there was wide consensus that free primary school education does not contribute to community resilience against climate change and has not been useful in promoting biocultural innovations. School was widely reported to decrease community resilience to climate change, and only 5% of household interview participants credited local primary and secondary school with teaching climate related innovations or adaptations. Furthermore, the lack of attention played to local adaptation challenges in school was thought to decrease climate resilience within their communities. Duruma leaders stated that in their community, parents are generally responsible for passing knowledge on local history and biocultural innovations for sustainability to their children, and school takes significant time away from elder-child information exchanges. Rabai and Giriama key informants argued that the current education system remains heavily reliant on imported westernized lesson plans and disassociated from traditional knowledge based systems and environments throughout Kenya. Furthermore, overcrowded public schools in the three communities and additional teacher fees were reported to discourage student attendance and learning.

In *The Bad Economics of Free Primary Education*, Kimenyi (2013) argues that weakened client (student/parent) power following the introduction of Kenya's FPE program has led to drastic differences in learning outcomes between Kenya's public and private primary schools. Even though public teachers are generally more qualified and higher paid than their private school counterparts, lack of accountability, minimized community power over the quality of government education, and policymakers' loyalty to teachers unions is leading to the exploitation of taxpayers and their children's education. The inadequate learning environment that exists within overcrowded schools is evidenced in the growing number of private schools since the FPE programme introduction, and families willing to pay for them, despite a "free" alternative (Kimenyi 2013).

In addition to education, the availability and usefulness of technology in accessing information about agricultural adaptations and strengthening biocultural innovations was studied. Radio was by far the most useful in all three of the communities. About 74% of the interviewed Mijikenda households use the radio to access information beyond their community. In the Giriama community, local radio stations play an important role in enhancing biocultural innovations. Key informants reported that community members are often interested in getting information regarding farming practices that enhance agricultural

productivity. The most useful radio agricultural programs were stated to include information about field extension services, access to quality seeds and land preparation and traditional conservation tillage technologies. Other biocultural information sought from the radio was stated to include health information, entertainment from traditional songs and dances and programs on networking and information exchange. In addition, agribusiness, animal husbandry, and horticulture programs were found to be very valuable for community members.

Less significant for strengthening biocultural innovations and community resilience to climate change are cell phones (16%), television (13%), and internet (12%), according to the household questionnaires (Figure 4.7). The Rabai community had an overall higher use of communication technology in accessing biocultural innovation related knowledge, as compared to the Duruma and Giriama. This was especially true in the case of TV (33% of Rabai found it useful, as compared to 7% of Duruma and 2% of Giriama), cell phone use (43% as compared to 2% in Duruma and 4% in Giriama), and internet (22% as compared to 2% in Duruma and 12% in Giriama). The Duruma community had significantly low levels of access to communication technology for strengthening biocultural innovations. Age and gender disparities regarding technology access were revealed through the household questionnaire. It was found that boys are nearly two times more likely than girls to access internet in the Rabai community. This may be related to gender disparities regarding mobility (boys are more likely to access markets outside of the village as well as urban centers) and education. Elders had limited access to information technology as well. 11% of Rabai stated that elders in their household have access to internet, compared to 0% in Giriama and Duruma.

Cell phones have played an important role in enhancing biocultural innovations and resilience to climate change in the Mijikenda communities. Farming methods, weather forecasts, cultural events, markets, and other community events are shared over the phone. The use of chat applications remains limited, especially among the adult population. In the focus group discussions, leaders were unaware of websites that might be useful in biocultural innovation information sharing, or how to access such websites. Of the people who did find internet useful in accessing information about biocultural innovations, 92% of access internet exclusively from a cell phone. Weather forecasts, specifically predicted rainfall, was the most useful climate related information that community members reported searching on the internet. Information obtained from the internet is useful in predicting rainfall, according to 29% of Mijikenda.

This was highest in Giriama (60%), followed by Rabai (26%), but insignificant in Duruma. Only a few community members (4%) stated that the internet is useful in searching information about agriculture, including market prices and seed availability (though in Giriama it was higher at 10%), cultural events, and communication (thought higher in Rabai at 11%). 2% of Mijikenda stated that internet was useful in predicting market prices, and 1% found it useful for spreading information on seed exchange. The websites that were listed as most useful in accessing biocultural innovation information were accessed through communication apps. In order of importance they were stated to be Facebook, WhatsApp and Google. Programs like Facebook's Free Basics are helping to remove traditional barriers to online information and exchange.

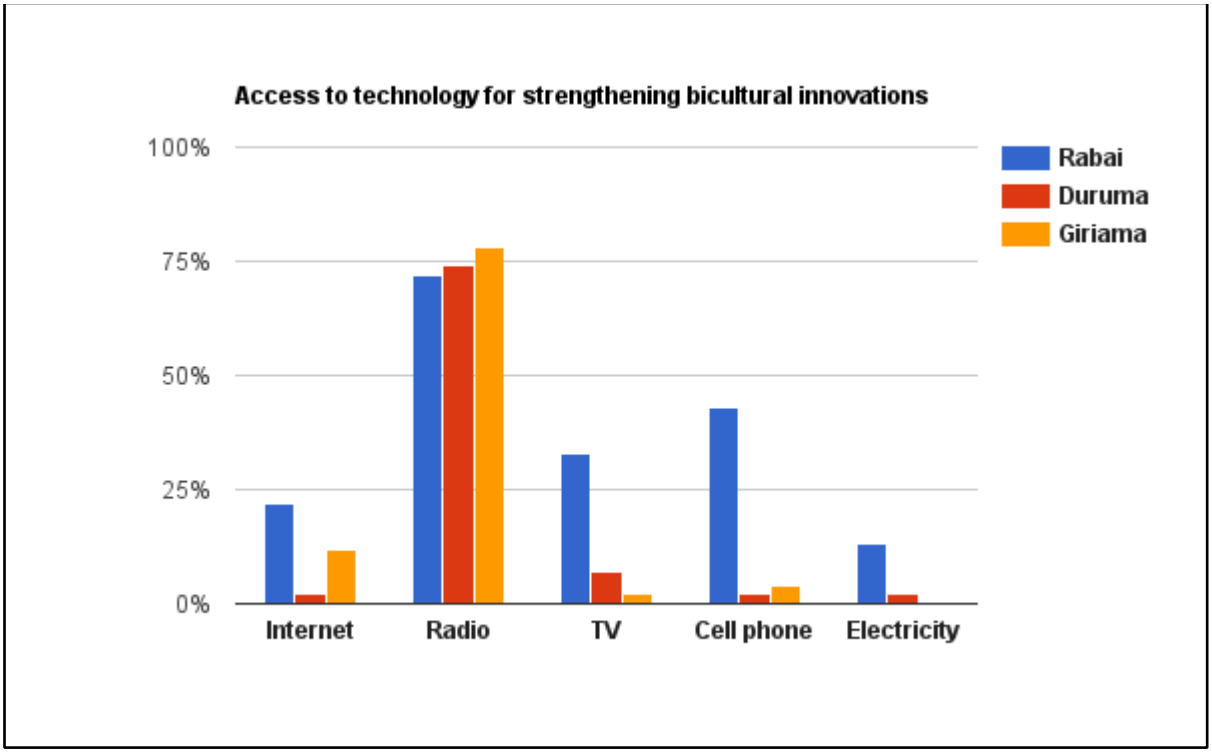


Figure 4.7: Access to technology for strengthening biocultural innovations

4.3.3 Other factors that influence innovation and adoption

It was found that Mijikenda with the highest levels of awareness of community based technological and social innovations have main household occupations that are related to high ecosystem awareness and or high levels of community interaction (in the case of farming, fishing, herbalist, livestock keeping, palm wine tapping, and charcoal burning) or regular trade and social interaction (in the case of casual labor, small businesses, and teaching).

