9 Transitioning toward climate-neutral and resilient smallholder farming systems

An institutional perspective

Giacomo Branca, Luca Cacchiarelli, Udaya Sekhar Nagothu, and Chiara Perelli

Introduction

The global food production system faces many challenges, including increasing food demand due to a growing population and climate change, which is expected to affect food production and stress the natural resource base upon which agriculture depends (IPCC, 2014). This is particularly true in sub-Saharan Africa, where a fast-growing population, food insecurity, environmental degradation, resource depletion, and increasing smallholder vulnerability to climate change is making it difficult to scientists and policy makers to address the problems (Li et al., 2019). For African smallholders, it is even more important to adopt climate-resilient agriculture in order to make a sustainable transition toward climate-neutral and resilient farming systems (CNRFS). However, the adoption and diffusion of climate-smart technologies have been slow (Branca and Perelli, 2020). The underdeveloped rural financial options, inadequate research and extension services, insufficient market infrastructure, and lack of policy support often contribute to the slow diffusion of innovation in the agriculture sector.

Value chains (VCs) represent one of the few options for small producers to access larger markets and innovative technologies (World Bank, 2007). However, the private sector does not see the smallholder segment as a potential market source for its products and services and vice versa. Indeed, most smallholders in developing countries face bottlenecks in accessing markets and in capturing the value addition, which is often exploited by intermediaries along the VC. Unlocking the complexity in VC pathways, strengthening linkages among the different actors of the VCs, and supporting the development of innovative business models for small producers can contribute to overcome such barriers to market entry. This is particularly relevant for the smallholder adoption of CNRFS-related innovations.

The objective of the chapter is to provide an institutional perspective about innovations for a transition toward CNRFS, with a focus on VCs. In highlighting the role played by stakeholders in the dynamics and partnerships for the diffusion of climate-resilient innovative technologies, we focus on the how and who should

DOI: 10.4324/9781003273172-9

be engaged, and what are the benefits and challenges of such engagement. In this context, the case of dairy VCs in two Eastern Africa countries (Kenya and Rwanda) will be discussed, with focus on the socio-economic barriers faced by smallholders. Adoption of technological innovations is dependent on the proper institutional and policy support. The recommendations from the chapter can help in developing frameworks for upscaling adoption of CNRFS. Right policy and institutional settings are necessary to overcome barriers to innovation adoption, and to foster coordination.

The chapter is organized as follows: the next section presents the conceptual framework. The case studies are described in section "Case studies", followed by the results in section "Discussion". Toward the end, conclusions are presented.

Conceptual framework

Multiple institutional factors can prevent primary producers from adopting innovative technologies and, in turn, exploiting market opportunities and the business environment (Poulton et al., 2006; Markelova et al., 2009; Nagothu, 2015, 2018). They include (i) households' socio-economic characteristics, including their assets, education, gender, and property rights; (ii) limitations in infrastructure and input markets, for instance, credit, seed, or fertilizer; and (iii) insecure access to information services.

Smallholder farmers' decision to adopt agricultural innovations requires a good combination of the institutions and policies, which can help to overcome barriers and limiting factors. From an institutional perspective, different models of VC integration are possible (Montefrio and Dressler, 2019), ranging from informal agreements to more complex and formalized relations such as out-grower schemes (Branca et al., 2016). The VC partnerships are increasingly becoming useful pathways to tackle these limitations, evidenced in the active promotion of multi-stakeholder groups represented by the different VC actors – for instance, producers, farmer organizations, input and service providers, private sector, research institutions, government agencies and non-governmental organizations (NGOs), small and medium enterprises (SMEs) that operate at different levels. The synergy derived from the partnerships can overcome barriers in the adoption (Kolk et al., 2008). Partnerships should be based on interactive learning, empowerment, and collaborative governance that enables stakeholders with interconnected problems and ambitions, but with different interests, to be collectively innovative and resilient when faced with the emerging risks, crises, and opportunities of a complex and changing environment (Woodhill and van Vugt, 2011). By addressing the institutional business environment, partnerships can play a pivotal role in enhancing the chances for producers to be viable suppliers of VCs being a combination of organizational activity functional to production and marketing (Wijk et al., 2010). Partnerships can be vehicles for the diffusion of agricultural innovations (Hermans et al., 2017).

Successful cases of innovation adoption invariably demonstrate a range of partnerships and network-like arrangements that connect knowledge users, knowledge producers, and others involved in the market, policy, and civil society arenas (Hall, 2012). In this context, public extension services can play a brokerage role, beyond their traditional role of linking technology and farmers, networking with relevant VC actors, and can help to negotiate changes in the policy environment and investment arrangements. Several factors and processes enable or hinder interactions, both within and external to multi-actor co-innovation partnerships (Cronin et al., 2021). Factors that enable partnerships to achieve their own goals are based on the inclusion of partners linked with already existing networks that can facilitate internal collaboration and couple with external environment including policy and market conditions.

Smallholder farmers need to be genuinely engaged with the VC actors so that they benefit from the added value for their products (AFI, 2017). The success of a particular product in VC development will depend on smallholder stewardship of the program and their involvement early in the VC development process (CGI, 2016). On their own, small farmers who constitute a majority are disadvantaged when it comes to accessing markets, credit, and agricultural resources. This is one of the reasons for poor adoption of innovations on small farms. In response, countries such as India have initiated Farmer Producer Organizations (FPOs) to enable farmers work collectively to reduce costs, improve market access, drive higher agricultural productivity, enhance food security and livelihood development (Verderosa, 2021). The FPOs provide a good platform for strengthening smallholder stewardship in the VC development.

From the policy point of view, a stable political environment with adequate legislative measures can favor innovation adoption and encourage rural revitalization (Kosec and Resnick, 2019; Branca et al., 2022). A wide variety of options exist to create a policy environment conducive to innovation adoption (Lybbert and Sumner, 2012), ranging from legislative and regulatory instruments to direct investments, property right allocations, and economic incentives or subsidies.

