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Farmers' agency and experiences of agricultural change in rural Kenya: Insights from exploratory fieldwork

Joanes Atela, Charles Tonui and Dominic Glover

Making Change

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Using novel agricultural technologies to boost farm productivity in the face of climatic and demographic disruption remains a priority for African policy and research. This paper uses an innovative, participatory and ethnographic methodology to explore, through farmers' experiences, the historical pathways of social, ecological and technical (socio-eco-technical) change that have reshaped agriculture, livelihoods and rural landscapes in three sites in Kenya (Machakos, Siaya and Kisumu Counties) over recent decades. The paper identifies events and processes that triggered major changes in farming systems at household and community levels. Insights from engagements with farmers reflect an evolution in the strategic direction of agricultural development in Kenya from a more 'bureaucratic' mode during the colonial and immediate post-independence periods to a more 'technocratic' mode today. In the bureaucratic mode, the state was at the centre and aspired to align all farming practices and technologies with the priorities and programmes determined by the national government. In the contemporary period of technocratic development, agricultural programmes and interventions have been designed by scientific experts and implemented by technical agencies through the institutional form of short-term projects and programmes. In both the bureaucratic and technocratic systems, the agency of local farmers has remained weak and constrained. Both systems of management established formal development processes and power structures that largely side-lined meaningful contributions by ordinary farmers to technological change processes. We argue that the agency and capacities of farmers and rural communities, to make choices and respond to opportunities arising from or introduced into their local situations, should be recognised as an important engine of socio-eco-technical transformations towards a sustainable future for African agriculture. We therefore propose that this exploratory study helps to build a platform for further research both conceptually and methodologically, with the potential to inform the design and implementation of future agricultural development interventions.

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Acronyms

ACIAR	Australian Centre for International Agricultural Research
ASDS	Agricultural Sector Development Strategy (2010—2020)
CBO	Community-Based Organisation
CCAFS	Research Programme on Climate Change, Agriculture and Food Security (a research programme of the CGIAR)
CGIAR	Consultative Group on International Agricultural Research (a global network of 18 international agricultural research centres including CIMMYT, ICRAF and ILRI, and convenor of the CCAFS programme, Washington DC, USA)
CIMMYT	International Centre for Maize and Wheat Improvement (*Centro Internacional de Mejoramiento de Maíz y Trigo*) (an international agricultural research centre and a member of the CGIAR network, México DF, Mexico)
CIP	International Potato Centre (*Centro Internacional de la Papa*) (an international agricultural research centre and a member of the CGIAR network, Lima, Peru)
COMESA	Common Market for Eastern and Southern Africa
CSA	Climate-Smart Agriculture
FOKODEP	Friends of Katuk Odeyo Environmental Programme
GEF	Global Environment Facility (a financial mechanism for environmental programmes, supported by United Nations agencies, multilateral and bilateral development donors, and international NGOs, Washington DC, USA)
GoK	Government of Kenya
ICDP	Integrated Conservation and Development Programme
ICRAF	International Centre for Research in Agroforestry (also known as the World Agroforestry Centre. An international agricultural research centre and member of the CGIAR network, Nairobi, Kenya)
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics (an international agricultural research centre and a member of the CGIAR network, Hyderabad, India)
ILRI	International Livestock Research Institute (an international agricultural research centre and a member of the CGIAR network, Nairobi, Kenya and Addis Ababa, Ethiopia)
IMF	International Monetary Fund
KANU	Kenya African National Union

KARI	[former] Kenya Agricultural Research Institute, now reconstituted as KALRO
KALRO	Kenya Agricultural and Livestock Research Organisation (formerly KARI)
KEPHIS	Kenya Plant Health Inspectorate Service
KICOMI	Kisumu Cotton Millers
LVEMP	Lake Victoria Environmental Management Programme
NACODEP	North Agoro Community Development Programme
NALEP	National Agriculture and Livestock Extension Programme
NECODEP	Northeast Community Development Programme
NGO	Non-Governmental Organisation
OFSP	Orange-Fleshed Sweet Potato
Sida	Swedish International Development Agency
UCRC	Ugunja Community Resource Centre
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

Abstract

Using novel agricultural technologies to boost farm productivity in the face of climatic and demographic disruption remains a priority for African policy and research. This paper uses an innovative, participatory and ethnographic methodology to explore, through farmers' experiences, the historical pathways of social, ecological and technical (socio-eco-technical) change that have reshaped agriculture, livelihoods and rural landscapes in three sites in Kenya (Machakos, Siaya and Kisumu Counties) over recent decades. The paper identifies events and processes that triggered major changes in farming systems at household and community levels. Insights from engagements with farmers reflect an evolution in the strategic direction of agricultural development in Kenya from a more 'bureaucratic' mode during the colonial and immediate post-independence periods to a more 'technocratic' mode today. In the bureaucratic mode, the state was at the centre and aspired to align all farming practices and technologies with the priorities and programmes determined by the national government. In the contemporary period of technocratic development, agricultural programmes and interventions have been designed by scientific experts and implemented by technical agencies through the institutional form of short-term projects and programmes. In both the bureaucratic and technocratic systems, the agency of local farmers has remained weak and constrained. Both systems of management established formal development processes and power structures that largely sidelined meaningful contributions by ordinary farmers to technological change processes. We argue that the agency and capacities of farmers and rural communities, to make choices and respond to opportunities arising from or introduced into their local situations, should be recognised as an important engine of socio-eco-technical transformations towards a sustainable future for African agriculture. We therefore propose that this exploratory study helps to build a platform for further research both conceptually and methodologically, with the potential to inform the design and implementation of future agricultural development interventions.

Key words: Kenya, agriculture, technology, agency, development, participation

1. Introduction

A well-established perception of the Green Revolution is that the agricultural transformation that occurred in swathes of Asia and Central and South America did not reach, did not establish itself in, or failed in, the African continent. The widely accepted master narrative is that sub-Saharan Africa experienced a few scattered and isolated cases of agricultural intensification and increases in crop productivity, but these were not sustained (Haggblade 2005; Holmén 2005). Short-lived bursts of productivity growth were achieved for some crops in certain places, but progress often stalled or was reversed by Structural Adjustment-inspired policy reforms and a lack of sustained investment in agricultural research and plant breeding (Evenson and Gollin 2003; Holmén 2005; Oluoch-Kosura and Karugia 2005).

To the extent Africa experienced a Green Revolution at all it was largely a story of maize grown on commercial farms, notably in Kenya, Zimbabwe and Malawi. Unlike classic African food security crops (such as millet, cowpeas, sorghum and cassava) maize, which was formerly a rather minor African food crop, became a signature crop of the Green Revolution in Africa (as wheat and rice did in Asia), which benefited from early investments in scientific research and breeding (Byerlee *et al*. 1994; Byerlee and Eicher 1997; McCann 2001; Evenson and Gollin 2003). By the 1990s maize had become a vital food security crop for many small-scale growers, especially in Eastern and Southern Africa, but production levels were low. More attention had been given to maize breeding and seed distribution than to improving resource management, increasing labour productivity, reducing post-harvest losses, and other concerns, including policy frameworks (Byerlee *et al*. 1994). Small-scale maize farmers remained in need of agricultural intensification strategies (because they are confined to small plots of land), yet compared to the commercial growers their needs had been largely overlooked or neglected (Holmén 2005; Oluoch-Kosura and Karugia 2005).

Many of the problems facing small-scale cultivators in sub-Saharan Africa in former decades persist up to the present day, and improving agricultural productivity continues to be recognised as a key target for development and poverty reduction (Dercon and Gollin 2014). Asia's experience of agricultural transformation has continued to be invoked as a relevant source of lessons for African policy makers and development agencies to apply (Djurfeldt *et al*. 2005). During the past decade and a half, several significant initiatives have attempted to translate the Asian experience to the African context, and kick-start a new and 'uniquely African' Green Revolution (Toenniessen *et al*. 2008; Blaustein 2008). These include the Comprehensive Africa Agriculture Development Programme (CAADP) under the umbrella of the African Union's (AU) New Partnership for Africa's Development (NEPAD), which was launched in 2002, and which included a commitment by African governments to allocate 10 per cent of national budgets to agricultural development; the Abuja Declaration on Fertiliser in 2006, which set a target to increase fertiliser use by African farmers; the launch of the Alliance for a Green Revolution in Africa (AGRA), also in 2006, which engages public, private and philanthropic organisations in African agricultural development programmes; and the Malabo Declaration of 2014, which refocused the CAADP towards a new goal of ending hunger in Africa by 2025.

In historical narratives about the Green Revolution, and in the founding documents and declarations of forward-looking initiatives that aspire to create a new Green Revolution for Africa, there is a common tendency to position 'technologies' – such as improved crop varieties, hybrid seeds, irrigation systems and chemical fertilisers – as drivers of technological and socio-economic change. In fact, a recent discourse analysis found that histories of the Green Revolution in East Africa typically attribute agency to almost any 'prime mover' besides the farmers themselves. The power of driving change is usually ascribed to governments, aid donors, scientific organisations, markets, 'technologies' and soils,

and encompassing both human and nonhuman entities, but very rarely are ordinary farmers and farm workers credited for the technological transformations that have shaped agriculture in the region over the past half century (Arora 2017). We believe that this type of techno-centric perspective overlooks the importance of farmers' agency in determining whether novel agricultural techniques and inputs, which are introduced from outside, will be accepted and adopted. This makes it hard to diagnose why agricultural development interventions succeed or fail. In this paper, we take a different approach. First, instead of adopting a macro-scale perspective on the Green Revolution as if it were a singular and top-down historical process, we explore how agricultural development interventions and processes of technological change were experienced from the bottom up, by farmers in rural parts of Kenya. Second, rather than seeing technology itself is an agent of change, we try to understand how farmers and their communities responded, as the principal actors in their own lives and development processes, to interventions that were brought to them by government programmes, development projects and agricultural extension services. We try to understand the historical processes of agricultural transformation in Africa through the experiences of people at the grassroots, recognising them as agents and decision-makers in their own right.