Famine coupled with lack of information on weather forecasts was found to be the greatest hindrances to innovation development and expansion within the Mijikenda community. Economic and geographic isolation enhanced by insufficient access to technology and infrastructure were reported to depress significant progress towards enhanced food security and economic opportunities within the Mijikenda communities, although some key informants recognized that these adverse conditions have stimulated an awareness of innovation need in their communities. Other barriers that have hindered development and promotion of local innovations were identified by community members to include: general ignorance of where or how to access information about technological innovation development, lack of capital, reduced or unpredictable rainfall, lack of farm tools, labor intensiveness, inadequate land, lack of animals or access to manure, livestock invasions, increased cases of crop and animal pests and diseases, dependence on traditional farming methods, land ownership conflicts, inadequate arable land, poverty, animal diseases, impatience, lack of incentives and capacities, and modern education, and religious beliefs that conflict with traditional rituals and ceremonies (Figure 4.8).

Social challenges within the communities related to reduced social collectivity were found to discourage the development of biocultural innovations and process by which climate related information is shared. The prevalent reluctance to share information regarding practiced innovations beyond an individual's family, gender, neighbors, or groups levels, was found to hinder information exchange. Furthermore, socially reinforced concepts of success and jealousy, lack of information sharing platforms and tools, erosion of culture, infrequent and non-sustainable government and nongovernmental organizations handouts, urban migration, and lack of patent protection were reported to discourage biocultural information exchange. Rabai and Giriama leaders specifically singled out the westernised school systems as well as Christianity and Islam, as seriously hindering the development of biocultural innovations in

their community. While most traditional Mijikenda ceremonies have been lost or fused with western additions and/or religion, thus losing their "originality", religious teachings and related social pressure have generally discouraged community members from participating in the remaining traditional ceremonies. The alienation of individuals and families who participate in traditional ceremonies is not uncommon, nor is labeling their activities as "witchcraft". Failure to recognize the fear associated with witchcraft in the breakdown of Mijikenda culture would overlook one of the most powerful tools used to influence individual acts and associations in the community.

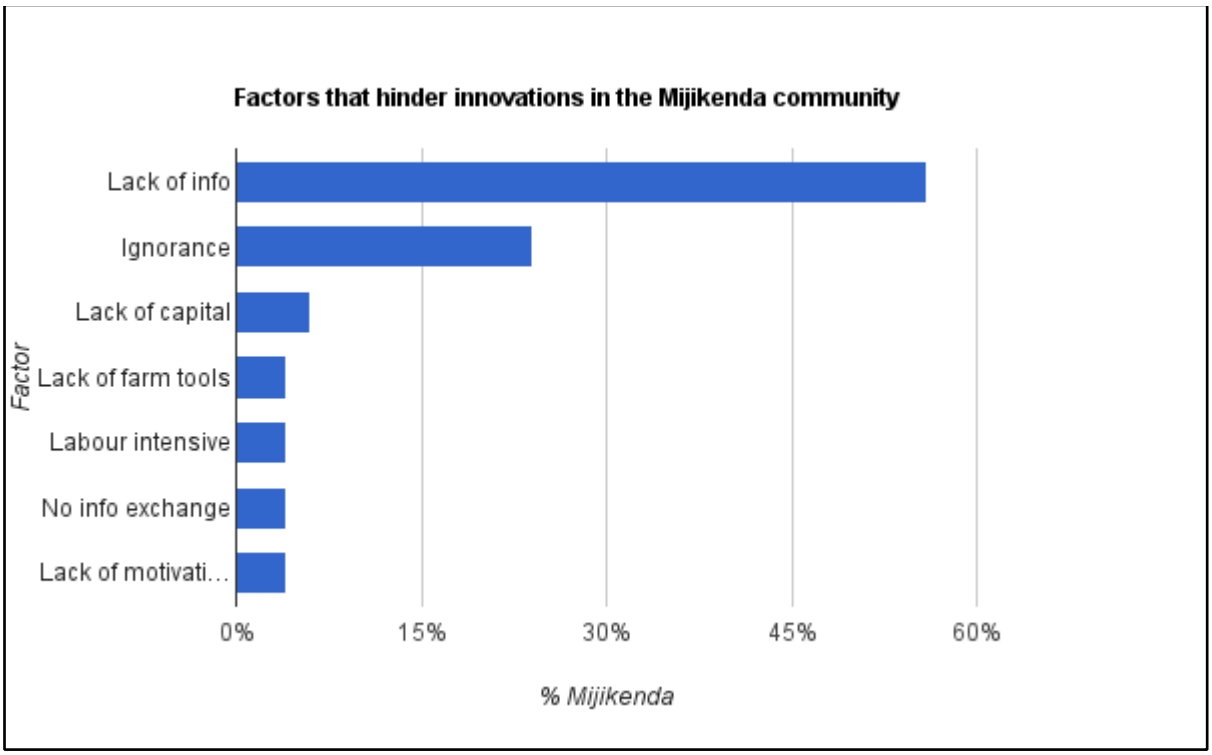


Figure 4.8: Factors that hinder local innovations in the Mijikenda community

Apart from individual creativity and the outside introduction of certain tools or methods, specific networking activities (such as farm field days, training sessions, and advertisements) that aim to encourage local innovations within the Duruma community do not exist. Beyond the family, information

about innovations is passed through observation, site-visits, and trial and error. Misunderstandings between community members decreases community support. As mentioned earlier, people judge an innovation more by the person who developed the innovation, and less on the innovation itself. Disappearance of plant species (mostly wild fruit trees) that previously supported food security (regularly or as improvisations in times of hunger) are increasing community dependence on fewer crops, and community members are no longer able to earn their living from activities that utilized these species for other economic activities including construction, furniture, and boat making. Thirty four tree species of this nature were identified as endangered by the key informants (See Appendix F).

4.4 Mijikenda opinions on how to strengthen biocultural innovations for climate change

Financial, technological, and infrastructural input, as well as cultural sensitisation and empowerment were widely regarded as necessary for promotion of community based innovations to improve resilience to climate change. Key informants stated that community members need more information about why biocultural heritage is important and how technology can enhance the spread of biocultural innovations to improve climate resilience within their communities. Sensitizing the community to the benefits of protecting endangered biocultural heritage would reduce the stigmatization associated with participation in such events. The research showed that community members are eager to develop the process of agricultural innovation development and diffusion throughout and beyond their communities. 36% of females stated that training sessions would help to promote innovations, as compared to 20% of males. This is likely because women are more typically excluded from such training sessions, and feel the consequences of not having equal access to information, purchasing power, and leadership roles.