The adoption of CNRFS will succeed when there are stable and assuring markets for the farmer's produce also providing adequate opportunity to farmers to earn higher incomes. The extent of adoption will also depend on social and environmental context, whether farmers are educated and used to new tools and knowledge, age and gender (Nagothu, 2018). It is important to consider whether the knowledge transfer takes into proper consideration factors such as gender with differentiated needs. A transformative change of smallholders toward CNRFS is required to cope with climate change and ensure food and nutrition security. Climate-resilient innovative farming practices could include (i) improved agronomic practices and effective crop management, (ii) tillage and residue management, and (iii) efficient water management. A combination of improved agronomic technologies and practices can be used to cope with the more unpredictable conditions and the resulting impacts caused by climate change. Examples of such technology packages comprise use of improved crop varieties (e.g., heat and pest tolerant), implementation of crop rotation or intercropping (e.g., cereal-legume), planting cover crops, and avoiding bare fallow (Scialabba et al., 2010). Tillage cropping systems focus on minimum soil disturbance in conjunction with the retention of crop residues on the soil surface (mulching) to enhance water infiltration, prevent runoff, and protect the soil from erosion and crusting by rainfall (Scopel et al., 2004). Proper water management can help capture more rain, making more water available to crops, and using water more efficiently (Rockstrom and Barron, 2007; Vohland and Barry, 2009; Branca et al., 2013), e.g., through planting pits and tied ridge systems which increase infiltration, reduce erosion and the loss of water and soil from arable land (Wiyo et al., 2000). Such conceptual links are shown in Figure 9.1 and discussed below.

Households' socio-economic characteristics. Socio-economic characteristics of smallholder producers are highly heterogeneous (de Oca Munguia and Llewellyn, 2020). Their capacities can be different in terms of education and knowledge intake. According to Huffman (2020), innovation adoption is facilitated by enhanced knowledge and access to formal education which may improve human capital and management capacity. Besides, assuring physical assets' property rights (e.g., land tenure) can help farmers obtain long-term benefits from current investments, thereby increasing the likelihood of adoption (Kassie et al., 2015; Mwangi and Kariuki, 2015; Branca and Perelli, 2020). In this context, social capital (e.g., inclusion in a social network) facilitates innovation adoption, especially on smallholder farms (Husen et al., 2017). Social capital cannot ignore the importance of women and their contribution to agriculture. However, agricultural research and extension has been traditionally biased toward men and there has not been an

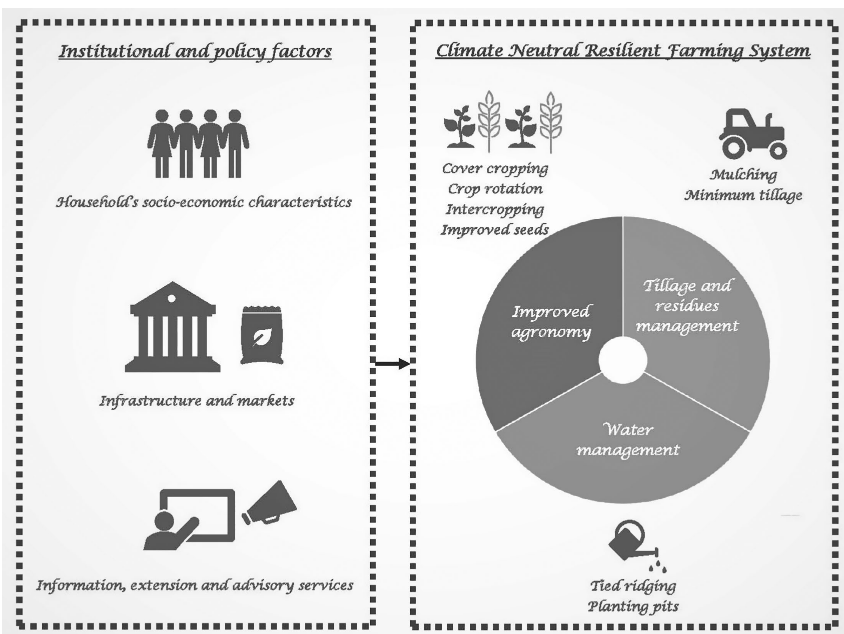

Figure 9.1 Institutional and policy factors affecting smallholders' adoption of CNRFS-related innovations: a conceptual framework.

adequate focus on women (Nagothu, 2015). This is a major challenge in societies where the gender divide is large, and women are not allowed to make decisions on par with men. CNRFS innovations that ignore the specific needs of women can be a major setback to ensure the success of adoption. This can become a major concern where out-migration of men is happening due to economic, climatic, and other reasons, which leaves the burden of agriculture on women. This is the case in several developing countries, including parts of Africa, where men and youth are migrating to cities, as agriculture is becoming risky and is no longer profitable.

Infrastructure and markets. Poor infrastructure and marketing services, costly inputs and transportation, limited access to output markets, and inadequateness of post-harvest facilities (e.g., storage and agro-processing options) represent critical barriers to vertical coordination, preventing smallholders' market access and value addition (Barrett, 2008). This can influence producers' capacity and propensity to make investments in technology innovations, and to determine the appropriate innovation strategy (Mutenje et al., 2016). Most smallholders in Africa are not linked to markets due to various reasons including their remoteness in location, low farm-gate prices, and lack of organization (Wiggins and Keats, 2013). Often a catalyst is necessary to establish linkages between farmers and markets or organize them into groups or collectives. In any case, functioning and accessible markets, particularly for agricultural commodities, are vital for agricultural growth to realize its potential as a powerful driver of rural poverty reduction (Kürschner et al., 2016). Since farming is a risky business, planning and development of VCs should consider all possible risks, including market and political, to ensure that adequate mitigation measures are in place.

Information, extension, and advisory services. Access to information and knowledge about agricultural innovations is another limiting factor of technology adoption (Cafer and Rikoon, 2018). Public extension and advisory services (EAS) often offer low-quality services but the increased private sector involvement in public agricultural extensions (e.g., through public-private partnerships) may also leave resource-poor farmers underserved (Birner et al., 2009; Branca et al., 2022). Advisory services should be designed to facilitate smallholder households' access (Norton and Alwang, 2020) and to link technology adoption to enhancement of market opportunities (Haug et al., 2021). Digital extension tools are being increasingly used these days to bridge the knowledge, gender, and digital divides and empower the rural community by fostering inclusive development and participatory communication (Raj and Nagothu, 2016). An innovative example of digital extension platform is the village knowledge center that can facilitate timely dissemination of knowledge through multiple communication tools.

Case studies

This section presents the results of two case studies in Eastern Africa (Kenya and Rwanda).[1] The case studies explore the socio-economic, physical, and agro-ecological factors that influence on-farm adoption of innovative climate-smart agricultural practices and the related adoption barriers, with a focus on the VC and the relevant institutional and policy perspectives. This chapter focuses on the introduction of the *Brachiaria* grass forage to improve the livestock dairy value chain and the factors that influenced its success in adoption. The forage is an innovation in the case study areas and has contributed to increased climate resilience of the current dairy production systems, fostering their transition toward CNRFS.