To frame our approach, we found it useful to conceptualise unfolding processes of agrarian technological change as pathways which were shaped and influenced by interacting social, material, political and discursive factors. The particular pathways of technological change that emerged and evolved for particular families or households in particular locations would have been shaped historically and could have unfolded differently. This 'pathways approach' recognises that many different pathways or trajectories are theoretically possible, but that the speed, direction and destinations of real historical pathways of technological change are shaped by actors, their interests and their power relations in processes that are inherently political and ideological. These processes determine how social, ecological and technical (socio-eco-technical) change occurs, closing down and excluding some potential directions of societal transformation, and helping to institutionalise and 'lock in' a small number of dominant pathways (Keeley and Scoones 2003; Leach *et al*. 2010).

The paper is organised as follows. In the next Section, we offer some information on the historical background and contemporary context of current efforts to stimulate a Green Revolution in Kenya. In Section 3 we describe the methodological approach for our exploratory study and in Section 4 we provide some contextual socio-economic and ecological background information on the three sites where we carried out our research – Machakos, Nyando and Ugunja. In Sections 5 and 6 we present and discuss the insights from our exploratory fieldwork, focusing on farmers' experiences of historical pathways of technological change. We then describe and discuss the agency of farmers in the technological process before providing concluding insights and discussions on the lessons that might be learned for the future and consider some policy options for the new GR initiatives in Africa.

2. Agricultural Development and Green Revolution in Kenya: a Brief Historical Review

Agriculture is often identified as 'the backbone of Kenya's economy', an engine of development and the key to national food security and the fight against hunger (e.g. GoK 2010b: xiii). During the colonial period, agriculture in Kenya was dominated by white settlers, who engaged in large-scale production of cash crops, such as coffee, horticultural products and livestock including dairy animals, within the settlement schemes. Indigenous workers provided labour to these large farms and ranches. Most subsistence farmers engaged in small scale, rain-fed cultivation of maize and beans under low- or zero-input traditional systems of farming and shifting cultivation. Kenya achieved independence from Britain in 1963. During the 1970s and 80s, the post-colonial Government of Kenya pursued agricultural development and land management policies that embraced shifting cultivation, shamba farming systems, and *fanya juu* terraces,[1] which were intended to conserve and regenerate natural resources such as soil and water. During this period, farm cooperatives were launched in Kenya, driven mainly by white settlers who established various agro-industries and who used farmer cooperatives to supply labour and raw materials. Public investments were made in national agricultural research capacity, with the establishment of the Kenya Agricultural Research Institute (KARI) in 1979. Unfortunately, by the late 1980s the national Government faced numerous financial and administrative challenges. The state struggled to provide adequate extension services and the national agricultural sector was failing to keep up with advancements in farming technology. After 1988, Kenya agreed to adopt Structural Adjustment reforms imposed by the International Monetary Fund (IMF). Agricultural extension services were reorganised as public-private partnerships and a market-oriented agricultural development strategy was adopted, which prioritised the deployment of modern farm inputs including improved crop varieties (GoK 1994; GoK, 1996).

Structural Adjustment has been blamed for undermining national economic growth, reducing living standards, damaging social security and increasing socio-economic inequality (Rono 2002). During this period rapid population growth and a series of climate-related shocks destabilised national agriculture policies. In the 1980s and 1990s Kenya experienced rates of population growth ranging between 3.2 per cent and 3.9 per cent, considerably higher than the global average annual rate of 3.1 per cent (World Bank 2015). In the late 1980s and in 1992, Kenya experienced some of the first serious droughts and food shortages the country has faced, which stimulated new efforts to confront looming hunger.

Subsequent development plans, such as the Economic Recovery Strategy (GoK 2003), continued to target a market-oriented technological transformation in agriculture, as that sector was called upon not only to sustain but to revive the national economy. A succession of national agricultural development strategies, including the Strategy for Revitalising Agriculture (2004—2014) (GoK 2004), have aimed to transform traditional agricultural systems progressively, such as shifting cultivation, into more input-intensive and capitalistic styles of modern agriculture. In 2010, Kenya's new constitution (GoK 2010b) recognised agriculture as a key pillar of the country's economy and food security. The new constitutional order also created county governments capable of enacting policy for agriculture and other sectors at subnational level. Since that time efforts have been made to support governance reforms for the agriculture sector and adopt enabling policies that align with emerging technological opportunities. Land reforms enacted in 2016 (the Land Laws (Amendment) Act and the Community Land Act) have encouraged a transition from traditional patterns of collective land

[1] *Fanya juu* is the Swahili name for a type of agricultural terracing that follows the contours of hillside slopes. *Fanya juu* terraces are created by digging ditches and throwing the spoil up-slope, to form a bund. Over a period of time, the processes of erosion and the redistribution of soil behind the bunds creates level terraces that are used for cultivation.

ownership to a system of private land tenure, signified by the subdivision of land and issuance of formal title deeds.

Current agricultural policy in Kenya is driven by the Agricultural Sector Development Strategy (ASDS), which covers the period 2010–2020 (GoK 2010b). The ASDS was developed with the support of the Swedish International Development Agency (Sida) and adopted the overall goal to 'transform Kenya's agricultural sector into an innovative, commercially oriented, competitive and modern industry that will contribute to poverty reduction, improved food security and equity in rural and urban Kenya' (GoK 2010b: vi). The ASDS embodies one of the key steps taken by Kenya to translate the discourse of an African Green Revolution into national practice (AGRA 2015). Alongside regional policies and frameworks such as the CAADP and the Malabo Declaration, Kenya's agriculture policy has also been influenced by the emergence and strengthening of market standards developed at regional and global levels, such as the ones within the COMESA[2] region.

Growing awareness of climate change and concerns about food security have also helped to drive the pursuit of a Green Revolution in Kenya. Kenya has been obliged to call for food aid on several occasions in the past two decades (GoK 2013). The ASDS aims to make agriculture a key pillar of Kenya's economy and its approach to hunger alleviation. The Strategy includes input subsidies for food and cash crops, support for the provision of fertilizer, promotion of market linkages, agro-industrialisation and sustainable land management (GoK 2010b). Other key steps include the reform of KARI into a new Kenya Agriculture and Livestock Research Organisation (KALRO)[3] and the establishment of new institutions such as the Kenya Plant Health Inspection Service (KEPHIS), National Cereal Boards and the National Fertilizer Board.

Over many years, the agriculture sector in Kenya has also been shaped by a wide variety of donor-funded development programmes and projects, many of them implemented by or in partnership with international agencies, research institutions and non-governmental organisations (NGOs). Some major international agricultural development organisations have headquarters or regional offices located in Kenya and carry out programmes in the country, including the World Agroforestry Centre (ICRAF),[4] the International Livestock Research Institute (ILRI), the United Nations Environment Programme, the International Centre for Maize and Wheat Improvement (CIMMYT),[5] and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). ICRAF, ILRI, CIMMYT and ICRISAT are all members of the global network of research institutes belonging to the Consultative Group on International Agricultural Research (CGIAR). Prominent international NGOs that have implemented development projects and programmes in Kenya include World Neighbours and CARE International.

Under KARI and its successor KALRO, a number of specialised research centres were established with mandates to conduct research into specific crops, livestock and marketing issues, with a strong emphasis on technology development and support for bio-enterprises. One example is the KALRO-Katumani Research Station in Machakos, whose mandate is to carry out maize breeding for semi-arid areas. The Katumani Research Station has worked with various donor-funded projects, including the Dryland Farming Research and Development Project and the Kenya Sorghum and Millet Development

[2] The Common Market for Eastern and Southern Africa.

[3] KALRO was established in 2013 and combines the former Kenya Agriculture Research Institute (KARI) with a number of other agricultural and commodity-focused research institutes.

[4] The International Centre for Research in Agroforestry, an international agricultural research centre with its headquarters in Nairobi, Kenya.

[5] CIMMYT is the Spanish acronym, which stands for *Centro Internacional de Mejoramiento de Maíz y Trigo*.

Project, which were funded by the United Nations Development Programme (UNDP) and the Food and Agriculture Organisation of the UN (FAO) in 1979; the Dryland Cropping Systems Research Project, which was funded by the United States Agency for International Development (USAID); and the Improvement of Dryland Crop and Forage Production in Semi-Arid Regions of Kenya Project, which was financed by the Australian Centre for International Agricultural Research (ACIAR) in 1984.

In the late 1990s ICRAF and the Government of Kenya collaborated with NGOs on a programme of capacity building and technology deployment relating to water and soil management, which was accompanied by the introduction of new crop and seed varieties. Farmers were encouraged to practise intercropping with shrubs such as calliandra. In 1997 Kenya joined with Tanzania and Uganda in the Lake Victoria Environmental Management Programme (LVEMP), a five-year programme that was supported by the Global Environment Facility (GEF)[6] and designed to restore the lake's ecosystem to a healthy state. The LVEMP included work to promote soil conservation and agroforestry in areas bordering on the lake. Farmers were encouraged to integrate conservation activities and crop and livestock farming to minimise soil erosion and improve productivity. Other programmes have aimed to strengthen and improve the quality of agricultural extension services. From 2000 to 2005, the Kenyan Government's National Agriculture and Livestock Programme (NALEP) used funds provided by Sida to reform and improve agricultural extension services for farmers and pastoralists.