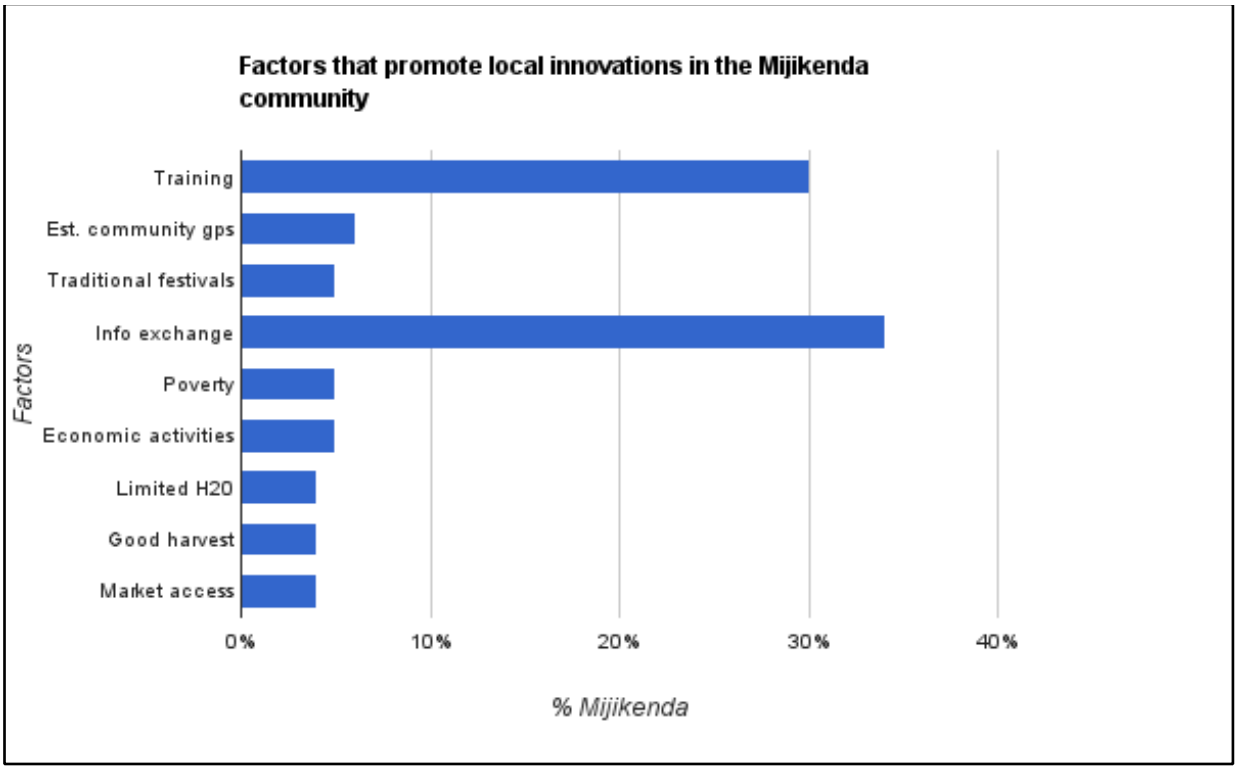


Figure 4.9: Factors that promote local innovations in the Mijikenda community

Participants were asked how to improve men, women, youth, and elder participation in strengthening local innovations. In addition to facilitated training sessions enhanced information sharing among groups, and incentivized innovation development, numerous inputs were specifically suggested for each of the groups. Regarding the improvement of women's participation in strengthening local innovations, enhanced women's rights, inclusion, and recognition were believed to be required steps towards sustainable innovation development and transfer among community members and generations. The following suggestions were made by key informants to improve women's participation: training of women, formation of women's groups, female empowerment that extends beyond innovation exchanges, awareness creation, local innovation competitions, facilitation of women's exchange visits, awarding system, system of innovation identification, encouraging women to teach their children about innovations. To improve men's participation in strengthening local innovations the following were suggested: formation of men's groups, training of men, awareness creation, competition, system of reward, and

sharing, facilitation of exchange visits between innovators beyond the village area, innovation information center, involving women in innovation information sharing. To improve the youth's participation in strengthening local innovations many people suggested training programs, such as formation of a youth center, parental involvement in biocultural information sharing, training youth to act as peer educators, awareness creation, training and participation, school training, community innovation center, sponsorship. Lastly elders guidance was stated to be underrated and increasingly devalued. It was suggested that to improve elders participation in strengthening local innovations, the following should be encouraged: more leadership and guidance of the youth, revival of cultural practices, designing a local law that protects innovations, continuous awareness creation, facilitating innovation promotions, market strategy development group, competitions (such as an innovation field day), rewards and incentives (Table 4.2).

Mijikenda opinions on strengthening biocultural innovations for climate resilience	Response (%)			
	Women	**Men**	**Youth**	**Elders**
Awareness creation	14	15	8	4
Training (workshops, school curriculum, exchange visits)	32	25	9	50
Cultural revival				17
Local laws that protect innovations				4
Participation	1		21	
Innovation marketing & production groups				3
Incentives/ rewards	1	2		3
Local innovation field day				1
Local innovation competitions	3	2		1
Community innovation center		<1	<1	

Women's empowerment	16	1		
Formation of youth centers			45	
Financial support			<1	
Formation of women's groups	21			
Formation of men's groups		27		

Table 4.2: Mijikenda opinions on strengthening biocultural innovations for climate resilience

Rabai key informants stated that increased access to electricity, running water and reliable transportation systems would strengthen biocultural innovations by enhancing information and exchange networks amongst members of the community and within the region. Access to electricity would allow the use of technology. Reliable transportation would enhance free movement of goods, services and people. Running water would facilitate improved crop irrigation for enhanced productivity for food security. Rabai key informants suggested that community groups be trained on entrepreneurship to initiate sustainable income generating activities and address the challenges of food security as this could strengthen biocultural innovations. The main external support sought by groups and individuals is financial support and as well as sensitization to the importance and application of biocultural innovations. The elders should involve the youth more in traditional ceremonies for them to understand the importance, relevance, and application of biocultural innovations.

Strengthening community innovations in the Duruma community will depend on numerous information sharing enhancements, sensitization activities, capital input, output infrastructure, and system of rewards. Women's empowerment was stated to be essential for the success of community participation in biocultural innovations, according to a room full of (male) community leaders. Women's participation in the development and sustainability of innovations were stated to depend on gender empowerment and education, awareness creation, and relief from overburdening by household chores and unequal division of household responsibilities. Recognition, praise and reward (such as a goat) systems were thought to potentially offer incentive for men to participate in innovation information development and sharing.

Training youth at schools and polytechnic colleges through specialized programs and extracurricular activities was suggested to create awareness about cultural history, sensitisation, elder roles, and local environmental awareness. Elder's participation in strengthening biocultural innovations was stated to be essential for direction, guidance, and cultural sustainability. Publicly recognizing their leadership role and facilitating cooperation between government partners and the community would help to protect the both the innovations and innovators. Duruma key informants stated that access to electricity, running water, and reliable transportation systems would help to expand the development and application of innovations by improving work-time efficiency, and relieving household members (especially women) of time consuming domestic duties, such as collecting water. The potential indirect benefits of improved services were stated to include an improvement in overall community health, market access, and accessibility of visitors.

In the Giriama focus group discussion session leaders discussed how reduced social collectivity is affecting information exchange and discouraging the development of biocultural innovations by increasing ignorance on the importance of biocultural innovations. Giriama key informants were of the opinion that access to electricity, running water and reliable transportation systems would not strengthen biocultural innovations in their community. They consider this infrastructure to be "modern" and in conflict with the enhancement of biocultural innovations, with the exception of a reliable transportation system which was said to potentially play an important role in transporting farm produce to the markets. This view may be encouraged by negative associations with modernity, i.e.education and religion, and loss of cultural value. Furthermore, low levels of education in the Giriama community coupled with much needed infrastructure have alienated the general population from the benefits of technology, thus distorting their perception of its usefulness in climate adaptation. In order to strengthen Giriama community innovations, it was suggested that the community should focus on promoting useful traditional farming methods and enhancing information exchange among small scale farmers. Financial and technical support to conduct more training sessions, sensitization to the importance of biocultural innovations, and incentivization of the innovation process in order to encourage design, implementation, and improvement were recommended. Key informants stated that parents need to play a more important role in teaching the youth about cultural innovations, and that the traditional storytelling sessions at home between elders and youth (which used to take place in the evenings around a fire) should be revived. Furthermore, Giriama leaders suggested that school clubs and afterschool groups add climate adaptation

debates and technology and innovation development to their programs, in addition to incorporating localized curriculums that address community climate challenges and adaptations within schools.

CHAPTER V
CONCLUSION

The most most-reported climate-related incidents challenging food security and economic opportunity in the studied Mijikenda communities included reduced rainfall, droughts, flooding, high incidences of crop and livestock diseases, and decreased soil fertility. Difficulty in accessing weather forecasts and adaptation innovation technology were found to be the greatest hindrances to innovation development. Widespread food insecurity and high levels of poverty were also found to be an encumbrance on the development of agricultural and social innovations in the communities. While social and technological biocultural innovations were recognized by community key informants as being useful in improving community adaptation to climate change, innovations are practiced by very few community members and are not well shared.

Mijikenda gender and age distinctions were found with regard to knowledge sharing and practices surrounding biocultural innovations. The research revealed gender discrimination in access to agriculture related information, markets, leadership positions, and decision making responsibilities. Overall, men had more biocultural innovation awareness and practices, as compared to women. Groups were widely acknowledged as being useful for creation of capital and information exchange, especially among women. Age was found to be positively correlated with innovation knowledge and participation; elders had the greatest innovation awareness in the communities. While a number of technological and social/institutional biocultural innovations exist in the Mijikenda communities, they are increasingly becoming rare because youth are not practicing them.