Brachiaria grass is a perennial tropical forage with high productivity in terms of palatable and nutritious biomass, tolerates abiotic and biotic stresses, improves soil fertility, produces more nutritious animal feed, and increases overall livestock productivity (Mutimura and Ghimire, 2020). In addition to improvements in livestock productivity in terms of milk production, it is known to contribute significantly toward ecological restoration of degraded lands and soil erosion control (Ghimire et al., 2015). With its appositive traits, it can be one of the promising climate-neutral resilient forage and a good component that can strengthen adaptation and mitigation in crop-livestock integrated systems. In Rwanda, the *Brachiaria* grass has proved to improve the resilience of mixed crop-livestock systems and a buffer against frequent crop failures due to extreme weather events and climate change (Mutimura and Ghimire, 2020). It has large root systems, sequesters carbon into soils, resistant to droughts, performs well in low fertility soils, and provides several environmental benefits in the form of ecosystem services (Djikeng et al., 2014; Njarui et al., 2016, 2020). The fodder grass has a positive impact not only on milk production but also on crop yields (in crop rotation systems) due to the benefits it has on soil fertility. Overall, it generates significant ecological, nutritional, and socio-economic benefits (Table 9.1).

The introduction of *Brachiaria* grass in the farming systems of the case study areas has been achieved due to the promotion of a participative value chain governance approach supported by multi-actor platforms (MAP) established in the two cases, i.e., a partnership aimed at linking farmers' organizations, scientific community, public and private sector, non-governmental organizations (NGOs), and SMEs operating within the same product chain. The MAP members have been involved in different activities, including validation, extension, providing feedback, and upscaling of innovative *Brachiaria*-based dairy production systems. Experience has shown that the MAP members played an important role in strengthening science-policy linkage.

Table 9.1 Ecological, nutritional, and socio-economic benefits provided by *Brachiaria* forage

Ecological benefits	*Nutritional benefits*	*Socio-economic benefits*
• Increased livestock productivity • Reduced GHG emissions • Greater climate resilience	• Increased dairy cattle and beef productivity • Improved household nutrition and health	• Increased household income and improved livelihood • Adaptation through income diversification

Adapted from Ghimire et al. (2015).

Evidence shown here is supported by primary data collected through sample household surveys and focus group discussions, MAP meetings, and key informant interviews conducted in the project sites from 2018 to 2020 through a H2020 project "InnovAfrica" funded by the European Commission (www.innovafrica.eu). For each case study, we provide a list of actors operating at various stages of the VC; a description of smallholder farmers' characteristics, which are expected to have an impact on the innovation adoption process (and descriptive statistics resulting from the household survey); a catalog of the policies and institutions in place; and a narrative about the potential strategies to overcome adoption barriers along the VC, developed through the *Theory of Change* methodology through MAP meetings.

The case study in Kenya

The study was carried out in the Kangundo subcounty, which is situated in the eastern midlands. Most smallholders rely on agriculture income from the growing of maize and grain legumes and from livestock production. The introduction of *Brachiaria* grass forage into the dairy cattle production system was expected to generate benefits on biomass production and livestock productivity and, indirectly, on smallholders' livelihood and food security. The dairy VC is described below. It was centered on small producers and comprises input providers, traders, processors, and retailers.

The value chain structure

Input provision: Various entities supply inputs and services to farmers and dairy cattle herders. Agro-dealers sell seeds, fertilizers, and pesticides. The most preferred forage seed attributes are pasture quality, suitability for area/local climatic conditions, and durability in terms of harvesting period. Sales arrangements included cash, credit, discounted for bulk, and discounted for preferred customers. Fertilizers were subsidized under the National Accelerated Agricultural Inputs Access Program (NAAIAP). Agro-dealers were appointed as distribution agents for subsidized inputs by the government. To sell seeds, a license is required, in addition to a business permit provided by the county government. Agro-vet companies and aggregators (cooperatives) supply feeds, supplements, drugs, and artificial insemination (AI) services. They usually make a one-on-one contact with farmers as well as site visits (in collaboration with extension agents). The government requires that all agro-vets have an attendant trained in veterinary (e.g., a para-vets or veterinaries registered with the Veterinary Board).

Output production: Small-scale dairy farmers account for about 80% of producers. On average, they own one milking cow per family with a calf per cow per year. Daily milk production was about 5–7 liters per day per cow. Farmland size is 1,500 m^2/family, which also includes both animal housing and family house. Land dedicated to cropland is approximately one acre per farmer household. The remaining 20% of farmers are of medium and large scale. Productivity was estimated at

20–30 liters per day from three to four milking cows per household for medium-scale farmers, and at more than 150 liters per day from about ten milking cows for large-scale producers.

Trading: Our study showed that raw milk was sold to aggregators/cooperatives (32%), traders (23%), retailers (4%), and local basic processors (7%). Remaining quantity was directly sold to consumers. Dairy cooperatives allowed farmers to collectively market their produce and access various inputs and services as described below:

- a *Limuro Dairy Cooperative*, with around 8,000 active members. Services provided to members included raw material collection, processing and marketing, subsidized fertilizer provision, extension and technical services (e.g., veterinary, agriculture extension). Service provision to members is based on a credit-system (i.e., costs are charged at the end of each month and deducted directly from milk sales).
- b *Kambusu Cooperative* is the largest cooperative in the area. It collects approximately 3,000 liters per day. Payments to members were made monthly through a bank. Milk was mostly sold outside the area, while the remaining 30% was sold to local retail shops.
- c *Kakuyuni Cooperative* was recently established. Its members are mainly small-scale farmers.

Local traders connected farmers to milk outlets. They mainly comprised milk hawkers who collected milk from farmers and supply to different buyers, including hotels and schools. This marketing channel is preferred by farmers because of prompt payments.

Processing: Processors purchased raw milk directly from individual farmers (e.g., New Kenya Cooperative Creameries) or from farmer cooperatives. The latter option reduces transport and logistics costs. Processing consists of pasteurization and ultra-heating. Milk is then either packed into packets/containers or further processed into yoghurts, butter, cheese, and ghee.

Retailing: Retailers include supermarkets, milk dispensing machines (ATMs), mobile vendors, milk kiosks, and bars. Supermarkets sold a diverse range of dairy products and can operate ATMs which were also operated by individual entrepreneurs. Mobile vendors sold milk to shops, outlets, and small hotels, using private means of transport (motorcycles or bicycles). Milk kiosks or bars sold milk to consumers on behalf of shops or hotels.