A notable agriculture development programme that is currently active in Kenya is the CGIAR's Research Programme on Climate Change, Agriculture and Food Security (CCAFS). Since 2010 agriculture policy in Kenya has focused increasingly on building climate resilience through concepts such as 'climate-smart agriculture' (CSA) and programmes targeting agricultural water-use efficiency (e.g. drip irrigation), agricultural energy efficiency, soil and ecosystem health, integrated pest management, biotechnologies, conservation agriculture, agroforestry, greenhouse farming, the use of organic sources of fertiliser and various mobile technology applications. Since 2011 the World Bank has supported the Kenyan Government to establish a comprehensive CSA programme valued at USD$250 million. Alongside these climate-focused initiatives a strong market orientation continues to drive agricultural policy in Kenya.

The methods and institutions of agricultural extension have changed significantly over the years. An important trend is the emergence of community-based organisations (CBOs), such as farmer groups and cooperatives, and grassroots movements, which foster networks of support and information-sharing among farmers and which sometimes advocate for certain directions of technological change. Today it is common for development agencies and programmes to seek to work with and through these farmer organisations and CBOs, using approaches such as Community-Based Natural Resource Management and Integrated Conservation and Development Programmes (ICDPs). The ubiquity of this approach represents a substantial shift compared to colonial and post-colonial times, when agricultural and rural development interventions were typically introduced to farmers by central government in a top-down manner, through provincial and local administrative institutions and especially *barazas*, a type of community meeting convened by local Chiefs. *Barazas*were established by Kenya's colonial government as a decentralised local administrative forum where local governance issues could be discussed and new development initiatives from the government would be announced (Fleming 1966). Organisational and administrative reforms were implemented in Kenya in conjunction with the adoption of a new national constitution in 2010. These changes had implications for the organisation and delivery of agricultural support at local levels. The devolution of power to county

[6] The GEF is a financial mechanism for environmental programmes that was established in 1991, initially supported jointly by the World Bank, UNDP and UNEP.

governments is claimed to have improved the distribution of input subsidies and improved seeds (Ugunja Strategic Development Plan 2013).

This concise historical overview provides a limited insight into the agricultural development processes and transitions that have taken place in Kenya since the country became independent in 1963. In this study, we tried to unpack how these changes were experienced and evaluated by the farmers and rural communities whose lives and livelihoods were affected and shaped by them.

3. Methodology

Our aim in this exploratory study was to document historical pathways of socio-eco-technical change through the perceptions and perspectives of households and communities that had experienced these processes. In three rural counties of Kenya (Machakos, Siaya and Kisumu) we investigated community-members' own experiences of socio-eco-technical changes that have affected their livelihoods and economic fortunes over recent decades. We used an innovative, participatory and ethnographic methodology that was designed to elicit the perspectives of rural households and communities. Our goal was to try to understand at a more granular level how agrarian socio-eco-technical transitions unfolded in locally specific ways in three different places. Table 3.1 provides some key information about the data collection methods used in each site. The fieldwork was carried out during the period January–March 2017.

Table 3.1: Notes on Data Collection in the Three Study Sites

	Ugunja ward, Siaya County	**Kanyamlori/Cherwa village, Nyando Sub-county, Kisumu County**	**Kiima/Kimwe village, Machakos County**
Transect walk	Transect walk followed a route through small farms in the outskirts of Ugunja town, ending at the Ugunja Community Resource Centre (UCRC). Accompanied by Mr. Charles Ogada of Ugunja Community Resource Centre.	Transect walk began at the Kanyamlori shopping centre and proceeded towards Cherwa and along the Asao river, where most agricultural activities are concentrated. Accompanied by Mr. Wilson Okila and Mr. Joshua Amollo, Northeast Community Development Programme (NECODEP).	Transect took place in the outskirts of Machakos town ending at the KALRO-Katumani research station. Accompanied by Dr. Kwenzia Kizito of KALRO-Katumani Centre.
Focus Group Workshop	20 farmers (12 women, 8 men) RoL method	6 farmers (2 women, 4 men) RoL method	14 farmers (5 women, 9 men) Conventional FGD format
In-depth Interviews	Six key informants including: • 3 farming group leaders • 1 representative of the One Acre Fund initiative • 2 representatives of agricultural CBOs >10 informal chats with different farmers	Two key informants including: • 1 farming group leader • 1 representative of Vi-Agroforestry • 1 extension officer at the ministry of agriculture • 2 representatives of agricultural CBOs >6 informal chats with different farmers	Six key informants including: • 3 farming group leader • 1 extension officer at the ministry of agriculture-KALRO • 2 representatives of agricultural CBOs >5 informal chats with different farmers

In each site, our study began with a transect walk accompanied by key informants. The transect walk gave the research team a first impression of the local community including its livelihoods, farming systems, physical assets, natural resources, and important features of the biophysical landscape including built infrastructure. The key informants were chosen by the researchers, in consultation with local development workers with whom our field team has collaborated since 2009. The participants were chosen based on the depth of their local knowledge and typically included a person with deep roots in the local area, such as a community elder or an experienced farmer. During the transect walk, discussions with the key informants shed light on the historical interventions that had been made in the area, and identified some important local actors, such as farmers' cooperatives. Observations made during the transect walk were recorded in written notes and photographs.

Information gathered through the transect walk was used to inform the design of focus group discussion workshops in each of the three study sites (Figure 3.1). We selected participants, representing a range of different age cohorts, with the majority in the age range 35—55 years old, and including some very experienced and elderly farmers (particularly in the Machakos workshop). This enabled us to ensure that we included individuals who could share a depth of knowledge and experience about their experiences of historical social, ecological and technical change in each location.

Figure 3.1: Dr Joanes Atela Facilitating a Focus Group Discussion and Rivers of Life Session held at the Ugunja Community Resource Centre (UCRC)

Photo taken by Charles Tonui.

During some of the workshops, we used an adapted version of an exercise called Rivers of Life (RoL).[7] The RoL method was devised originally as an 'icebreaker' exercise, to enable workshop participants to get to know each other quickly. In this original format, each participant sketches the story of his or her own life in the guise of a river, and uses the resulting image to introduce themselves quickly to the other participants. This exercise allows each person to depict the historical path he or she has followed to arrive at the present moment, including the twists, turns, and discontinuities of the journey (Moussa 2009). We adapted this exercise for use as a participatory data-generating method in a group setting, and used it to explore our workshop participants' individual and collective experiences of socio-eco-technical change in agriculture.

When telling their personal rivers-of-life stories, we asked the participants to highlight critical periods or moments of technical change relating to farming, which had affected themselves, their families or

[7] Material in this section uses text that was written for a short summary published in the methods section of the STEPS Centre website, available at https://steps-centre.org/pathways-methods-vignettes/methods-vignettes-rivers-life/ (1 May 2017).

households, and their communities. Comments, questions and discussion were encouraged. The facilitator and note takers paid particular attention to key events, turning points, shocks and stresses that affected individuals and their households, as well as common events that featured in the life histories of more than one member of the community.

By including participants from different sections of the community, we were able to explore diverse perspectives on, and different experiences of, events that had affected the whole community, as well as sub-groups such as different genders, age cohorts or wealth brackets. Our aim was to learn not only about the events themselves but also their impacts or consequences, as experienced by the narrators, such as the opening up or closing down of livelihood opportunities, and positive or negative impacts on indicators such as income, wealth, health or wellbeing.

The insights generated during the transect walk, the individual RoL stories and the workshop discussions allowed our team to build a picture of the social, ecological and technical histories of the three communities, and the technological changes currently occurring in local agricultural livelihoods. In particular, we used the RoL method as a tool to explore community-members' own perceptions of having possessed, or having lacked, the capacity to influence the direction of socio-eco-technical change, or to be able to choose among alternative technical options and livelihood strategies, in response to wider socio-eco-technical change processes that had shaped or influenced their differential developmental pathways.

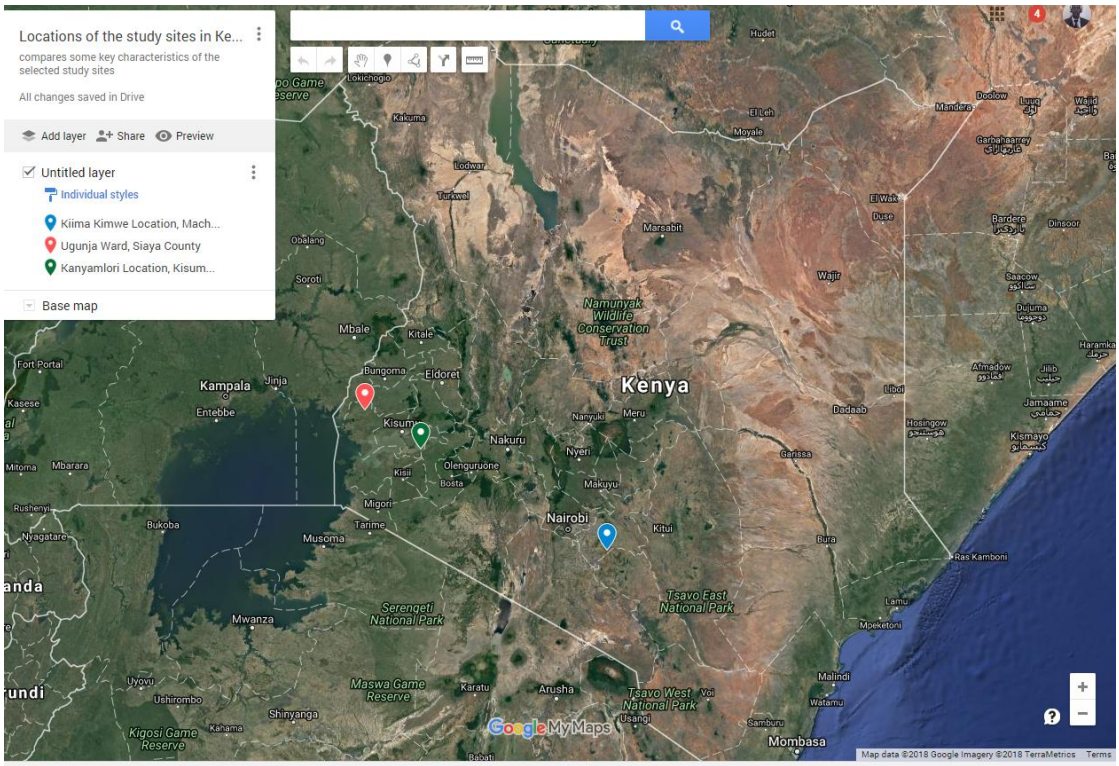
For the RoL approach to be effective it is important to involve a mixture of people from the community concerned, who are selected to reflect the breadth of different perspectives and interests that are thought likely to be useful for understanding the topic of interest. This implies that researchers need to know something about the issues and the community beforehand, and which explains why we carried out the transect walks before convening the RoL workshops in each site. Information gleaned during the transects provided valuable context to the subsequent workshops, equipping the field research team to pose questions about the history of pieces of infrastructure (such as irrigation canals), changes in cropping patterns, patterns of land use, market relations, and so on.