Many Mijikenda cultural ceremonies include youth but few specifically target them. Globalized worldviews and education models, lack of economic opportunities for young graduates who struggle to identify with the cultural practices of their elders, and the stigmatization of “traditional practices” due to Christianity and Islamic religious social pressure further hinders youth participation in developing and nurturing biocultural heritage innovations. Since the inception of Kenya’s Free Primary Education (FPE)

programme in 2003, the numbers of young people attending school have increased dramatically. Despite this, the education system is viewed skeptically among community members. In addition to overcrowded classrooms and mandatory fees, separation of youth and elders (traditional sources of information) and generalized lesson plans that disregard the dynamic and unique biocultural heritage and social needs of the community were stated by community leaders to contribute to the breakdown of the social structure of the Mijikenda communities and decrease resilience to climate change in the area.

This study demonstrated disintegrating cultural values and relationships related to changing environmental conditions. The socio-economic impacts of climate change are exacerbated by political opportunism and neglect, land-related conflicts (including unclear land titles), deforestation, degradation, urbanization, food insecurity, and erosion of culture. The struggle between culture and economic opportunity, fought within the coastal villages and urban centers and peripheries, is alienating youth from cultural practices that traditionally unified whole communities. Many of the key informants used the words “westernization” and “modernization” interchangeably, and often with a negative connotation. It would be empowering to recognize the historical context that has shaped cultural confusion between generations, and the fundamental social transformations that need to occur in order to empower young Kenyans to seize their own future, based on their own dynamic cultural, social, historical, political, and geographic realities and goals.

Innovation springboards were found to often be centered on cultural events involving cross-generational information exchange and participation. Availability of local landraces of crops, enhanced visibility, improved infrastructure, and access to financial capital help to develop and sustain biocultural innovations within the Mijikenda communities. Cultural activities that facilitate the intergenerational exchange of community values through music, dance, and drama were also found to contribute immensely to community climate resilience, food security, and empowerment. Despite the clear contribution of biocultural innovations to community preparedness for climate shocks, these innovations are hindered by species extinction, deforestation, lack of community participation, and stigmatization associated with participating in traditional ceremonies and rituals.

Mijikenda key informants suggested a number of strategies to improve climate resilience and food security in their communities. Establishment of climate adaptation innovation centers in the communities

could serve as a source of weather information, job training, loan and grant opportunities, workshops, improved access to information technology (including WiFi), innovation competitions, and expositions. These climate adaptation centers could bring together an interdisciplinary team of leaders, climate champions, farmers, business people, and students, and could cultivate the organization of groups or teams with complementary services and shared goals. As traditional systems of information exchange are threatened by rapidly changing societal and environmental conditions, information technology could be useful in promoting community cohesion and information exchange. Advances in internet access through programs like Facebook's Free Basics program in Kenya, which gives users with local cellular service free access to certain websites, are helping to bypass infrastructural barriers to information access. As these services expand, it will be easier for farmers to access information on the weather, market prices, and seed availability. In the meantime, taking advantage of the current most accessible form of information technology: radio, to promote climate adaptation information exchange will help farmers to access such information.

While the technology needed to assist small-scale farmers adapt to climate change exists and is improving every day, political, financial and infrastructural barriers to technology and information exchange are hindering its distribution. The development of climate change technological innovations should not reflect outdated aid development models, but rather encourage opportunities to create employment, diversify economies, strengthen environmental policies and incorporate climate resilience throughout other sectors. Though climate change is an increasingly common theme in development strategies, there is a need to refocus the methods and goals of such initiatives. Clear national climate policies are more important than ever. Governments should be held accountable for the design and implementation of climate policies that support and protect local innovations, and should not overlook the contribution of community innovation projects to national climate resilience.

Climate adaptation strategies should be specific to specific environments and livelihoods that exist in those environments. Adaptation should capitalize on existing biocultural innovations in indigenous communities, adding complementary technologies that improve local innovations for effectiveness in adaptation enhancement. This will empower communities, revive endangered but valuable traditions and specialized environmental knowledge, and include small scale farmers and their children in the development of global climate adaptation strategies. The long term gains of conserving the biocultural

heritage of indigenous communities who hold the keys to many varieties of edible food species, governance structures, and art practices should not be overlooked. Therefore, the creation of Mijikenda community centers, cultural villages, and UNESCO recognition of the Mijikenda Kaya forests as invaluable assets to national heritage are steps in the right direction.

REFERENCES

Amare, Tighisti (2014, July 11), "Africa's high youth unemployment: Is population to blame?", *The Guardian*, (Online).
Retrieved from: http://www.theguardian.com/global-development-professionals-network/2014/jul/11/africa-youth-unemployment-population-growth

Andersen, Stephen (2005), *Opportunities for Africa to integrate climate protection in economic development policy*, In P.S. Low (Ed.) *Climate Change and Africa*, Cambridge, Cambridge University Press.

Annan, Kofi & Dryden, Sam (2016, March 11), "Food and the Transformation of Africa", *Foreign Affairs*, (Online). Retrieved from: https://www.foreignaffairs.com/articles/africa/2015-10-16/food-and-transformation-africa

Awuor, Cynthia., Orindi, Victor., & Adwera, Andrew. (2008), "Climate change and coastal cities: The case of Mombasa, Kenya", *Environment and Urbanization*, 20(1), pp. 231-242.

Bagley, Katherine (2016, April 12), "For James Hansen, the Science Demands Activism on Climate", *Yale Environment*
360, (Online). Retrieved April 13, 2016, from:
http://e360.yale.edu/feature/james_hansen_science_demands_action/2981/

Bloomberg, Bloomberg New Energy Finance (2016, January 14), "Clean energy defies fossil fuel price crash to attract record $329 bn global investment in 2015", [Press release], *Bloomberg*, (Online).
Retrieved from: http://about.bnef.com/content/uploads/sites/4/2016/01/BNEF-2015-Annual-Investment-Numbers-FINAL.pdf

Brantley, Cynthia (1981), *The Giriama and Colonial Resistance in Kenya, 1800-192*0, Berkeley and Los Angeles, University of California Press.

Brown, Dwayne., Cabbage, Michael & McCarthy, Leslie (2016, January 20), "NASA, NOAA Analyses Reveal Record-Shattering Global Warm Temperatures in 2015", *NASA*, (Online). Retrieved March 16, 2016, from: http://www.nasa.gov/press-release/nasa-noaa-analyses-reveal-record-shattering-global-warm-temperatures-in-2015

Burke, Marshall., Miguel, Edward., Satyanath, Shanker., Dykema, John & Lobell, David (2009), "Warming increases the risk of civil war in Africa", *Proceedings of the National Academy of Sciences (PNAS)*, (Online), 106(49), pp.20670-20674.
Retrieved from:
http://emiguel.econ.berkeley.edu/assets/miguel_research/26/_Paper__Warming_Increases_the_Risk_of_Civil_Conflict_in_Africa.pdf

Carr, Edward & Thompson, Mary (2014), "Gender and Climate Change Adaptation in Agrarian Settings: Current Thinking, New Directions, and Research Frontiers", *Geography Compass,* (Online) *8*(3), 182-197.
Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/gec3.12121/epdf

Chikulo, Bornwell (2014), Gender, Climate Change and Energy in South Africa: A Review, *Gender & Behaviour*, 12(3), 5957-5970.

CIFOR (2015), "Adaptation of people to climate change in Eastern Africa: Forest and tree-based ecosystem services, risk reduction and human well-being (AdaptEA)", *Center for International Forestry Research (CIFOR)*, (Online). Retrieved March 26, 2016, from: http://www.cifor.org/library/5641/adaptation-of-people-to-climate-change-in-eastern-africa-forest-and-tree-based-ecosystem-services-risk-reduction-and-human-well-being-adaptea/

Dirix, Jo., Peeters, Wouter., Eyckmans, Johan., Jones, Peter Tom & Sterckx, Sigrid (2013),

"Strengthening bottom-up and top-down climate governance", *Climate Policy*, (Online), 13 (3), pp. 363-383. Retrieved from: http://dx.doi.org/10.1080/14693062.2013.752664

Dutfield, Graham (2014), "Towards a definition of biocultural heritage innovations in light of the mainstream innovation literature", *IIED*, London, (Online). Retrieved November 15, 2014 from: http://pubs.iied.org/pdfs/G03771.pdf

FAO (2014), "FAO Statistical Yearbook 2014: Africa food and agriculture", *FAO*. Retrieved March 25, 2016, from: http://www.fao.org/3/a-i3620e.pdf

Feola, Giuseppe & Nunes, Richard (2014), "Success and failure of grassroots innovations for addressing climate change: The case of the Transition Movement", *Global Environmental Change,* 24, pp.232–250.