Farmers' characteristics

The results of the survey conducted over a sample of 316 households indicated that only 11% of the households in the study area included *Brachiaria* into their farming systems. Table 9.2 reports the socio-economic characteristics of the sample. Most smallholder farmers are male, middle aged. They attended at least primary school. With reference to economic assets, households' average monthly

Table 9.2 Socio-economic and physical characteristics of farmers in Kangundo (n = 316)

Variables	*Description*	*Mean*	*Std. Dev.*	*Min*	*Max*
Brachiaria use	Household uses *Brachiaria* (1/0)	0.117	0.322	0	1
Household head characteristics					
HH head gender	Household head male (1/0)	0.759	0.428	0	1
HH head age	Age of household head (years)	57.946	12.935	27	90
HH head education	Household head attended at least primary school (1/0)	0.975	0.157	0	1
Economic assets					
HH total income	Total farm income (USD)	233.724	232.503	4.95	2376
Credit	Access to credit (1/0)	0.320	0.467	0	1
Subsidy fertilizers	Subsidy's access to buy fertilizers (1/0)	0.022	0.147	0	1
Physical assets					
HH total area	Total farm size (ha)	1.815	8.102	0.1	141.7
Local breed	Household own local breed (1/0)	0.427	0.495	0	1
Exotic breed	Household own exotic breed (1/0)	0.310	0.463	0	1
Crossbreed	Household own crossbreed (1/0)	0.472	0.500	0	1
Fertilizers use	Household uses of fertilizers (1/0)	0.665	0.473	0	1
Environmental context					
Semi-arid AEZ	Agro-ecological Zone semi-arid (1/0)	0.981	0.137	0	1
Drought experience	Household experienced drought (1/0)	0.911	0.285	0	1
Flood experience	Household experienced floods (1/0)	0.025	0.157	0	1
Irregular rain experience	Household experienced irregular rains (1/0)	0.873	0.333	0	1
EAS					
Extension provided by government	Access to extension services provided by government	0.206	0.405	0	1
Extension provided by private company	Access to extension services provided by private company	0.044	0.206	0	1
Extension provided by NGO	Access to extension services provided by NGO	0.016	0.125	0	1
Extension provided cooperatives/farmers	Access to extension services provided by cooperatives/farmers	0.098	0.298	0	1
Extension provided by bank/insurance	Access to extension services provided by bank/insurance	0.076	0.265	0	1
Group participation	Participation to groups (1/0)	0.449	0.498	0	1
Household food security					
Food security	Food Consumption Score	85.060	15.747	30	112

Based on own survey data collected.

income amounted to US$233.72. Nearly 32% of farmers had access to credit, while only 2% benefited from input subsidies. Considering the physical assets, the average land available to farmers is less than 2 hectares; most common livestock species are local and crossbreeds; fertilizers were commonly used. With reference to the environmental context, most farmers perceived climate alterations such as droughts (91%) and irregular rains (87%). With regard to social capital, about half of sampled households participated in some form of agricultural groups or associations.

Policies and institutions

Policy context. The main policies implemented in the sector were as follows:

- a Seed and fertilizer subsidies through the "Input policy". They aim to provide inputs to farmers at affordable prices, therefore expanding inputs access to smallholders. However, inadequate funds allocated to this policy and targeting difficulties limited policy effectiveness.
- b Public extension service support through the "Livestock policy". It aims to facilitate demand-driven extension services and increase production efficiency even if farmers lack awareness of its importance. The limiting factors to policy effectiveness were inadequate financial resources allocated to policy, limited capacity of extension workers, and lack of transportation means to reach rural areas.
- c Provision of small irrigation equipment through the "Agriculture irrigation policy". It aims to provide irrigation infrastructure to farmers in arid and semi-arid land. Inadequate financial resources, scarce technologies, and insufficient capacity of technical staff to facilitate implementation limited policy effectiveness.
- d Establishment of appropriate storage facilities through the "Agribusiness policy". It aims to provide storage facilities, make livestock commercially oriented and competitive, and provide capacity building on agribusiness skills. Inaccessibility of appropriate storage facilities (e.g., coolers), limited funds, and insufficient awareness regarding the efficient handling of post-harvest agricultural produce were found to be the main limiting factors.

Extension services: Extension service provision is guided by the National Agriculture Sector Extension Policy (NASEP). It is emphasized that the private sector should play a large role in providing extension services. Despite such a policy, the extension personnel to farmer ratio remained low, the main provider being the public sector. Also, budgetary allocation to extension services has dwindled, and the quality of private extension is questionable. To enhance access to markets, cooperative movements are promoted, but it is not adequate in their current form.

Market and other Institutions: More than three-quarters of sampled farmers had access to the market through traders, cooperatives, and individuals. Low prices and unstable prices were the most important constraints in marketing. Several institutions supported the dairy sector including the Kenya Dairy Board, responsible for ensuring efficient production, marketing, distribution, and supply of milk and dairy products; the Kenya Bureau of Standards (KEBS), with the responsibility of setting and enforcing standards for all products; the Public Health Division of the Ministry of Health, which ensured maintenance of hygiene standards along the chain; and the Kenya Agriculture and Livestock Research Organization, which is incharge of public agricultural research. The combined support from the government agencies plays an important role in strengthening the livestock value chain.

Value chain development strategies

The *Theory of Change* developed was based on inputs from the MAP meetings where members identified the following barriers to the adoption of *Brachiaria*, including lack of information on forage grass, expensive forage seeds due to high production costs and limited seed production capacity, small land size limiting the possibility to develop fodder production, and lack of irrigation opportunities and reliance on fluctuating rainfall patterns. Establishing knowledge platforms to share information might overcome the lack of knowledge about forage grass in general and *Brachiaria* in particular. Use of alternative propagation methods (e.g., splits) and wider involvement of public-private partnerships to multiply seeds are plausible interventions to enhance *Brachiaria* multiplication. Increasing farmers' knowledge about water harvesting techniques and mapping areas indicating suitable locations for irrigating pastures can support forage production expansion.

Smallholders' access to inputs can be increased by expanding subsidy access to a wider range of inputs (seeds, fertilizers, equipment) from a variety of providers, e.g., through the e-voucher digital service delivery. An increased efficient use of inputs might also be achieved through enhancing public-private extension and advisory services and strengthening linkages between research and farmers through innovation sharing. A summary of the Theory of Change exercise is reported in Figure 9.2.

The case study in Kenya

The case study refers to *Nyamagabe* district, situated in the Southern Province, characterized mainly by maize-cattle-based farming systems.

The value chain structure

Input provision: Agro-dealer and agro-vet companies supplied inputs and services. Some agro-dealers also provided technical assistance to farmers, together with public extension agents. Inputs' selling prices are partially set by the Ministry of Agriculture and Animal Resources (MINAGRI) under the subsidy input policy. However, most farmers cannot afford purchasing inputs, even if subsidized, due to income constraints.