We combined the transect walks and focus group discussions or RoL workshops with short key informant interviews that were designed to probe the views and experiences of selected individuals in a little more depth. We used this combination of methods as an economical and convenient alternative to formal Life Histories interviews, which are an established technique for exploring individual life experiences, but which typically require one or more in-depth, unstructured or semi-structured interviews with individual research subjects or key informants. Such interviews are time-consuming for both parties, and it can also be difficult for the analyst to understand and interpret personal stories, whose significance and implications may be obscure at first sight. Participatory, discursive methods such as transect walks and RoL workshops, supplemented by short interviews, enabled us to explore community-members' own understandings and framings of the life events they had experienced.

4. The Socio-eco-technological Context of the Study Sites

We carried out exploratory studies in three rural sub-counties of Kenya: Machakos, Nyando and Ugunja (Figure 4.1). These sites were selected to represent different sociological contexts and ecological settings, including the types of semi-arid and semi-humid locations where the majority of Kenyan agriculture takes place. About 80 per cent of Kenya's territory is classified as semi-arid while the remaining 20 per cent is semi-humid or humid. Agriculture is a dominant livelihood activity in all three areas, and land is typically held by families, although there are ongoing efforts to regularise individual land ownership through land surveys and formal titling. The three sites are also known to have been targeted by agricultural development interventions, therefore we expected them to offer insights into the unfolding history of agrarian technological transitions as well as prospects for a new Green Revolution in Kenya and other parts of East Africa. Our research team is also familiar with the three sites, having worked in these localities in the past, and therefore we were able to engage with existing networks of partners and collaborators in the three areas.

Figure 4.1: Locations of the Study Sites



Source: Google MyMaps

Table 4.1 compares some key characteristics of the selected study sites. Across the three sites as a group, the majority of farmers are small-scale cultivators practising subsistence agriculture of crops and livestock in rain-fed farming systems. Farm sizes are typically small (averaging less than 1–2 ha.) and face diminishing productivity. The sites face low and erratic rainfall, high levels of poverty, environmental degradation including deforestation and declining tree cover, extensive soil erosion and declining soil fertility, inconsistent provision of farm inputs, weak linkages to input and output markets and agro-services. This makes many farmers vulnerable to exploitation by middlemen and means that small-scale farmers are often poorly represented in farmers' groups and cooperatives and by political representatives.

Historical trajectories of technological change across the three sites indicate substantial changes in technical practices, livelihoods, demography, policy interventions, and institutional frameworks over several decades. As a broad generalisation, while the 1990s and 2000s were characterised by a focus on disseminating new technology packages, the period since 2010 has seen an increase in focus on innovations in policy and delivery methods that are intended to facilitate adaptation and technological change.

Table 4.1: Study Sites

	Machakos Sub-county	**Nyando Sub-county**	**Ugunja Sub-county**
County	Machakos County	Kisumu County	Siaya County
Study location	Kiima/Kimwe village, on the outskirts of Machakos town	Kanyamlori/Cherwa village, lower Nyando, on the outskirts of Kisumu municipality	Ugunja ward on the outskirts of Ugunja town
Poverty rate (population below $1.25 per day)	65%	62%	35%
Agroecological zone (AEZ)	Semi-arid	Semi-humid	Semi-humid
Climate	Dry ecosystem	Quasi-equatorial tropical climate ecosystem	Quasi-equatorial tropical climate ecosystem
Elevation (above sea level)	1,000m—2,100 m	1,100 m—1,400 m	1,140 m—1,500 m
Temperature	17°C—37°C	18°C—35°C	15°C–30°C
Rainfall	Highly variable, ~520 mm per year in two seasons	1,000—2,000 mm per year in two seasons	1,000—2,000 mm per year in two seasons
Principal agricultural activities	Subsistence farming of maize but with a large degree of diversification into commercial horticultural crops, supported by a relatively good irrigation system in the area and proximity to Nairobi	Mainly subsistence and rain fed farming of food crops, especially maize and millets. Farmers in the upper part of Nyando practise improved livestock farming, those in the lower parts raise local breeds including local zebu cattle, poultry, sheep and goats. Some farmers engage in production of high-value horticultural crops for sale	Mainly subsistence and rain-fed farming of food crops including cereals such as maize, and livestock production Some farmers engage in production of high-value horticultural crops for sale

Sources: Peters *et al*. (2012); Kinyangi *et al*. (2015); Place *et al*. (2006); Krishna *et al*. (2004); Odada *et al*. (2004) and Mungai *et al*. (2004)

4.1. Machakos, Machakos County

Machakos County is located about 80 km from Nairobi in a semi-arid region characterised by highly variable rainfall, amounting to about 520mm a year over two seasons. Our study took place in two villages, Kiima and Kimwe, on the outskirts of the municipality of Machakos. The majority of the inhabitants are smallholder farmers belonging to the Kamba ethnic group. Poverty and malnutrition are prevalent, with over 65 per cent of the population living on less than US$1.25 day. Farming and mining are the principal economic activities and land uses in the area. Most farms are small, averaging 0.4—2 ha. in size. Drought is a major concern for farmers in the area and some land is left fallow due to water scarcity. The area has also been blighted by pest and disease outbreaks over recent decades.

Agricultural land is under pressure from the urban development of Machakos town. The proximity of Machakos and Nairobi allows farmers in this area to produce high-value fruits and vegetables for urban markets. The level of farm mechanisation is relatively high (Tiffen *et al*. 1994; Republic of Kenya 2009).

4.2. Nyando, Kisumu County

Nyando is situated in the Nyando basin, an agricultural flood plain located in western Kenya, which drains into Lake Victoria. Our study site is located in the Kanyamlori/Cherwa area of Lower Nyando, where the predominant ethnic group is Luo. The poverty rate in the area is high, with 62 per cent of inhabitants living on less than US$1.25 per day. The area has a humid to sub-humid climate with highly variable rainfall, including periodic droughts and major floods. The landscape upstream of Nyando has been affected by deforestation leading to soil erosion, deep gullies and occasional flash flooding downstream. Local farms typically have a low agricultural potential and declining soil fertility. Small-scale subsistence agriculture remains the principal source of livelihood for most people. Very little agricultural produce is sold. Farmers typically cultivate rain-fed maize, sorghum beans and potatoes, and keep livestock including local zebu cattle, poultry, sheep and goats. Small patches of grazing land and natural vegetation are shrinking due to expanding settlements and increasing population (Kinyangi *et al*, 2015; Place *et al*. 2006; Krishna *et al*. 2004; Odada *et al*. 2004; Mungai *et al*. 2004).

4.3. Ugunja, Siaya County

Ugunja subdivision of Siaya County is located about 80 km from Kisumu on the Kisumu—Busia highway, which connects Kenya to Uganda. Ugunja has a mixed population of Luo and Luhyia ethnic groups, which are interconnected by marriage and trade; our fieldwork was carried out in an area dominated by the Luo community. Ugunja occupies an elevated position between 1,100m and 1,500m above sea level and lies close to the equator. The area experiences a quasi-equatorial tropical climate influenced by the Lake Victoria ecosystem, with temperatures ranging between 17°C and 30°C and annual rainfall fluctuating from 1,000—2,000mm per year, concentrated in two rainy seasons. The poverty level in this area is moderate, with about 35 per cent of the population living on less than US$1.25 per day. Farming is the main economic activity in the area, which is dominated by small farms averaging 1.03 ha. More than 90 per cent of the inhabitants are farmers and more than 70 per cent of households practise rain-fed agriculture for food and income, cultivating maize, bananas, sorghum, potatoes, cassava and beans. The area's proximity to the Kisumu-Busia highway and the Ugandan border enables farmers to engage in some production for the market. Small patches of grazing land and natural vegetation are under pressure from farming and urbanisation. Compared to Machakos and Nyando, Ugunja is less commonly affected by extreme weather-related events; pests and diseases are the major sources of agricultural stress.

5. Historical Agricultural Interventions in the Three Sites

All of the three study sites have been targeted over the years by agricultural development interventions implemented by a variety of international and national agencies. In the 1970s, soon after Independence, all three sites were characterised by largely traditional, low-intensity, rain-fed farming systems such as shifting cultivation, which were supported by government policy. Most land was still traditionally held by families. Most farmers grew maize and beans for domestic consumption only, and there was little crop diversification. Most farms were cultivated using traditional methods and hand tools. At that time, methods of seed selection, crop breeding, post-harvest processing and storage were largely based on indigenous, traditional systems. Farmers used to select maize seeds for re-planting, based largely on cob sizes. Seed storage practices involved smoking and applying ash to protect the seeds until planting time. As well as cultivating crops, farmers typically kept relatively large stocks of local animal breeds. The small number of farmers who benefited from the distribution of former white settlements immediately after Independence, continued to work in groups under a farmer cooperative framework, producing silage for livestock, delivering milk, and dipping cows in cattle dips managed by the cooperative. The national government played a key role in determining which farming technologies would be disseminated and applied, depending on prevailing political and ecological circumstances.