Field, Christopher., Barros, Vicente., D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi,

Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken (2014), "Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change", *IPCC*, Cambridge University Press, New York. Retrieved from: http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-PartA_FINAL.pdf

Gebre Michael, Yohannes & Kifle, Mebratu (2009), "Local innovation in climate-change adaptation by Ethiopian pastoralists", PROLINNOVA–Ethiopia and Pastoralist Forum Ethiopia (PFE), Addis Ababa

Gore, Al (2016), "The case for optimism on climate change", *TED*, (Online Video). Retrieved March 16, 2016, from: https://www.ted.com/talks

Hallegatte, Stephane., Bangalore, Mook., Bonzanigo, Laura., Fay, Marianne., Kane, Tamaro., Narloch, Ulf., Rozenberg, Julie., Treguer, David & Vogt-Schilb, Adrien (2016) "Shock Waves Managing the Impacts of Climate Change on Poverty", *The World Bank*.
Retrieved from: https://openknowledge.worldbank.org/bitstream/handle/10986/22787/9781464806735.pdf

Hansen, James., Sato, Makiko., Hearty, Paul., Ruedy, Reto., Kelley, Maxwell., Masson-Delmotte, Valerie., . . . Lo, Kwok-Wai. (2016), "Ice melt, sea level rise and superstorms: Evidence from paleoclimate data, climate modeling, and modern observations that 2 °C global warming could be dangerous", *Atmospheric Chemistry and Physics Atmos. Chem. Phys.,16*(6), pp. 3761-3812.

IEA (2014), *Africa Energy Outlook: A focus on energy prospects in Sub-Saharan Africa*, (Online), pp.1-4, Paris: International Energy Agency. Retrieved from: http://www.iea.org/publications/freepublications/publication/AEO_ES_English.pdf

ILO (2016), "World Employment Social Outlook Trends 2016", *International Labour Organization,* (Online), pp.1-89. Retrieved from: http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_443480.pdf

IPCC (2014), "Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change", [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)], *IPCC*, Cambridge University Press, Cambridge, United Kingdom and New York, pp. 1-32.
Retrieved from: http://ipcc-wg2.gov/AR5/images/uploads/WG2AR5_SPM_FINAL.pdf

Ireland, P., & McKinnon, K. (2013), "Strategic localism for an uncertain world: A postdevelopment approach to climate change adaptation", *Geoforum, 47*, pp. 158-166.

J. R. A. Butler, R. M. Wise, T. D. Skewes, E. L. Bohensky, N. Peterson,

W. Suadnya, Y. Yanuartati, T. Handayani, P. Habibi, K. Puspadi, N. Bou, D. Vaghelo & W. Rochester (2015) "Integrating Top-Down and Bottom-Up Adaptation Planning to Build Adaptive Capacity: A Structured Learning Approach", *Coastal Management*, (Online), 43 (4), pp.346-364. Retrieved from: http://www.tandfonline.com/doi/pdf/10.1080/08920753.2015.1046802

Jury, Mark (2013), "Climate trends in southern Africa", *South Africa Journal of Science*, 109 (1-2), pp. 1-11. Retrieved from: http://dx.doi.org/10.1590/sajs.2013/980

Justice, Christopher., Wilkie, David., Putz, Francis & Brunner, Jake (2006), *Climate Change in sub-Saharan Africa: Assumptions, realities, and future investments*, In P.S. Low (Ed.) *Climate Change and Africa*, Cambridge: Cambridge University Press.

KEFRI (2013). *Kenya Forestry Research Institute Strategic Plan 2013-2018,* Nairobi, Kenya Forestry Research Institute.

Kenya Population Data Sheet 2011 (2011), *Population Reference Bureau (PRB),* (Online), pp. 1-8. Retrieved from: http://www.prb.org/pdf11/kenya-population-data-sheet-2011.pdf

Kimenyi, Mwangi (2013, September 07), "The Bad Economics of Free Primary Education", *Brookings*, (Online). Retrieved January 02, 2016 from: http://www.brookings.edu/research/opinions/2013/09/07-kenya-economics-primary-education-kimenyi

Laddey, R., Kumamoto, M., & Treichel, P., (2011), "Africa Adaptation Program Experiences Gender and Climate Change: Advancing Development Through an Integrated Gender Perspective", *UNDP Discussion Paper Series*, 1.

Levine, Simon., Ludi, Eva., & Jones, Lindsay (2011), "Rethinking Support for Adaptive Capacity to Climate Change: The Role of Development Interventions", *Overseas Development Institute (ODI)*. Retrieved from: http://community.eldis.org/.5a35bbfb/ACCRA%20Rethinking%20Support%20Report%20Final.pdf

Manyika, James., Cabral, Armando., Moodley, Lohini., Moraje, Suraj., Yeboah-Amankwah, Safroadu., Chui, Michael & Anthonyrajah, Jerry (2013), "Lions go digital: The Internet's transformative potential in Africa", (Rep.), *McKinsey & Company*, (Online). Retrieved from: http://www.mckinsey.com/industries/high-tech/our-insights/lions-go-digital-the-internets-transformative-potential-in-africa

Matin, Nilufar., Islam, Mohammad., Mbuvi, Musingo., Odit, Bernard., Ongugo, Paul & Syed, Mohammad (2014), "Group Inequality and Environmental Sustainability: Insights from Bangladesh and Kenyan Forest Commons", *Sustainability,* (Online), *6*(3), pp.1462-1488. doi:10.3390/su6031462 Retrieved from: http://www.mdpi.com/2071-1050/6/3/1462

Mutta, Doris., Swiderska, Krystyna., Song, Yiching., Li, Jingsong & Reid, Hannah (2011), Adapting agriculture with traditional knowledge. *The International Institute for Environment and Development (IIED),* (Online), pp. 1-4. Retrieved from: http://reliefweb.int/sites/reliefweb.int/files/resources/17111IIED.pdf

NASA (n.d.), "Global Climate Change", (Online). Retrieved March 11, 2016, from: http://climate.nasa.gov/

Niang, Isabelle., Ruppel, Oliver., Abdrabo, Mohamed., Essel, Ama., Lennard, Christopher., Padgham, Jonathan & Urquhart, Penny (2014), Africa. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1199-1265.