Output production: Dairy farmers are mostly (about 90%) small-scale producers with an average of one to two dairy cows per household. Large dairy farmers owned on average six dairy cows. Milk productivity was about 3 liters per cow per day. Production within both small- and large-scale farming was based on integrated crop-livestock systems. Dairy farmers sold milk to dairy cooperatives (30%), local consumers (20%), and local traders (5%), while self-consumption varied between

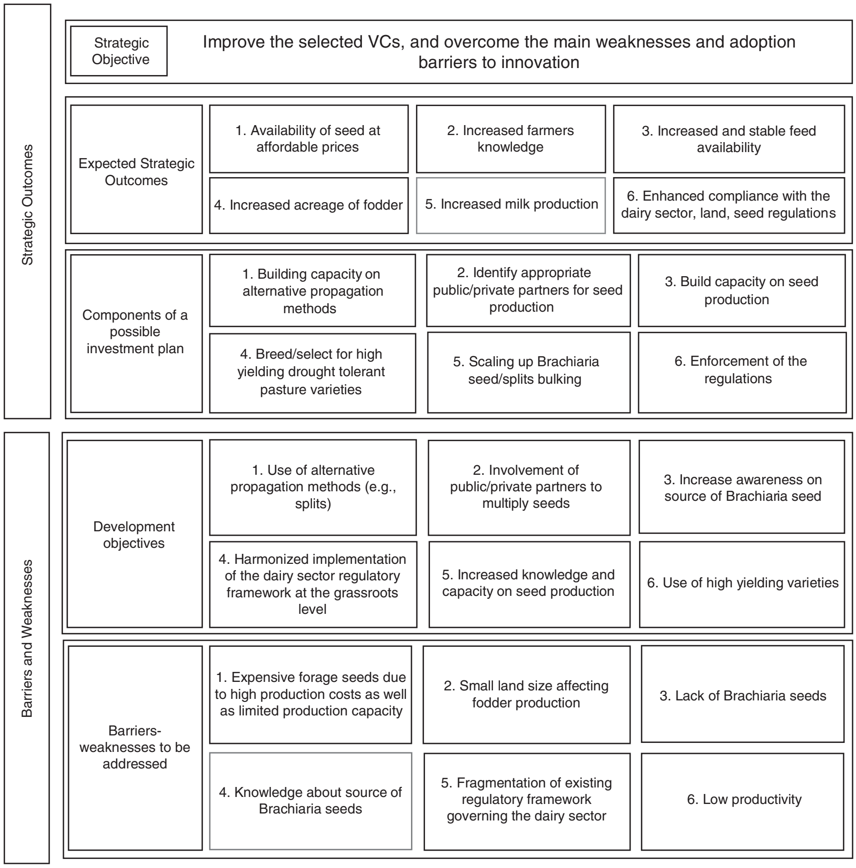

Figure 9.2 Theory of Change: introducing *Brachiaria* into the dairy VC in Kangundo (Kenya).

Source: Authors' own elaboration.

30% and 50%. The minimum price for milk at the farm gate was set by the government and was 200 Rwandan franc (RWF) per liter[2] in 2017. However, on the informal market, the price for local consumers was 160 RWF per liter in the same year. Farmers did not process raw material for the formal market, but they processed fermented milk for self-consumption and for sales to local consumers.

Trading: One dairy cooperative collected the raw product through a milk collection center. With reference to 2017 (when the data collection has been conducted), despite its milk collection capacity of 5,000 liters per day, local dairy farmers supplied only between 500 and 800 liters per day (in the dry and wet season, respectively). The cooperative bought raw milk from local dairy farmers (at a price of 200 FRW per liter) and from local traders (at 220 FRW per liter). The collected and cooled milk was sold at 250 FRW per liter to local traders, restaurants, and single consumers. Local traders in the area operated at two different levels, playing an intermediary role in two stages of the supply chain: (i) they bought milk from farmers at 200 FRW per liter and resold it to the dairy cooperative at 220 FRW per liter; (ii) they bought milk from the dairy cooperative at 250 FRW per liter and resold it to local supermarkets and local restaurants at 300 FRW per liter.

Processing: Packed milk was supplied by national processors, who bought milk from farmers located in other production areas. The largest national company was *Inyange Industries*, which processes and distributes most produced milk in the country. It processed a wide variety of dairy products (packed milk, pasteurized milk, flavored milk, ghee, butter, yoghurt). Products were also exported to Sudan, South Africa, Uganda, Kenya, and Tanzania. Within the domestic market, dairy products were supplied to retailers via independent or own distributors.

Retailing: Independent distributors were registered with the *Inyange Industries*. They bought packed milk at 880 FRW per liter from national processors and sold it to the groceries/supermarket at 930 FRW per liter. Raw milk was bought by distributors at 350 FRW per liter and sold to local groceries at 400 FRW per liter. At the retail level, consumer prices were 1,000–1,200 FRW per liter for packed milk and 430 FRW per liter for raw milk (consumers bring their own containers). Distributors sold packed milk on various markets in the country, whereas individuals mostly sold unpacked cooled milk mainly in urbanized and business center areas.

Farmers' characteristics

The results of the survey conducted over a sample of 308 households indicated that only 4% of the households in the study area included *Brachiaria* into their farming systems. Table 9.3 reports the socio-economic characteristics of the sample. Most smallholder farmers were male, middle-aged, and attended at least primary school. Considering the economic assets, the average monthly income amounted to US$43.9. Almost 40% of sampled farms had access to credit, while only a few farmers benefited from seed and fertilizer subsidies (2% and 3%, respectively). Considering physical assets, the average land parcel size was less than 1 ha; dairy cattle production relied mostly on crossbreeds (79%); fertilizers used was limited (only 13% of sampled farmers). With reference to climate change, most farmers perceived climate alterations, mainly droughts (85%). Approximately 30% of farmers were part of agricultural groups/associations.

Policies and institutions

Policy context: The main policy instruments implemented were as follows:

- A gradual increase in the number of improved dairy cows bred was promoted by the government through the "One cow per poor family" program, whose objectives included fighting malnutrition and poverty through productivity increase and a reduction of pressure caused by grazing on the limited pasture resources.