Nyando and Ugunja in Western Kenya were testing grounds for new agricultural technologies during the colonial period. According to local perceptions, as revealed in our focus group discussions, Nyando has a relatively low level of farm mechanisation whereas Ugunja has an intermediate level of mechanisation, reflecting its relatively higher degree of market integration. KALRO, ICRAF, ICRISAT and CIMMYT have all carried out research and development projects in Nyando and Ugunja, where agricultural development programmes such as the LVEMP have been implemented. Since 2011, the CCAFS programme has promoted climate-smart agriculture in the area through a partnership between CGIAR institutes, KALRO and Vi Agroforestry, a Swedish development cooperation organisation that works in the Lake Victoria basin. Whole villages are targeted with agricultural technologies such as greenhouse cultivation, improved seeds for maize, sorghum, pigeon peas, cassava and sweet potatoes, and improved methods of aquaculture and livestock husbandry (Atela 2012). ICRAF, World Neighbours and the North Agoro Community Development Programme (NACODEP, an NGO), among other organisations, are working in the area to support improved natural resource management and promote new livestock breeds. Various soil and water management techniques have been deployed, which aim to restore degraded land and transform productivity in Nyando and the wider western region (Place *et al.* 2006). Numerous NGOs are also active in agriculture in Nyando and Ugunja, including World Neighbours, CARE international, Vi Agroforestry, NACODEP and the One Acre Fund. The One Acre Fund represents a new wave of NGO interventions that aim to promote agricultural micro-enterprises. It provides farmers with agricultural inputs and other assets through a credit arrangement. Government interventions in this area include subsidy support with maize seeds or fertilizers. Some local critics told us that this support is timed cynically, to coincide with political events such as elections.

Compared to the other two sites in our study, the level of agricultural development in Machakos sub-county is considered relatively high, for example farmers in the area benefit from irrigation infrastructure. Machakos has benefited from its proximity to KALRO—Katumani, from which several improved maize varieties have been released over time, including types that are resistant to biotic and abiotic stresses. KALRO—Katumani collaborates with ICRISAT and CIMMYT and the CCAFS programme. Besides new maize varieties, new technologies and techniques have been promoted in

the area including rainwater harvesting, micro-irrigation, conservation agriculture,[8] agro-forestry, crop production in greenhouses and polytunnels, and goat-rearing for dairy and meat production. CBOs and farmers organisations are quite strong in Machakos, which advocate for and support the adoption of new agricultural technologies. An example is the Mikivo Self-Help Group, which seeks to mobilise farmers, link them with extension officers, manage group savings and coordinate farming activities. A number of NGOs, agro-dealers and agricultural entrepreneurs have been authorised to promote various farming technologies, facilitate access to farm inputs and build farmers' skills.

[8] Conservation agriculture involves reduced ploughing of soils and the use of crop residues and cover crops to reduce rainwater runoff, conserve soil moisture and minimise soil erosion.

6. Farmers' and Communities' Experiences of Socio-eco-technical Change

The previous Section documented in brief detail the histories of technical interventions, development programmes and processes of socio-eco-technical change that have affected our three research sites over the past half century. During our fieldwork, we discovered that local farmers' understandings and expectations of these interventions resonated with the overarching narratives of the Green Revolution, which anticipated the transformation of agriculture through new technologies as a driver of economic development and the alleviation of poverty and hunger. However, we also learned from farmers' experiences that poverty and hunger remain prevalent, and their expectations of economic benefits arising from changing their agricultural methods and technologies had not been achieved. In fact, the farmers' testimonies during our focus groups and the Rivers of Life narratives showed that many farmers still face significant food security challenges. Most are far from achieving self-sufficiency in food, let alone integration into lucrative markets for their agricultural products. As we describe below, farmers were typically aware of many of the interventions and technologies that had been targeted in their communities, but it was clear that these had not necessarily resulted in positive impacts on their lives and prospects.

In this Section we present the key insights from our engagements with farmers in the three research sites. We focus on the farmers' capacities as agents of technological change and advancement, which represent key engines of change that determine the size and distribution of the impacts of technological change. We use the term 'capacities' here to refer to farmers' capabilities to engage, as principals in their own livelihoods and development trajectories, with technological change interventions that were introduced by other actors, from outside the local farming system. We concentrate, in particular, on our informants' perceptions of the interventions and programmes to which they and their communities were exposed, and especially on their views about the degree to which they felt a sense of agency in response to the opportunities presented to them by different agricultural development and technology interventions. We begin by considering the farmers' awareness of those interventions, the organisations that brought them, and the types of technologies that had been introduced.

6.1. Farmers' Awareness of Interventions.

Farmers in the three communities were able to name organisations, projects and programmes that had been active in their area, and mentioned specific technologies and other forms of support that these interventions had brought. For example, a woman in Ugunja mentioned the provision of seeds and fertilisers by the One Acre Fund, and reported that the assistance had enabled her farm to produce ten bags of maize, which had substantially improved her family’s food security status. A woman in Nyando mentioned an intervention by CCAFS to provide training in a new method of fertiliser application. Most of the farmers we spoke to in the three sites mentioned farming technologies that they had taken up or benefited from as a result of different interventions, such as new irrigation facilities that were built in Machakos, new seeds that were introduced in Nyando, or easier access to fertilizers in Ugunja. Farmers we spoke to believed that the interventions they had experienced had helped them to improve low yields of food crops, especially maize and beans. However, our informants' ability to name specific projects and generic technologies did not necessarily imply that they also displayed a deep knowledge about technical details, or that they had been able to integrate novel techniques and new inputs readily into their existing farming routines, or that they had embedded them sustainably into their local agro-ecological contexts and socio-economic frameworks. Our informants often invoked the names of programmes and modern agricultural technologies abstractly, without explaining in any great detail how they were supposed to boost production, raise incomes and promote food security.

6.2. Declining Agricultural Yields and Smaller Farms

Most rain-fed farmers in all three study sites observed that crop yields have been declining over the past few decades. We were told that some farmers in Nyando and Ugunja used to be able to harvest as many as 10 bags of maize from an acre of land in the past, but nowadays could hope for only two to three bags per acre. This had caused a dramatic decline in food security for households that rely on rain-fed farming as a principal source of livelihoods and income. In Machakos farmers explained that the unpredictability of rainfall and reductions in the amount of rain had made it hard not only to produce enough food for the whole year, but had also made farming a very unpredictable source of livelihood. Farmers associated declining agricultural yields with an increase in the variability of rainfall, but some opined that yields could be increased with new drought-tolerant and fast growing varieties.

While variable and unpredictable rainfall was identified as the primary cause of declining yields and food insecurity, some farmers also believed that their farms had become unproductive due to a decline in soil nutrients resulting from many years of cultivation. They argued that better access to fertilisers and inputs credits would help them address such cases of nutrient exhaustion. The decline in soil fertility was more prominent in our discussions with farmers in Machakos and Ugunja, where farm sizes are also declining due to the expansion of Machakos and Ugunja towns, and population growth resulting from immigration.

6.3. Demographic Change, Migration, Urbanisation and Industrial Development

The increase in national population and the effects of migration during the 1980s and 1990s were felt in the study sites. In Machakos, farmers remembered an increase in rural—urban migration in this period, with an influx of migrant workers. Machakos offered a better option than Nairobi for many immigrants wanting to settle, because the area was industrialising with the arrival of steel (e.g. Devki Ltd), cement (e.g. Bamburi Cement) and iron industries, which offered casual employment opportunities to most immigrants. Immigration and industrialisation triggered the rapid growth of Machakos town, with ramifications for the availability of farmland. A similar demographic boom was experienced in Lower Nyando, where farmers recalled that many of their number had shifted to food production and storage following the population and climatic shocks of the 1980 and 1990s. In Ugunja, farmers narrated that this period was characterised by a high rate of immigration from neighbouring regions, leading to the expansion of Ugunja town. Many farmers sold off their lands to immigrants, who offered favourable prices and used the land to build houses. The consequence was that many farmers ended up with small farm sizes at a time when they had to contend with the effects of drought.

6.4. Climate Change and Ecological Stresses

In all three sites, farmers attested that rains used to be reliable and predictable in the early post-colonial period, which made it easy to make planting and harvesting decisions. They said that their farms used to enjoy high levels of natural fertility, although they would occasionally apply farmyard manure when it was available. Artificial fertilizers were very rarely applied and the low population density allowed farmers abundant space in which to practise shifting cultivation and allow for natural regeneration. From the 1990s onwards, the three sites experienced numerous ecological and demographic changes, which stimulated various agricultural technological changes. Machakos, being a semi-arid area, was particularly affected by the droughts experienced during the 1980s and 1990s. The emerging effects of climate change as well as population increases intensified the search for and adoption of Green Revolution farming technologies.

6.5. New Seeds and Intensive Cultivation Methods

It was particularly in Machakos that we found farmers who have begun embracing improved seeds, including improved varieties of maize, beans, cow peas, wheat, sweet potato, millet, sorghum and potato. Farmers have also been introduced to more intensive farming systems and methods of value

addition for various crops and livestock products. Our informants in Machakos were able to recall and name various seeds and planting materials, soil and forest conservation methods and livestock technologies that they had adopted with the help of KARI/KALRO—Katumani Centre and donor support over many decades. They mentioned the introduction of improved varieties of seeds and livestock; improvements in seed quality; improved cultivation methods such as timely ploughing; methods of conservation including control of soil erosion and practices of conservation agriculture. KARI introduced a new maize variety in the 1980s called KCB-KARI-Katumani, which was intended to help farmers adapt to droughts and unpredictable weather. This was followed by other varieties including DH0204, which was distributed by Kenya Seed Ltd. These drought-tolerant varieties grow fast and need very limited amounts of rainfall to mature. But the crop breeding programmes from which they emerged were driven by experts' perceptions in response to changes in weather patterns and the unreliability of rainfall; they did not necessarily engage with farmers' own knowledge, experiences and priorities.