Retrieved from: http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap22_FINAL.pdf
OECD/IEA (2014), "The way forward: Five key actions to achieve a low-carbon energy sector", *OECD/ IEA International Energy Agency*, France, (Online).
Retrieved from: http://www.iea.org/publications/freepublications/publication/The_Way_forward.pdf
Okonjo-Iweala, Ngozi., & Wilcox, Richard (2014, September 26), "Africa to Issue $1 Billion in Climate Bonds", *Huffington Post*, (Online). Retrieved April 19, 2016, from: http://www.huffingtonpost.com/ngozi-okonjoiweala/africa-to-issue-1-billion_b_5890638.html
Ongugo, P., Wekesa, C., Ndalilo, L., Amur, A & S. Mwalewa (2015), "Smallholder Innovation for Resilience: Strengthening Innovation Systems for Food Security in the Face of Climate Change", *IIED*, pp.1-79.
Ongugo, Paul., Wekesa, Chemuku., Ongugo, R., Abdallah, A., Akinyi, Leila & Pakia, M. (2014), "Smallholder Innovation for Resilience (SIFOR) Qualitative Baseline Study, Mijikenda Community, Kenyan Coast", *IIED*, (Online), pp.1-36. Retrieved from: http://pubs.iied.org/pdfs/G03830.pdf?
Orlove, Ben., Lazrus, Heather., Hovelsrud, Grete & Giannini Alessandra (2014), "Recognitions and Responsibilities;
On the Origins and Consequences of the Uneven Attention to Climate Change around the World", *Current Anthropology*, (Online), 55(3), pp. 249-275.
Retrieved from: http://www.wcaanet.org/downloads/dejalu/feb2016/Current%20Anthropology.pdf
Parenti, Christian (2011), *Tropic of chaos: Climate change and the new geography of violence*. New York: Nation Books.
Randall, Tom (2016), "Solar and Wind Just Did the Unthinkable: Cheap oil and gas couldn't stop another record year for renewables, or a turning point for energy investment", *Bloomberg Business*, (Online). Retrieved March 17, 2016, from: http://www.bloomberg.com/news/articles/2016-01-14/solar-and-wind-just-did-the-unthinkable
Reid, Hanna., Alam, Mozaharul., Berger, Rachel., Cannon, Terry & Angela Milligan (2009), "Community-based adaptation to climate change", *Participatory Learning and Action, IIED,* (Online). Retrieved March 17, 2016, from: http://pubs.iied.org/pdfs/14573IIED.pdf
Rowlands, Ian (2006). *Regional Approaches to global climate change policy in Sub-Saharan Africa* (Ed.) In P.S. Low (Ed.) *Climate Change and Africa*. Cambridge: Cambridge University Press.
Sachs, Wolfgang (2010), *The Development Dictionary: A Guide to Knowledge as Power*. London: Zed Books.
Schaeffer, Michiel., Baarsch, Florent., Adams, Sophie., De Bruin, Kelly., De Marez, Laetitia., Freitas, Sandra., Hof, Andries & Hare, Bill (2013), *Africa's Adaptation Gap, Technical Report: Climate-change impacts, adaptation challenges and costs for Africa* (pp. 1-44, Rep.). Nairobi, UNEP, (Online).Retrieved from: http://climateanalytics.org/publications/2013/africas-adaptation-gap-climate-change-impacts-adaptation-challenges-and-costs-for-africa.html
Schipper, Lisa (2009), "Climate Change Adaptation and Development: Exploring the Linkages", (Working Paper No. 107), Tyndall Centre for Climate Change Research, (Online).
Retrieved from: http://www.tyndall.ac.uk/sites/default/files/wp107.pdf
Schmidhuber, Josef & Tubiello, Francesco (2007), "Global food security under climate change", *Proceedings of the National Academy of Sciences U.S.A. (PNAS),* 104(50), pp.19703-19708
Retrieved from: http://ieham.org/html/docs/Global_food_security_under_climate_change.pdf
Sultana, F. (2013), "Gendering Climate Change: Geographical Insights", *The Professional Geographer, 66*(3), pp. 372-381.
Syroka, Joanna & Wilcox, Richard (2014), "The Extreme Climate Facility (XCF) – A Multi-Year

Financial Vehicle to Secure Direct Access to Climate Adaptation Funds for Africa". *Global Risk Forum Davos Planet@Risk, 3*(1), pp.146-153.

The Global Risks Report 2016 (11th ed., Rep.). (2016). Geneva: World Economic Forum. http://wef.ch/risks2016

Tompkins, Emma & Adger, W. Neil (2004), "Does adaptive management of natural resources enhance resilience to climate change?" *Ecology and Society,* (Online), *9*(2),10, pp. 1-10. Retrieved from http://www.ecologyandsociety.org/vol9/iss2/art10/

UNEP (2015, March 4), *Costs of Climate Change Adaptation Expected to Rise Far Beyond Africa's Coping Capacity*

Even if Warming Kept Below 2°C [Press release], UNEP, (Online). Retrieved April 19, 2016, from: http://www.unep.org/newscentre/Default.aspx?DocumentID=26788&ArticleID=34788

UN Habitat (2008), "African cities at risk due to sea-level rise [Map]", In *United Nations Human Settlements Programme - Headquarters (UN-Habitat)*, Nairobi, UN-Habitat.

Vieira, Ines (2011), "Environmental migrants from Africa to Europe: State of the art and research clues", 7.º Congresso Ibérico De Estudos Africanos, Lisbon, *CEA*, (Online), pp.1-20. Retrieved from: http://hdl.handle.net/10071/2263

Wekesa, Chemuku., Ndalilo, Leila., Ongugo, Paul., Leley. N., & Swiderska, K (2015), "Traditional knowledge based

innovations for adaptation and resilience to climate change: the case of coastal Kenya", *XIV World Forestry Congress, (Durban, 7-11 September 2015)*, pp. 1-9.

World Bank (2010), "World development report Development and Climate Change", *The World Bank*, Retrieved from: http://siteresources.worldbank.org/INTWDR2010/Resources/5287678-1226014527953/WDR10-Full-Text.pdf

World Economic Forum (2016), "The Global Risks Report 2016, 11th Edition", *WEF*, pp. 1-97. Retrieved from: http://www3.weforum.org/docs/GRR/WEF_GRR16.pdf

ATTACHMENTS

Appendix A - Household questionnaire

Section A: Administrative **Qs. No……..**

Interviewer Name…….. **Date……..**

Interview duration: Start…….end…….

Section B: General Geographic Information

Sub-County…….... **Division……** **Location…….**

Sub-Location……... Community…… **Village ……**

GPS: Longitude ……... Alt……

Section C: General characteristics of the respondent

i. **Name……..**
ii. **Ethnicity……...**
iii. Resident Status (tick √): Permanent ( ), Immigrant ( ), Visitor ( ), Neighboring locality ( )
iv. **Duration of time you lived in the area……..**
v. Age of respondent (please tick √) in years

Younger than 15 **16-25** **26-35** **36-45** **46-55** **56-65** **Older than 65**

i. Gender of respondent (tick √): Male ( ), Female ( )

ii. Household size…….. No. of adults…….Household head (tick √): Male ( ), Female ( )

iii. **Household head occupation: Main…….**

iv. **Other household head occupations in order of importance: …… ……..…… ……**

v. Marital status (tick √): Single ( ), Married ( ), Widow ( ), Widower ( ), Divorced ( )

vi. Education status (tick √):

No formal education **Primary** **Secondary** **Tertiary** **Graduate** **Post-graduate**

Section D: Community Based Innovations

i. Which of the following technological innovations have been developed or adopted in your

community? (tick √)

i. Re-introduction of traditional farming methods ( )
i. Planting large areas of resilient crop varieties ( )
ii. Combination of herbal plants to treat livestock diseases ( )
iii. Domestication of wild plants ( )
iv. Planting diversified varieties of the same crop on the same piece of land in one season ( )
v. Preservation of land races in communal seed banks ( )
vi. Value addition of traditional crops and products ( )

ii. Which of the following social/institutional innovations have been developed or adopted in your community? (tick √)

vii. Free seed exchange ( )
viii. Formation of communal farming and marketing groups ( )
ix. Formation of cultural centers ( )
x. Revival/preservation of customary laws and practices ( )
xi. Preservation of community registers ( )
xii. Free primary school education ( )

Section E: Gender participation in Innovations

i. How is information about innovations shared?
Innovation____
Who taught you about the innovation?
Is it a man or a woman? (M/F)
How long have you been practicing this innovation?
Have you shared information about this innovation with others? (Yes/ No)
Who have you shared the information with?
How many males have you shared the information with? (#)
How many females have you shared the information with? (#)
Where do men obtain information about the innovation?
Where do women obtain information about the innovation?

What role did women play in promoting the innovation?
(Leader/ advocate/ trainer/ peer educator/ group member/ group official/ school teacher)

What role do men play in promoting the innovation?
(Leader/ advocate/ trainer/ peer educator/ group member/ group official/ school teacher)

Section F: Gender roles in sustaining Biocultural Innovations *(Personal opinions)*

i. Who develops biocultural innovations in your community? (tick √): Men ( ), women ( ), youth ( ) Others (specify)……..

ii. How many innovations have been developed by men in your community?.....
iii. How many innovations have been developed by women in your community?.....
iv. How many innovations have been developed by youth in your community?……
v. How many innovations have been developed by Kaya elders in your community?……
vi. Do your children know about local innovations? (tick √): Yes ( ), No ( )
vii. If yes, which innovations do they know? List them
……...
……
……
……
……
viii. What is the percentage number of boys and girls in your family that know about the innovations?