Table 9.3 Household socio-economic and physical characteristics in Nyamagabe (308 HHs)

Variables	*Description*	*Mean*	*Std. Dev.*	*Min*	*Max*
Brachiaria	Household uses *Brachiaria* (1/0)	0.020	0.057	0	1
Household head characteristics					
HH head gender	Household head male (1/0)	0.714	0.452	0	1
HH head age	Age of household head (years)	52.237	12.418	21	89
HH head education	Household head attended at least primary school (1/0)	1.049	5.617	0	99
Economic assets					
HH total income	Total farm income (USD)	43.975	48.833	0	300
Credit	Access to credit (1/0)	0.377	0.485	0	1
Subsidy seed	Subsidy's access to buy seeds (1/0)	0.019	0.138	0	1
Subsidy fertilizers	Subsidy's access to buy fertilizers (1/0)	0.029	0.169	0	1
Physical assets					
HH total area	Total farm size (ha)	0.693	0.879	0	5.7
Local breed	Household own local breed (1/0)	0.188	0.392	0	1
Exotic breed	Household own exotic breed (1/0)	0.078	0.268	0	1
Crossbreed	Household own crossbreed (1/0)	0.792	0.406	0	1
Fertilizers use	Household uses fertilizers (1/0)	0.133	0.340	0	1
Brachiaria	Household uses *Brachiaria* (1/0)	0.003	0.057	0	1
Environment					
Drought experience	Household experienced drought (1/0)	0.854	0.354	0	1
Floods experience	Household experienced floods (1/0)	0.172	0.378	0	1
Irregular rain experience	Household experienced irregular rains (1/0)	0.169	0.375	0	1
Social assets					
Extension provided by government	Access to extension services provided by government	0.058	0.235	0	1
Extension provided by private company	Access to extension services provided by private company	0.013	0.113	0	1
Extension provided by NGO	Access to extension services provided by NGO	0.003	0.057	0	1
Extension provided by cooperatives/farmers	Access to extension services provided by cooperatives/farmers	0.026	0.159	0	1
Extension provided by bank/insurance	Access to extension services provided by bank/insurance	0.000	0.000	0	1
Group participation	Participation to groups (1/0)	0.315	0.465	0	1
Household food security					
Food security	Food Consumption Score	46.979	19.357	0	100

Based on own survey data collected.

- Subsidies on livestock inputs (AI, forage, seeds) were included in the "Strategic and investment plan to strengthen the animal genetic improvement in Rwanda" whose objectives were to increase the number of AI users and improve livestock nutrition and feeding. However, inadequate funds allocated to this policy and high taxation level for vet pharmacies and feed industry limited its effectiveness.
- Subsidies on agricultural inputs were included in the "National agriculture policy" to enhance farm inputs' use and its efficiency. The limiting factors were inadequate financial resources allocated to the policy.
- Import and distribution of dairy cattle (with higher genetic potential) was included in the "Strategic and investment plan to strengthen the animal genetic improvement in Rwanda". The program aimed to increase the productivity of animal resources in a sustainable way and ensure that agriculture and livestock contribute to enhanced dietary diversity and quality at national and household levels. The following factors reduced policy effectiveness: taxes and licenses limiting semen imports for AI, low capacity of smallholders, lack of coordination, low involvement of the private sector.
- Tax exemption on importation of agricultural equipment and machinery in the "Agricultural Mechanization Strategy for Rwanda" policy, whose objectives were to increase the use of modern agricultural technologies and facilitate farmers in shifting from subsistence to commercial agriculture. However, available funds constrained effective policy implementation.

Extension services: They serve as focal points for facilitation and information related to the market, inputs, credits, and producer coordination. Options for extension delivery methods are becoming more pluralistic with the widespread use of mobile phones and information and communication technology (ICT). An extension communication system was built to allow direct feedback from extension workers to farmers for questions and queries. In addition, farmers can obtain information from different government institutions, also at decentralized level. This enabled farmers to access information on inputs markets available in the area. At the sector level, the government organizes savings and credit cooperatives (SACCO) which assisted farmers in obtaining loans for their business though micro-finance options. However, smallholders' access to extension advisory services was constrained by the exclusive availability of public extension agents and resources which were limited in size and scope.

Markets and other Institutions: Cooperatives, traders, and individuals were the most important marketing channels. However, half of sampled households had inadequate market access and were constrained by low and unstable farm-gate prices. The National Agricultural Export Development Board supports stakeholders' activities to process and export agricultural and livestock products. An exemption from taxation for selected agricultural inputs and equipment is an instrument established to enable and encourage the private sector to invest in agriculture.

Value chain development strategies

MAP members identified the following barriers to the adoption of *Brachiaria* forage in Rwanda despite its positive traits and benefits in terms of enhanced forage supply: lack of information on forage grasses, shortage of land for forage production, and lack of available seed material. The strategies suggested to overcome challenges included practical trainings, and on-farm demonstrations and trials that could mitigate the lack of technical and technological know-how, establishing a hub model for selling forage and exploiting cropping niches (e.g., under banana plantation) to overcome the issue of land shortage. Policies are required to support productivity enhancement through the increase in the available improved dairy cattle breeds. This can be reached by expanding the number of importers and streamlining the procedures for obtaining import licenses. Cooperatives might effectively provide both upstream and downstream services, facilitating access to input markets (fertilizers, credit) and training and serving as aggregators and quality promoters. The results from the Theory of Change exercise applied to the case study area are reported in Figure 9.3.

Discussion

The introduction of *Brachiaria* forage into the current farming systems of Kenya and Rwanda may generate ecological, nutritional, and socio-economic benefits

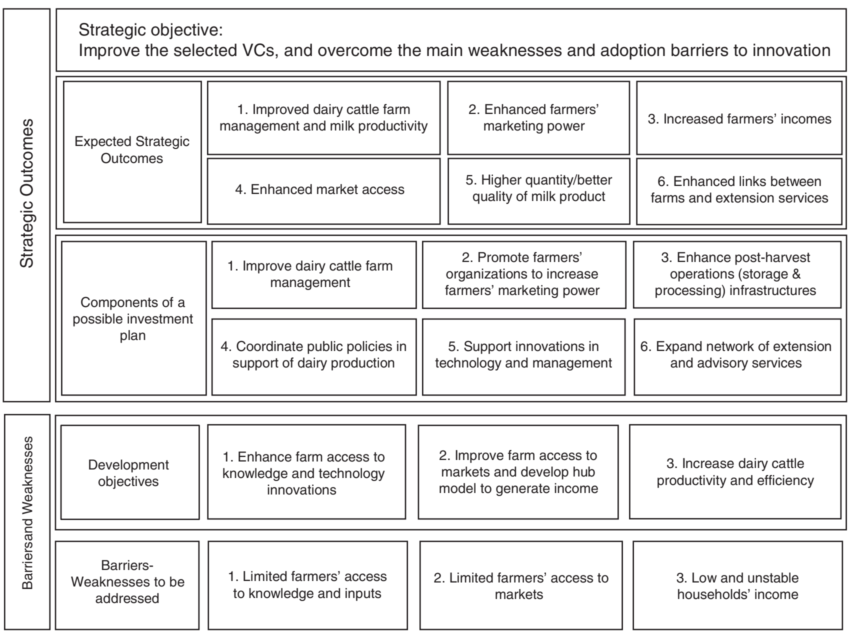

Figure 9.3 Theory of Change: introducing *Brachiaria* into the dairy VC in Nyamagabe (Rwanda) (authors' own elaboration).

along the VC. For example, *Brachiaria* cultivation fostered higher milk yields, expanded product flow along the chain, and improved dairy farmers' incomes. Thanks to the promising market opportunities and consumers' demand for a wide range of dairy products. Also, *Brachiaria* grass can be introduced as an intercrop or border crop, and on marginal lands, being able to survive in poor soils with low nitrogen and phosphorus contents with evident positive externalities in the form of enhanced soil fertility and climate resilience.