6.6. Methods and Practices of Natural Resource Management

Whereas in Machakos development interventions have been targeted towards enhancing intensification and market linkages, in Lower Nyando and Ugunja the technological response to the climatic and demographic pressures of the 1980s and 1990s was oriented mainly towards natural resource management. However, participants in our workshops commented that practices of soil fertility management and climate smart cultivation methods had been designed by technical experts without consulting them. Various NGO, private sector and government interventions have focused on restoring degraded agricultural lands, enhancing soil fertility and improving the management of catchment areas. Part of the explanation for the difference in focus is that Machakos has ready access to markets in nearby urban centres, including Nairobi, whereas in Nyando and Ugunja the agenda has been driven by programmes designed to improve the management of the Lake Victoria basin. The Lower Nyando area has also been targeted by the climate-smart village initiative under the CCAFS programme. The programme established a number of on-farm CSA demonstration sites, which are managed by local umbrella CBOs such as the Northeast Community Development Programme (NECODEP). Our informants explained that these interventions are intended to provide alternative livelihoods and reduce pressure on natural resources, such as the practice of cutting trees for charcoal – an activity which many informants associated with deforestation, land degradation and soil erosion in Lower Nyando. In Ugunja, we were told that most farmers engage with new technologies for the sake of achieving self-sufficiency and a level of market integration, rather than motives to do with natural resource conservation or restoration. Agro-forestry may contribute to agricultural productivity and resource conservation goals, and has been promoted as a sustainable farming method in the Lake Victoria region since the 1970s. Vi Agroforestry is among the non-state actors that have played leading roles in supporting community-based agroforestry projects (especially tree planting among crops) and soil conservation in the region since 1983.

6.7. New Crops and Livestock, New Livelihood Options

Various interventions have sought to introduce farmers to new crops and livestock. In 2000, the International Potato Centre (CIP), KALRO—Kakamega, the Ugunja Community Recourse Centre and other partners began to promote orange-fleshed sweet potato (OFSP) in Ugunja and other parts of western Kenya. OFSP is a biofortified crop that contains elevated levels of beta carotene, an important micronutrient. Value addition is under way on a small scale at village and household levels, e.g. the addition of sweet potato to flour, crisps, and snacks, which may then be sold locally. Another novel crop that has been promoted in the area is banana from tissue cultured clones, developed by KALRO.

Some historical crops have also declined. In the 1980s Lower Nyando was known for commercial cotton production, but cotton farming declined after the local cotton factory, Kisumu Cotton Millers (KICOMI) in Kisumu, collapsed in the mid-1990s. In more recent times CCAFS in Nyando has organised

demonstrations of greenhouse farming, aquaculture, irrigation systems, drought-tolerant varieties of sorghum and finger millet, and early-maturing crops, such as pigeon peas, cowpeas, green grams and sweet potatoes, as supplements to the traditional staples such as maize, cassava and beans. Also in Nyando we observed that some farmers, particularly those leading farmers' groups, have started keeping improved livestock breeds to improve milk and meat quality and quantity, including fast-maturing Gala goats and Red Maasai sheep.

6.8. Farm Inputs and Subsidies

In areas with declining soil fertility, farmers have increased their use of fertilizers in an effort to boost production. At the time of this study, various efforts were in place to enhance access to fertilizers. However, farmers with whom we interacted affirmed that they had never been asked to express views about the pricing, types or quantities of fertiliser and other inputs they required. In Nyando CCAFS has partnered with the Ministry of Agriculture and Livestock, Vi Agroforestry, CARE International, farm input suppliers and CBOs to support farmers to access agricultural inputs. The county governments in Ugunja and Machakos have partnered with the national government and agro-industries to subsidise fertilizer, seeds and tractor services. The National Cereals and Produce Board and county government supply subsidised farm inputs through stores in wards, but Ugunja has one privately owned store offering subsidised fertilizer and seed. The market price for DAP fertiliser at the time of this study was Ksh3,500 (USD$35) per 50 kg bag, but farmers were able to pay Ksh1,800 (USD$18). Maize seeds were available on the market for Ksh400 (USD$4) per 2 kg bag, reduced to Ksh200 (USD$2) per bag with the subsidy. Farmers told us that these subsidies were instrumental in enabling them to enhance their yields, but even so, many farmers and especially the poorer ones were unable to afford even the subsidised prices. In 2013 the One Acre Fund received a grant from the Bill and Melinda Gates Foundation to support technology adoption among Africa's smallholding farmers. In Ugunja, this initiative is supporting small-scale farmers by advancing farm input in credit which is to be settled after harvest.

6.9. Farmer Organisations and Cooperatives

In all three sites, we observed a strengthening and reorientation of farm cooperatives and other farmer organisations. Technological advancements and agricultural intensification created space for a new generation of agricultural cooperatives to emerge or evolve, which were more farmer- or producer-driven. Farmers were motivated to form or join cooperatives by market opportunities that were emerging locally, nationally and regionally. An example is the Machakos District Co-operative Union (MCU) in Machakos, which was originally established in 1964 to consolidate produce for sale to specific agro-dealers. Today the cooperative has 81 affiliate co-operative societies representing 70,000 individual producers, providing a platform for more robust and diverse market linkages and a wider distribution of agricultural products. In Nyando new grassroots farmer organisations have appeared, which link farmers to various technological, market and funding opportunities. These movements advocate on behalf of farmers as well as providing cooperative services. Two prominent examples are NACODEP and the Friends of Katuk Odeyo Environmental Programme (FOKODEP), umbrella organisations that bring together several groups of farmers to adopt new agricultural technologies and engage in conservation initiatives. These movements support their members with information on pricing agricultural products and help to link farmers to donor-funded projects and interventions in the area. In Ugunja, new cooperatives and farmer organisations have emerged, including the Ugunja Dairy Cooperatives and the Ugunja Community Resource Centre (UCRC). The UCRC in particular is encouraging the dissemination of new varieties of cassava, which are deemed to be high-yielding and resistant to climatic shocks. The UCRC is also supporting various farmer groups and cooperatives to engage in value addition, for example the production of potato chips and other products. Another thriving form of farmer organisation are 'table banking' associations, which were observed across all three study sites. Table banking is a new kind of savings and credit practice, in which small groups of farmers, often women, come together to pool their savings in order to make

small loans to group-members. These associations enable their members to invest in farm production and exploit commercial opportunities.

6.10. Agricultural Extension

The farmers participating in our interviews and focus group discussion in Machakos agreed that KARI extension services had played an important role in supporting them during the 1980s but these services declined in 1990s and 2000s, until on-farm experiments, demonstrations, field days and training courses picked up again after 2013, when a new government came into power. The rise of new farmer organisations coincided with the re-appearance of agricultural extension services and contributed to the emergence of innovative approaches to extension. Other organisations were named by farmers as having contributed to the transformation of the agricultural sector in Machakos, including the CCAFS programme, ICRISAT and CIMMYT, which have been working in the area since 2011 to support farmers on climate change adaptation, mitigation and risk management. Local CBOs such as Mikivo Self Help Group also play a role in mobilising farmers, linking them with extension officers, managing group savings and coordinating the implementation of field activities. Some farmers received agronomic advice through product certification schemes and programmes, and became certified producers. This period also witnessed the appearance of ICTs in extension, notably the provision of agronomic, market- and climate-related information services to farmers using mobile phones. Farmers also mentioned the provision of novel financial services, such as insurance for seeds and crops, by private sector organisations and government agencies.

In Nyando and Ugunja government extension work significantly declined with the structural adjustment programmes and never picked up. This absence was exacerbated by the fact that few public research projects and centres appeared in these sites compared to the scale of research and development activities in Machakos. After the implementation of structural adjustment programmes, government extension services were meant to be demand-driven or supported through donor-funded projects. Many grassroots organisations and conservation and development NGOs took up the slack and began to perform extension-related roles, such as training farmer groups in conservation practices, providing market information, and other services.

7. Who Made the Revolution? Exploring Farmers' Agency

As described in the previous Section, our interactions with farmers and other key informants confirmed that the three research sites had been targeted over the decades since Independence with a range of technological and policy interventions, led by various governmental, non-governmental and private sector actors. However, our main aim was to explore farmers' and community members' own experiences and perceptions of the technological changes that had occurred in their communities, and particularly the extent to which they had felt a sense of agency in response to the opportunities that had been presented to them by external agencies and by the processes of technological change in which they had been involved. To what extent could ordinary farmers and rural people shape the pathways of technological change in which they were caught up?

Our focus on agency was guided by two sets of insights from scholarly literature. First, scholarship in fields such as innovation studies (IS, including work on agricultural innovation systems, AIS), and science, technology and society studies (STS) guides us to recognise that the direction, speed and destinations of technological change are determined partly by human activity, but that human agency to pursue goals or reach preferred destinations is enabled and constrained, and may be enlarged or reduced, by the particular local configurations of power relations among people and organisations, and by the affordances and utility of the natural resources and tools available to individuals and groups within a particular biophysical, socio-economic and institutional setting. This means that the capacity to act and to shape preferred outcomes is distributed unevenly, for example between rich and poor, men and women, and between generations (Ockwell and Byrne 2015).