Boys
Girls

ix. How did they learn about these innovations? (tick √): School ( ), peers ( ), elders ( ), cultural festivals ( ), others, specify……
x. If learned in school, at which school level did they learn about the innovations? (tick √): Nursery ( ), primary ( ), Secondary ( ).....
xi. How often do they apply this knowledge to their farming practices? Often ( ), occasionally ( ), rarely ( )
xii. How often do they apply this knowledge to their networking practices? Often ( ), occasionally ( ), rarely ( )
xiii. How often do they apply this knowledge to their cultural practices? Often ( ), occasionally ( ), rarely ( )
xiv. Are there specific rituals and festivals that target youth? Yes ( ), No ( )
xv. If yes, which ones? List them
……
……
……
……
xvi. Do your children attend ritual events/ ceremonies? Yes ( ), No ( )
xvii. Which ones do they attend?
.....
……
……
……...
xviii. Which ceremonies/ events are attended by boys?
……
……
……

……

xix. Which ceremonies/ events are attended by girls?

……

……

……

……

xx. Which ceremonies/ events are attended by both?

……

……

……

……

Section G: Factors promoting/hindering biocultural innovations

xxi. Which practices/factors promote local innovations in your community?

……

……

……

……

……..

xxii. What practices/factors hinder local innovations in your community?

……

……

……

……

……

xxiii. In your opinion, how can innovations in your community be strengthened?

……

……

……

……

xxiv. What can be done to improve women's participation in strengthening local innovations?

……

……

……

……

……

xxv. What can be done to improve men's participation in strengthening local innovations?

……

……

……
……
……

xxvi. How can youth be better involved in sustaining biocultural innovations?

……
……
……
……
……..

xxvii. How can elders be better involved in sustaining biocultural innovations?

……
……
……
……
……

xxviii. Which of the following have been useful to your household in strengthening biocultural innovations? (tick √): Internet ( ), radio ( ), TV ( ), cell phone ( ), electricity ( )

xxix. If the internet is useful, how do you access the internet? (tick √): Phone ( ), computer ( )

xxx. If the internet is useful, how has it been useful? (tick √): Predicting market prices ( ), predicting rainfall ( ), seed exchange ( ), cultural events ( ), agricultural related research ( ), other

……
……
……
……

xxxi. If the internet is useful, which websites are most useful in strengthening biocultural innovations?

……...
……
……
……

xxxii. If the internet is useful, which household members have found it useful? (tick √): Woman ( ), man ( ), boy ( ), girl ( ), elder ( )

Table A.1: Household questionnaire

Appendix B - Reported participation in biocultural innovations

Reported participation in biocultural innovations	Response (#)			
	Rabai	**Giriama**	**Duruma**	**Total**
Digging gabions in a swampy area in order to conserve water for plant's consumption	1			1
Free seed exchange	2			2
Cultural centre	2		1	3
Use of herbal treatment	2	18	1	21
Microfinance	10			10
Use of organic manure	7	2	2	11
Early tilling of land before the rains	2	2	1	5
Fish farming			2	2
Tree nursery	1	1		2
Planting of coconut		1		1
Intercropping		5	1	6
Traditional birth attendant		2	2	4
Planting in zaypits		1	7	8
Fresh milk to treat chicken diseases		5		5
Women's groups (silk)	6			6
Wild plant domestication		3	1	4
Wild bird keeping on a tree to predict farm season conditions		2	1	3
Oxen plough	1		5	6
Utilising local rocks for building materials			1	1
Goats and poultry upgrading			2	2

Indigenous poultry hatching using maize husks			1	1
Tree planting			2	2
Maintaining/ planting indigenous vegetable seeds			1	1
Local seed preservation through hanging			1	1

Table B.1: Reported participation in biocultural innovations

Appendix C: Photo documentation of Mijikenda biocultural innovations for climate change

Figure C.1: Rabai Kaya Elders Council

Photographed under the tree where they hold a weekly community court to resolve community issues. Photographed with KEFRI research scientist, Leila Akinyi (center)

Figure C.2: Rabai Cultural Village

Community members demonstrating a traditional dance at the Rabai Cultural Village

Figure C.3: Duruma Grain Storage Structure

Husband and wife in front of their grain storage structure. The man in an herbalist and their homestead contains numerous domesticated medicinal tree species, in addition to other biocultural innovations including: oxen-plough innovations, aerating seed storage techniques (maize hung in trees), landrace maize crops, and a *Zay pit*.

Figure C.4: Duruma oxen-plough for seed planting

Family tilling land with their oxen-plough next to their landrace maize stalks

Figure C.5: Birds used as a weather indicator on a Duruma farmer's homestead

Figure C.6: Duruma homestead with birds as weather indicator

Husband and wife in front the tree (filled of doves) that they use to predict seasonal weather patterns.

Figure C.7: Duruma seed preservation technique

Duruma woman with maize aerating in tree to enhance seed preservation

Figure C.8: Duruma Kaya elder discussing the cultural significance of tree species existing in the Kaya forests

Appendix D - Significant sources of household income

Significant sources of household income	% Mijikenda
Small business	39%
Farming	79%
Security officer	2%
Commercial driver	3%
Mechanic	1%
Casual labour	23%
Palm wine tapping	9%
Teacher	4%
Fishing	9%
Herbalist	4%
Charcoal burning	7%
Livestock keeping	17%
Weaving	1%
Police officer	1%
Contractor	1%
Community labor	1%
Tourism	1%
Restaurant	1%
Making construction materials / sales	2%
Carpenter	1%

Oxen ploughing	1%
Driver	1%

Table D.1: Significant sources of household income

Appendix E- Duruma community demographics

Duruma	
Area (km2)	4,011.7
Population: Male Female Total	 99,369 110,191 209,560
Village Demographics: *Mwalukombe A* Households Population *Fulugani* Households Population *Tsunza Mikanjuni A* Households Population *Karyaka B* Households Human population	 84 577 334 1447 144 874 65 792

Table E.1: Duruma community demographics

Source: Kinango District Development Office

Appendix F - Endangered plant species that previously supported food and economic security in Duruma

Plant	**Latin**
Chungu misizi	
Coconut	*Cocos nucifera*
Mbambakofi	*Afzelia quanzensis*
Mbukwale	
Mdzaje	
Mfadu	
Mfuolu	*Euclea natalensis*
Mgama	
Mgama mto	
Mgandi	
Miembe (kienyeji)	
Mikoma (wild palm trees)	
Mkalakala	*Bridelia cathertica*
Mkipa	
Mkuha	*Dobera loranthifolia*
Mkulu	*Barchemia discolor*
Mkwakwa	*Strychnos madagascarensis*
Mnago	

Mnyenze	
Mphingo	*Dalbergia melanoxylon*
Mtanga	*Spirotachys venenifera*
Mtanga mto	
Mtansi	
Mtengezi (soap plant)	
Mtundu kula	*Ximenia americana*
Mufune	*Sterculia appendiculata*
Muhonga	
Mukanazi	*Ziziphus mauritiana*
Muphala mwake	
Muriro	
Mviru	*angueria madagascaresnsis*
Mvule (African teak)	*Milicia excelsa*
Mwanga	*Taminadia spinosis*
Mwatsa acassia	

Table F.1: Endangered plant species that previously supported food and economic security in Duruma