However, smallholders' adoption of *Brachiaria* was constrained by limited access to VCs' opportunities, seed material, including value addition and transformation. Small farmers often operated with limited knowledge and capacity, and in a context of poor infrastructures and weak access to technology and knowledge services. Also, they cultivated small land parcels and could not introduce forage production due to the need to prioritize land use for crop production and food security purposes. Milk was undersupplied and economies of scale could be introduced along the chain, with efficiency losses for all operators.

In both case studies, strategies to overcome adoption barriers included information dissemination, demonstration, and on-farm trials to motivate new farmers to uptake forage cultivation, coupled with investments to enhance availability of forage seeds as well as suitable land areas for forage production (e.g., through irrigation). Actions to improve coordination along the chain may lead to more efficient dairy VCs.

In this context, multi-actor initiatives as MAPS have the potential to be a forum to enhance the diffusion of information and knowledge as well as coordination along VC actors, with benefits for all the participants. Such platforms face the problem from a multi-stakeholder point of view, and can identify suitable development strategies including options to harmonize institutions and agricultural policies to facilitate diffusion of agricultural innovation.

Our findings confirmed results from other studies available in the literature according to which the low innovations adoption by smallholders was influenced by farm size, farmer's education status, institutional assets, marketing possibilities, and profits (e.g., Kangogi et al., 2021). The effect of households' physical assets on technology innovation adoption was positive, due to households' improved management capacity (Mwangi and Kariuki, 2015). Access to knowledge is also a critical factor for adoption. For example, Obi and Maya (2021) showed that awareness creation targeting remote rural areas as well as institutions to ease farmers' access to information can contribute to higher adoption rates. Information access and association membership positively influenced technology adoption and innovation (Chowdhury et al., 2014).

Some limitations to our findings exist. Farmer entrepreneurship plays an important role in influencing adoption decisions of smallholders. Mizik (2021) showed that small-scale farmers consider the length of the payback period when they decide on any adoption of climate-smart agricultural practices. One way is to compensate them for providing environmental benefits, which is still not an option in the case study areas. Also, aspects related to drivers of coordination, cooperation, and institutional transformation processes, as well as to economic incentives to attract spontaneous participation of VC stakeholders deserve further investigation.

Conclusions

The case studies of Kenya and Rwanda presented in this chapter demonstrated that the diffusion of climate-friendly and resilient forage grasses such as *Brachiaria* offered promising results and demonstrated how technology innovations can transform current systems into CNRFS. However, investments are to be made to improve availability and on-farm access to forage grass seed material and improve fodder and dairy-cattle management. At the same time, technology and institutional interventions in off-farm VC segments (marketing, processing, storage, standards regulation) are required to capitalize the expected benefits deriving from on-farm innovations. Despite challenges, the sub-Saharan Africa is slowly becoming a competitive marketplace for agri-products.

Smallholder production systems must enhance their productivity in a more resilient way to respond to the increasing food demand in the context of climate change. As in other sustainability transitions, innovations in the technology as well as in the institutional settings play a critical role. Indeed, adoption of innovative technology to increase production efficiency and transform farming systems toward CNRFS will not be possible without farmers' access to properly functioning institutions, including effective information and knowledge systems, timely delivery of modern input technologies, and market access.

In this context, existing policies and institutions operating in the African agri-food system should be harmonized, along with an effective governance for multi-stakeholder VCs. The development of stakeholders' platforms – such as MAPs – represents an institutional innovation which could respond to such demand. Other studies have also shown that MAPs play an increasing role in scaling up innovations in agricultural systems (Barzola et al., 2020). In the two case studies, MAPs identified specific strategies to develop the VC in a coordinated manner. This included structuring the public-private EASs in support of the development of professional capacities and skills of extension workers; supporting cooperatives to enhance smallholders' participation in the VC, including their access to knowledge and inputs; improving regulations for license import of technical inputs for animal production; setting adequate hygienic standards related to milk commercialization; promoting public-private-producer partnerships on information and knowledge management; introducing labor market policies to lift the labor scarcity constraint and ease the adoption of labor-consuming innovation technologies. MAPs can provide a conducive entry point for smallholders' linkage with markets, especially those requiring assurances that adequate volumes of commodities can be traded. They will also play a key role in improving smallholder farmers' innovation skills and designing entrepreneurial agribusiness models, which could be replicated to different VCs and upscaled to national and regional markets.

Notes

1 The case studies refer to the activities conducted within the H2020 InnovAfrica project (www.innovafrica.eu) funded by the EU (Grant agreement no 727201 and call SFS-42-2016).
2 US$1 is equal to 1,183 RWF.

References

Agriculture for Impact (AFI) (2017) 'Agriculture for Impact: Agriculture Value chains'. Available at: http://ag4impact.org/sid/socio-economic-intensification/building-social-capital/agricultural-value-chains/

Barrett, C.B. (2008) 'Smallholder Market Participation: Concepts and Evidence from Eastern and Southern Africa', *Food Policy*, vol. 33, no. 4, pp. 299–317.https://doi.org/10.1016/j.foodpol.2007.10.005

Barzola Iza, C.L., Dentoni, D. and Omta, O.S.W.F. (2020) 'The Influence of Multi-stakeholder Platforms on Farmers' Innovation and Rural Development in Emerging Economies: A Systematic Literature Review', *Journal of Agribusiness in Developing and Emerging Economies*, vol. 10, no. 1, pp. 13–39. https://doi.org/10.1108/JADEE-12-2018-0182

Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J. and Cohen, M. (2009) 'From Best Practice to Best Fit: A Framework for Designing and Analysing Pluralistic Agricultural Advisory Services Worldwide'. *Journal of Agricultural Education and Extension*, vol. 15, no. 4, pp. 341–355. https://doi.org/10.1080/13892240903309595

Branca, G., Cacchiarelli, L., Haug, R. and Sorrentino, A. (2022) 'Promoting Sustainable Change of Smallholders' Agriculture in Africa: Policy and Institutional Implications from a Socio-economic Cross-country Comparative Analysis'. Available at: https://www.frontiersin.org/articles/10.3389/fsufs.2022.738267/full

Branca, G. and Perelli, C. (2020) "Clearing the Air': Common Drivers of Climate-smart Smallholder Food Production in Eastern and Southern Africa'. Available at: https://www.sciencedirect.com/science/article/pii/S0959652620319478?via%3Dihub

Branca, G., Cacchiarelli, L., Maltsoglou, I., Rincon, L., Sorrentino, A. and Valle, S., (2016) 'Profits Versus Jobs: Evaluating Alternative Biofuel Value-chains in Tanzania', *Land Use Policy*, vol. 57, pp. 229–240. https://doi.org/10.1016/j.landusepol.2016.05.014.