Second, we take it as the essential purpose and key measure of any development intervention, that it should empower individuals and communities to pursue the ends that matter to them (Nussbaum 2011; Sen 2001). However, a classic criticism of agricultural development interventions is that they are frequently top-down programmes, designed and imposed by technocrats and bureaucrats, built upon unspoken assumptions and suiting some members of the community better than others. Development programmes do not automatically translate into successful and sustained technological change or beneficial development outcomes. Interventions face diverse and complex local settings, characterised by distinctive agro-ecologies, histories, cultural institutions, social frameworks and socio-economic circumstances. Our goal in this exploratory study was to explore the extent to which ordinary farmers and rural communities had been enabled to improve their own circumstances through development interventions that were brought to them by external actors.

Farmers who participated in our workshops held in January 2017 recalled how, in the 1970s and 1980s, news of incoming agricultural technologies that were announced through *barazas* were treated with utmost gravity. Our interviewees told us that technological packages delivered through the offices of the Chiefs were regarded as law. The democratic and political spaces, in which alternative technological pathways might have emerged, were relatively restricted. They attributed this to the authoritarian models of governance adopted by the colonial government, which continued during the early years of independent government. Policy measures adopted by the central government would be passed down to the Provinces and thence to Chiefs for implementation in rural areas. This top-down style of development governance allowed very little consultation but, according to farmers we spoke to, the policies and interventions at least had the merit of being based on a long-term, programmatic approach.

During the 1980s and into the early 1990s, Kenya was a 'single party democracy'. This meant that there were very few pathways through which alternative technological approaches could be pursued, and limited opportunities for farmers to advocate for their preferences. Chiefs were held responsible for introducing and promoting soil and water conservation technologies required by the government.

Technologies and farming methods would be assessed for their alignment to the government's interests and existing programmes before they could be announced in *barazas*. The Chief would gather people together and direct them to undertake specific activities on their farms, either collectively (*harambes*) or individually, and as laid down by the government. Failure to comply would result in corporal punishment including being denied seeds to plant for that season. The former ruling party, the Kenya African National Union (KANU), established so-called '4K clubs'[9] to organise farmers and disseminate new technologies. The 4K clubs were sometimes organised around schools. During this time even non-state actors, which started working on soil fertility problems in Western Kenya during the 1980s, were obliged to work within the confines of the party regime. Farmers told us that ICRAF's field officers would only discuss soil fertility technologies with the Chief and village elders, constituted as the village committee.

The democratic space made available through the *barazas* was very narrow, since not everybody was allowed to speak openly, express opinions or question the technologies being proposed. Our focus group participants in all three sites acknowledged unanimously that the voices of women and other marginalised groups were rarely heard in the *barazas*, even though women played a major role in farming and had useful insights that could have informed technological progress.

Farmers we spoke to characterised the technical and social interventions proposed by the central government in former decades as top-down solutions imposed on them from above, based on whatever the political class felt was suitable. The proposed solutions were often very general and not adapted to particular contexts. According to some of the farmers interviewed, most farming technologies focused on the enhancement of maize productivity because maize was conceived as the primary staple crop. Other crops and foods were relatively neglected. Farmers would be measured by the amount of maize in their granaries. Particularly in Nyando and Ugunja, farmers who produced a lot of maize were labelled as 'good farmers' and their examples would be praised during public *barazas* in front of the Chief, village elders and other members of the community. While such approaches were conceived as opportunities to create local farming champions, they degenerated into pantomimes of technology adoption, through which multiple interventions seem to achieve little discernible impact on agricultural productivity or sustainability (Atela 2012).

The political space opened up after 1991, when the single party clause of the constitution was removed. Under the pressure of the demographic and climatic shocks and stresses discussed in this paper, new approaches to agricultural technology development were needed, which would involve new approaches to farmer engagement. New institutional forms emerged, including public—private and multilateral partnerships aiming at delivering agricultural transformation'. Together with a wider trend in international aid and technical cooperation, project-based approaches became very common, in which short- or medium-term interventions would be financed to achieve specific objectives for a target community or area within a defined period of time. Within projects, farmers were expected to adopt the technology packages presented to them. Project evaluators would seek and count the so-called 'adopters' of recommended technology packages as a primary indicator of the impacts of development projects, and a key measure of 'success'.

The project officers we interviewed across the three sites regarded the project approach as an effective way to test and evaluate the feasibility of technologies within a short period of time and within the confines of specified indicators. They felt that the important stressors affecting farming systems in the three sites were driven partly by external factors, and could only be addressed adequately with the benefit of scientific expertise and the resources that could be obtained through

[9] The 'four Ks' stands for the Swahili slogan *Kuungana*, *Kufanya*, *Kusaidia Kenya*, roughly meaning 'to unite, to act, to help Kenya'.

projects. However, community resource persons and community members agreed that the project approach primarily suits development agencies, which have a particular interest in seeing that pre-defined outputs and outcomes are delivered and reported upon within specified time periods. The project model is predominantly a top-down framework, in which farmers are recipients of new technologies, and depend on external contact persons for training, information and guidance.

The benefits of projects are potentially open to capture by elites, such as the community leaders and opinion influencers, who are selected by project implementers as the entry points into the community and nominated to be farmers' group leaders, and who are eligible to attend trainings and seminars. In most groups, the contact persons are also the custodians of equipment and material supplied to the group by the project. In initiatives discussed across the three sites, this hierarchical relationship led to concerns about resource allocation and transparency. We were told that the chairs of some groups would attend trainings but fail to disseminate the knowledge to other group members. Our observations and interactions with farmers indicated that project activities rarely moved beyond the demonstration level, and we found little evidence that the technologies in question were taken up by farm households. Some farmers explained that particular technologies were new to them and expensive beyond their resource capacities.

The project model was observed across all three field sites. In Machakos, donor-funded projects were designed to breed new crops and develop new technologies for testing and dissemination to farmers. Most of the breeding programmes under the KALRO-Katumani Centre are donor-funded through projects implemented in collaboration with ICRISAT. In Lower Nyando, the climate smart village concept has been implemented within the framework of a five-year project. The project approach has been embraced by private sector players as well, in which investments are directed towards a target group of farmers over a specific period. Similarly, in Ugunja, the UCRC and state actors have supported the dissemination of improved seeds and provided input subsidies through short-term development projects. In programmes such as these the Kenyan state has provided the institutional framework in which short-term programmes and projects can be implemented, without institutionalising a long-term or consistent approach to research and technology development. This situation is reflected in the national budget for agriculture, in which nearly 95 per cent of activities are expected to be funded by donors and development agencies through individual projects.

If technological change in Kenyan agriculture during the first decades after Independence was driven largely by state-led, bureaucratic programmes that perpetuated a top-down, populist and colonialist style of governmental intervention in agriculture, in more recent years the enlargement of democratic space that followed the restoration of multi-party democracy, combined with new policy prescriptions from the international community to create a shift to more technocratic approaches in which agricultural development schemes were driven by aid donors' agendas, scientific expertise and industry interests. In this new era, the state receded in importance as an agricultural development actor. Instead of leading the development process on behalf of Kenyan farmers and citizens, while promoting and protecting their rights and interests, government institutions often served as conduits for aid funds provided and directed by others. The involvement of state agencies could help to legitimise programmes that were largely designed by foreign donors and technical experts, or merely to assess the technical feasibility of interventions over which the Government of Kenya had little real control. Kenya's farmers remained at the end-tail of proposed agricultural revolutions, as targets of programmes that were conceived by others. At the same time, Kenya’s rural communities struggled to adapt to rapidly unfolding processes of geopolitical, demographic and environmental change. While they could have minimal influence over these powerful drivers of secular change, they also had a limited capacity to anticipate them, understand them, or respond to them effectively.

Farmers in the three communities were able to exercise agency of a limited kind, as consumers of subsidies, inputs and services. This was especially evident with regard to the uptake of fertiliser

subsidies, which had been offered by state agencies and private sector organisations, such as the One Acre Fund. However, the range of choices available to farmers, such as the types of fertiliser on offer, were limited, determined by more powerful decision makers. But the farmers' testimonies confirmed that, all too often, the technological responses to the challenges they faced, especially climatic and agro-ecological changes, were rarely informed by their own perceptions and priorities. They focused primarily on breeding programmes (e.g. the development of drought-tolerant maize varieties) that were driven by scientific expertise and sometimes insensitive to the farmers' socio-economic and cultural circumstances.

Signs of hope for the expression and empowerment of farmers' own agency appear from the development of farm cooperatives and farmer organisations. These could represent a framework for building alternative pathways of technological development that are driven and shaped by farmers, or at least are sensitive to their needs, perspectives and priorities. In principle, farmer organisations should be able to help farmers to access new technologies and develop market opportunities more easily and on more favourable terms. Potentially, farmer organisations could be a vehicle through which farmers' perspectives and priorities can have more influence over the design or adaptation of programmes and technologies designed by others. Farmer organisations can play important roles in extension, enabling their participants to access new agronomic techniques and practices, share knowledge, and articulate their own demands for information and education – especially in the light of failures by state-led extension services. Farmer organisations could become vehicles for disruptive grassroots innovations emerging from farmers and rural communities.

8. Summary and Conclusions

The governance and strategic direction of agricultural development in Kenya may be said to have evolved from a more 'bureaucratic' mode during the colonial and immediate post-independence period to a more 'technocratic' mode today. In the bureaucratic mode, the State was at the centre. Farming practices and technologies were supposed to be aligned with the priorities and programmes determined by the national government. In the contemporary period of technocratic development, agricultural programmes and interventions have been designed by scientific experts and implemented by technical agencies through the institutional form of short-term projects and programmes. The transition from the bureaucratic mode to the technocratic mode took place under the pressure of climatic and demographic turbulence, and political pressure for a transition to a multi-party democratic system of government. The space for civic participation increased with the expansion of CSOs and NGOs, while international agencies aimed to introduce new agricultural solutions to the intractable problems of food security, economic development and poverty alleviation.