Appendix G - Ceremonial plants of Duruma

Ceremony	Plant	Latin	Description	Endangered (X)
Matanga	*Reza*		Cleansing plant	
Matanga	*Muyu*	*Adansonia digitata*	Baobab	
Matanga	*Chitwadzi*		Short shrub tree	
Matanga	*Mgoza*			
Matanga	*Genda wa lufu*			
Matanga	*Munyumbu*	*Lannea schweinfurthianum*		
Matanga	*Mkone*	*Grewia plagiophylla*		
Matanga	*Phozo*			
Makayamba	*Mshinota maji*			
Makayamba	*Mranze*	*Euginia spp*	Endangered due to herbal use/ demand	X
Makayamba	*Mphorogiondo*		Currently endangered due to herbal use/ demand	X
Makayamba	*Toro*		Always in swamp	
Makayamba	*Turituri*	*Abrus precatorius*	Use seeds	
Makayamba	*Msaro*		Currently endangered due to herbal use/ demand; use seeds	X
Makayamba	*Mvumo*		Currently endangered in one out of the three represented Duruma villages	X

Makayamba	*Mrindazia*			
Makayamba	*Mdzala*	*Uvaria lucida*		
Makayamba	*Mkangaga*			
Makayamba	*Mduga*			
Makayamba	*Mkorosho*	*Anarcadium occidentale*	Cashew nut	
Makayamba	*Mwembe*	*Mangifera indica*	Mango	
Kulomba mvula/ Kupiga ndunda	*Mkunga mvula*			
Kulomba mvula/ Kupiga ndunda	*Msuko*			
Kulomba mvula/ Kupiga ndunda	*Mware*	*Bombax rhodonaphalon*		
Kulomba mvula/ Kupiga ndunda	*Karumbani*			
Kulomba mvula/ Kupiga ndunda	*Vumba manga*	*Occimum lamiifolium*		
Kulomba mvula/ Kupiga ndunda	*Mwamfunza*			

Table G.1: Ceremonial plants of Duruma

Appendix H - Giriama plants of cultural importance used to treat animal, plant, and human diseases

Plant	Latin	Description/ use
Mbanje		Burnt ash to enhance sense of smell
Mnyangakitswa		Burnt ash to enhance sense of smell
Mkuro		Burnt ash to enhance sense of smell
Mjaji		Pounded roots mixed with mboho roots to treat snake bite wounds
Mboho		Pounded roots mixed with mjaji roots to treat snake bite wounds
Neem	*Azadirachta indica*	Tree soup used to spray crops against pests and diseases
Mtupa		Soup used to treat jiggers in humans and crop pests and diseases
Mbirandu		Bark mixed with water to ease constipation in livestock (cows, goats and sheep)
Aloe	*Aloe vera*	Soup to treat diarrhoea, worms and constipation in livestock
Mtsatsa		Used to treat pregnancy related complications in humans
Pepper		Pounded with donkey manure and fed to poultry as a vaccine against poultry diseases
Jatropha	*Jatropha curcus*	Leaves mixed with water to prevent pests on plants

Table H.1: Giriama plants of cultural importance used to treat animal, plant, and human diseases

Appendix I - Rabai plants of cultural importance

Plant	**Latin**	**Description/ use**
Cowpeas	*Vigna unguiculata*	Cowpeas and green grams (mung beans) are feasted on during most Rabai traditional ceremonies
Green grams (mung beans)	*Vigna radiata*	Cowpeas and green grams (mung beans) are feasted on during most Rabai traditional ceremonies
Castor oil	*Ricinus communis*	Castor oil (no longer present in the community), *Mranze*, and *Vifuvu* plants were used to decorate and perform rituals on the bride and groom during traditional Rabai weddings
Mranze		Castor oil (no longer present in the community), *Mranze*, and *Vifuvu* plants were used to decorate and perform rituals on the bride and groom during traditional Rabai weddings
Vifuvu		Castor oil (no longer present in the community), *Mranze*, and *Vifuvu* plants were used to decorate and perform rituals on the bride and groom during traditional Rabai weddings
Maize	*Zea mays*	Eaten during rainmaking ceremonies and other events
Sorghum	*Sorghum sp.*	Eaten during rainmaking ceremonies and other events
Rice	*Oryza sp.*	Eaten during rainmaking ceremonies and other events
Millet		Eaten during rainmaking ceremonies and other events
Finger millet	*Eleusine coracana*	Eaten during rainmaking ceremonies and other events

Table I.1: Rabai plants of cultural importance

Appendix J - African cities at risk due to sea-level rise

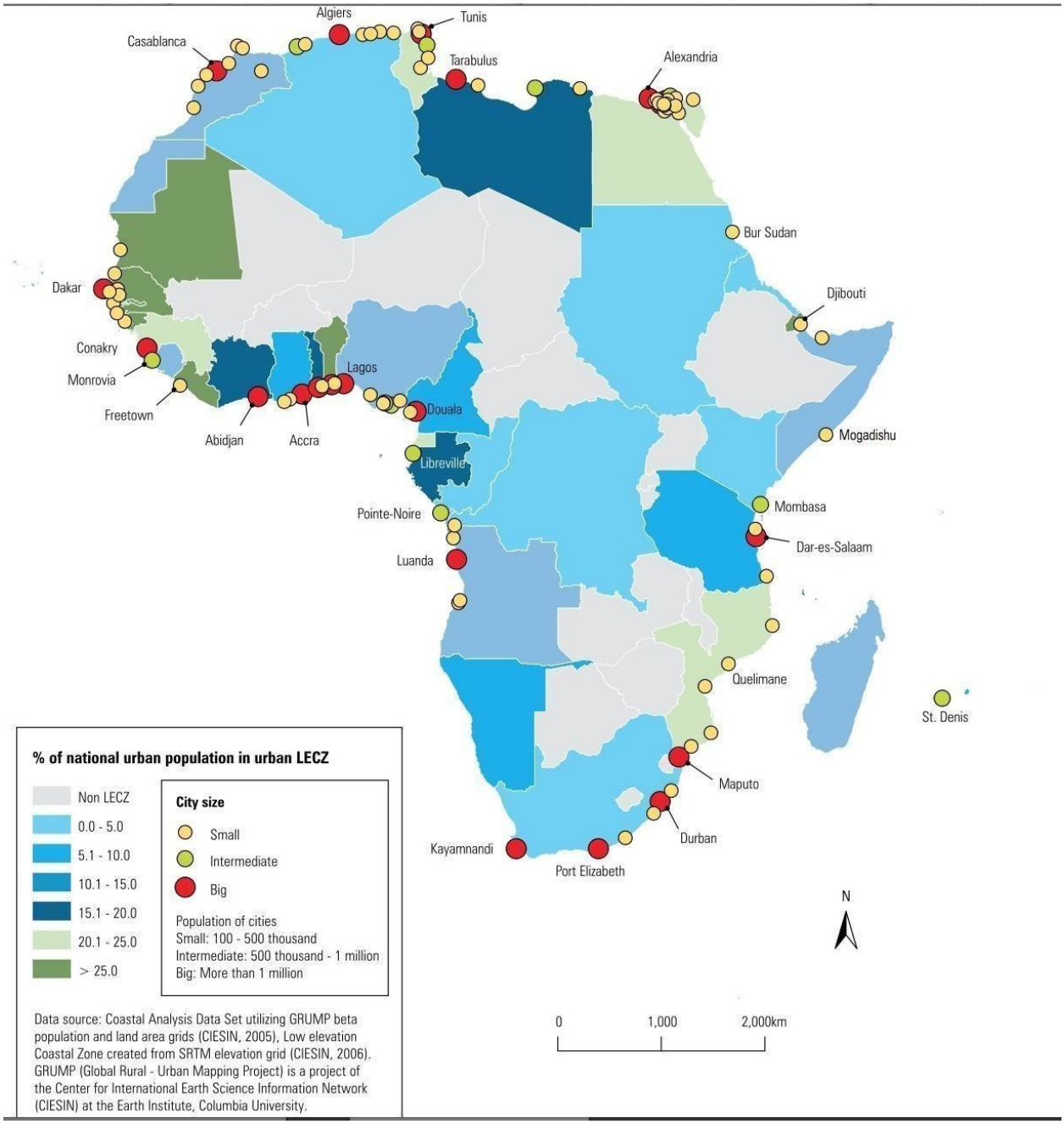


Figure J.1: African cities at risk due to sea-level rise

Source: UN-HABITAT Global Urban Observatory 2008