The status of ordinary farmers in the transition from bureaucratic to technocratic modes of governance remained more or less unchanged. The farmers' agency in relation to technological methods and practices has continued to be constrained by actors and organisations that have continued to occupy more powerful positions in relation to technology policy, research, innovation and extension. Consequently, well-meant efforts to engage farmers, in the late twentieth and early twenty-first centuries, in participatory approaches to natural resource management or farmer-led and demand-driven extension systems, have struggled to break down the established bureaucratic and technocratic power structures and processes. Farmers may have been 'connected' to the systems of technology development and dissemination, yet they have scarcely been integrated as key players within the innovation and technological change process, in ways that could empower them meaningfully or succeed in mobilising their capabilities and agency. Significant technical and ecological changes have taken place in rural areas during the decades since Kenya's independence, but these have been driven largely by larger, impersonal processes and by more powerful actors than the farmers and rural communities whose livelihoods are directly affected. According to the testimonies of our informants, their agency has rarely been given the opportunity to select or shape their own technological futures. Farmer organisations might enable this to happen, but it could be naïve to assume that individual farmers will necessarily be empowered or included, or that participation will necessarily generated benefits that would be widely shared. More research is needed into these issues.

In this working paper, we have explored the perceptions of local farmers who experienced socio-eco-technical change processes in three rural sites in Kenya. We have sought to show how agricultural technology in the country has evolved in the context of particular establishments of actors, institutions and power relations that have shaped the direction, speed and destinations of technological change. Our engagements with farmers in the three research sites have indicated how the commonly used project-based approach to development interventions has led to a top-down dynamic, in which technology packages designed through external processes have been delivered to local communities to adopt – hopefully to share benefits in some way. The project-development approach has used incentives or worked with opinion leaders in the communities, to encourage adoption. This approach has often failed to stimulate sustained technology adoption; indeed, in certain cases technologies and practices are often abandoned after a project ends, because the users revert to their traditional ways – practices in which they have a stronger sense of agency.

When projects focus on achieving pre-defined outputs and give insufficient attention to the quality of participation, the opportunity to involve and engage farmers is lost, and with it the change to integrate their locally rooted skills and capabilities with the technical expertise of outsiders. Farmers could be

involved in the development process and in shaping its outcomes, as agents of technological change. This could create a mechanism for integrating scientific expertise with the socio-cultural frameworks and local agro-ecological knowledge and skills already possessed within local communities, particularly the knowledge of marginalised and weaker groups.

References

AGRA (2015) *Africa Agriculture Status Report: Youth in Agriculture in Sub-Saharan Africa*, issue 3, Nairobi: Alliance for a Green Revolution in Africa (AGRA)

Arora, S. (2017) *Configurations of Agency and Power in the Academic Discourse on the Green Revolution in East Africa*' STEPS Working Paper 97, Brighton: STEPS Centre

Atela, J. O. (2012) *The Politics of Agricultural Carbon Finance: The Case of the Kenya Agricultural Carbon Project*, STEPS Working Paper 49, Brighton: STEPS Centre

Blaustein, R. J. (2008) 'The Green Revolution Arrives in Africa', *BioScience* 58.1: 8–14

Byerlee, D. and C. K. Eicher. (eds) (1997) *Africa's Emerging Maize Revolution*, Boulder CO: Lynne Rienner Publishers

Byerlee, D., Ananadajayasekeram, P., Diallo, A., Gelaw, B., Heisey, P. W., Lopez-Pereira, M., Mwangi, W., Smale, M., Tripp, R. and S. Waddington, S. (1994) *Maize Research in Sub-Saharan Africa: An Overview of Past Impacts and Future Prospects*, CIMMYT Economics Working Paper, El Batan: CIMMYT.

Dercon, S. and Gollin, D. (2014) *Agriculture in African Development: A Review of Theories and Strategies*, CSAE Working Paper, Oxford: Centre for the Study of African Economies, Department of Economics, Oxford University

Djurfeldt, G., Holmen, H., Jirström, M. and Larsson, R. (eds) (2005) *The African Food Crisis: Lessons From the Asian Green Revolution*, Abingdon: CABI Publishing

Evenson, R. E. and Gollin, D. (2003) 'Assessing the Impact of the Green Revolution, 1960 to 2000', *Science* 300.5620: 758–762

Fleming, D. (1966) *Administrative Science Quarterly*, Volume 11, Ithaca NY: Graduate School of Business and Public Administration, Cornell University

GoK (2013) *Kenya National Climate Change Action Plan, 2013 -2017*, Nairobi: Government of Kenya

GoK (2010a), *The Constitution of Kenya, Section 5 Land and Environment,* Nairobi: Government of Kenya

GoK (2010b) *Agricultural Sector Development Strategy for 2010-2020*, Nairobi: Government of Kenya

GoK (2004) *Strategy for Revitalizing Agriculture* (SRA 2004-2014), Nairobi: Government of Kenya

GoK (2003) *Economic Recovery Strategy for Wealth and Employment Creation, 2003 – 2007*, Nairobi: Government of Kenya

GoK (1996) *The Policy Framework Paper. Economic Reforms for 1996–1998*, Nairobi: Government of Kenya

GoK (1994) *National Food Policy*, sessional paper 2, Nairobi: Government of Kenya

Haggblade, S. (2005) 'From Roller Coasters to Rocket Ships: the Role of Technology in African Agricultural Successes', pp. 139–159 in G. Djurfeldt, H. Holmén, M. Jirström and R. Larsson. (eds) *The African Food Crisis: Lessons from the Asian Green Revolution,* Wallingford and Cambridge, MA: CABI Publishing

Holmén, H. (2005) 'Spurts in Production - Africa's Limping Green Revolution' pp. 65–85 in G. Djurfeldt, H. Holmén, M. Jirström and R. Larsson. (eds) *The African Food Crisis: Lessons from the Asian Green Revolution,* Wallingford and Cambridge, MA: CABI Publishing

Keeley, J. and Scoones I. (2003) *Understanding Environmental Policy Processes; Cases from Africa,* London: Earthscan/James and James

Kinyangi, J., Recha, J., Kimeli, P. and Atakos, V. (2015.) *Climate - smart villages and the hope of food security in Kenya,* CCAFS Info Note, Copenhagen: CGIAR Research Program on Climate Change, Agriculture and Food Security

Kristjanson, P., Krishna, A., Radeny, M. and Nindo, W. (200) 'Escaping Poverty and Becoming Poor in 20 Kenyan Villages', *Journal of Human Development* 5: 211–226

Leach, M., Scoones, I. and Stirling, A. (2010) *Dynamic Sustainabilities: Technology, environment, social justice*, London: Routledge

McCann, J. (2001) 'Maize and Grace: History, Corn, and Africa's New Landscapes, 1500-1999', *Comparative Studies in Society and History* 43.2: 246–272

Moussa, Z. (2009) 'Tips for Trainers. Rivers of Life', *PLA 60*, London: International Institute for Environment and Development (IIED): London, http://pubs.iied.org/G02828 (30 January 2018)

Mungai D. N., Ong,. C. K., Kiteme, B., Elkaduwa, W. and Sakthivadivel, R. (2004) 'Lessons from two long-term hydrological studies in Kenya and Sri Lanka', *Agriculture, Ecosystems and Environment* 104: 135–143

Nussbaum M. (2011) *Creating Capabilities: The Human Development Approach*, Cambridge M A: Harvard University Press, pp. 237

Ockwell, D. and Byrne, R. (2015) 'Improving technology transfer through national systems of innovation: climate relevant innovation-system builders (CRIBs)', *Climate Policy* 16.7: 836–854

Odada, E., Olago, D., Kulindwa, K., Ntiba, M. and Wandiga, S. (2004) 'Mitigation of environmental problems in Lake Victoria, East Africa: Causal Chain and policy options analysis', *Ambio* 33.1-2: 13–23

Oluoch-Kosura, W. and Karugia, J. T. (2005) 'Why the Early Promise for Rapid Increases in Maize Productivity in Kenya was not Sustained: Lessons for Sustainable Investment in Agriculture' pp. 181–196 in G. Djurfeldt, H. Holmén, M. Jirström and R. Larsson (eds) *The African Food Crisis: Lessons from the Asian Green Revolution*, Wallingford and Cambridge M A: CABI Publishing

Peters, A. R., Domingue, G., Olorunshola, I. D., Thevasagayam, S. J., Musumba, B. and Wekundah, J. M. (2012) 'A survey of rural farming practice in two provinces of Kenya. 1. Demographics, agricultural production and marketing', *Livestock Research for Rural Development* 24.5, http://www.lrrd.org/lrrd24/5/pete24087.htm (30 January 2018)

Place, F., Andato, M., Hebinck, P. and Omosa, M. (2006) *Impacts of Agro-based Soil Fertility Replenishment Practices on the Poor in Western Kenya,* Research Report no 142, Washington D C: International Food Policy Research Institute (IFPRI)

Rono, K. (2002) 'The impact of the structural adjustment programmes on Kenyan society', *Journal of Social Development in Africa* 17.1: 81–98

Sen, A. (2001) *Development as Freedom*, Oxford: Oxford University Press

Toenniessen, G., Adesina, A. and DeVries, J. (2008) 'Building an Alliance for a Green Revolution in Africa', *Annals of the New York Academy of Sciences* 1136.1: 233–242

Ugunja Strategic Development Plan (2013) *Ugunja Constituency Development Plan for 2013-2018,* County Government of Siaya, http://bit.ly/2E29abp (30 January 2018)

World Bank (2015) *World Development Indicators 2015*, Washington DC: World Bank