Branca, G., McCarthy, N., Lipper, L. and Jolejole, M. C. (2013) 'Food Security, Climate Change and Sustainable Land Management. A Review', *Agronomy for sustainable development*, vol. 33, no. 4, pp. 635–650.

Cafer, A. M. and Rikoon, J. S. (2018) 'Adoption of New Technologies by Smallholder Farmers: the Contributions of Extension, Research Institutes, Cooperatives, and Access to Cash for Improving Tef Production in Ethiopia'. *Agriculture and Human Values*, vol. 35, no. 3, pp. 685–699. https://doi.org/10.1007/s10460-018-9865-5

Chowdhury, A. H., Hambly Odame, H. and Leeuwis, C. (2014) 'Transforming the Roles of a Public Extension Agency to Strengthen Innovation: Lessons From the National Agricultural Extension Project in Bangladesh', *The Journal of Agricultural Education and Extension*, vol. 20, no. 1, pp. 7–25. https://doi.org/10.1080/1389224X.2013.803990

Clinton Global Initiative (CGI) (2016) 'Engaging Smallholder Farmers in Value Chains: Emerging Lessons'. Available at: https://www.clintonfoundation.org/sites/default/files/cgi_smallholder_report_final.pdf

Cronin, E., Fosselle, S., Rogge, E. and Home, R. (2021) 'An Analytical Framework to Study Multi-Actor Partnerships Engaged in Interactive Innovation Processes in the Agriculture, Forestry, and Rural Development Sector', *Sustainability*, vol. 13(11), pp. 6428.

de Oca Munguia, O.M. and Llewellyn, R. (2020) 'The Adopters Versus the Technology: Which Matters More When Predicting or Explaining Adoption?' *Applied Economic Perspectives and Policy*, vol. 42, pp. 80–91. doi:10.1002/aepp.13007.

Djikeng A., Rao, I.M., Njarui D., Mutimura, M., Caradus, J., Ghimire, S.R., Johnson, L., Cardoso, J.A., Ahonsi, M. and Kelemu, S. (2014) 'Climate-smart Brachiaria Grasses for Improving Livestock Production in East Africa'. *Trop Grassl-Forrajes Trop*, vol. 2, no. 1, pp. 38–39.

Ghimire, S., Njarui, D., Mutimura, M., Cardoso, J., Jonhson, L., Gichangi, E., Teasdale, S., Odokanyero, K., Caradus, J., Rao, I. and Djikeng, A, (2015) 'Climate Smart Brachiaria for Improving Livestock Production in East Africa: Emerging Opportunities', In: Vijay D. Srivastava, M.K., Gupta, C.K., Malaviya, D.R., Roy, M.M., Mahanta, S.K., Singh, J.B., Maity, A. and Ghosh, P.K. (eds.) *Sustainable Use of Grasslands Resources for Forage Production, Biodiversity and Environmental Protection*. Proceedings of 23rd International Grassland Congress, Range Management Society of India, pp. 361–370.

Hall, A.J. (2012) 'Partnerships in Agricultural Innovation: Who Puts Them Together and Are They Enough?' Available at: https://www.researchgate.net/publication/316736798_Partnerships_in_agricultural_innovation_Who_puts_them_together_and_are_they_enough

Haug, R., Nchimbi-Msolla, S., Murage, A., Moeletsi, M., Magalasi, M., Mutimura, M. and Westengen, O. T. (2021) 'From Policy Promises to Result through Innovation in African Agriculture?', *World*, vol. 2, no. 2, pp. 253–266.

Hermans, L. M., Haasnoot, M., ter Maat, J. and Kwakkel, J. H. (2017) 'Designing Monitoring Arrangements for Collaborative Learning about Adaptation Pathways,' *Environmental Science & Policy*, vol. 69, pp. 29–38. https://doi.org/10.1016/j.envsci.2016.12.005

Huffman, W.E., (2020) 'Human Capital and Adoption of Innovations: Policy Implications', *Applied Economic Perspectives and Policy*. vol. 42, no. 1, pp. 92–99. https://doi.org/10.1002/aepp.13010.

Husen, N. A., Loos, T. K. and Siddig, K. H. (2017) 'Social Capital and Agricultural Technology Adoption Among Ethiopian Farmers', *American Journal of Rural Development*, vol. 5, no. 3, pp. 65–72. https://doi.org/10.12691/ajrd-5-3-2

IPCC, 2014. AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability-Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar5/wg2/

Kangogi, D., Dentoni, D. and Bijman, J. (2021) 'Adoption of Climate-smart Agriculture among Smallholder Farmers: Does Farmer Entrepreneurship Matter?' Available at: https://www.sciencedirect.com/science/article/pii/S0264837721003896

Kassie, M., Teklewold, H., Jaleta, M., Marenya, P. and Erenstein, O. (2015) 'Understanding the Adoption of a Portfolio of Sustainable Intensification Practices in Eastern and Southern Africa', *Land Use Policy*, vol. 42, pp. 400–411. https://doi.org/10.1016/j.landusepol.2014.08.016

Kolk, A., van Tulder, R. and Kostwinder, E. (2008) 'Business and Partnerships for Development', *European Management Journal*, vol. 26, no. 4, pp. 262–273.

Kosec, K. and Resnick, D. (2019) *Governance: Making Institutions work for Rural Revitalization*. In Global Food Policy Report, pp. 68–77. Washington, DC: International Food Policy Research Institute.

Kürschner, E., Baumert, D., Plastrotmann, C., Poppe A.K., Riesinger, K. and Ziesemer S. (2016) 'Market Access for Smallholder Rice Producers in the Philippines'. Available at: http://edoc.hu-berlin.de/series/sle/264/PDF/264.pdf

Li, L., Cao, R., Wei, K., Wang, W. and Chen, L. (2019) 'Adapting Climate Change Challenge: A New Vulnerability Assessment Framework from The Global Perspective', *Journal of Cleaning Product*, vol. 217, p. 216e224. https://doi.org/10.1016/j.jclepro.2019.01.162

Lybbert, T.J. and Sumner, D.A. (2012) 'Agricultural Technologies for Climate Change in Developing Countries: Policy Options for Innovation and Technology Diffusion', *Food Policy*, vol. 37, no. 1, pp. 114–123. https://doi.org/10.1016/j.foodpol.2011.11.001

Markelova, H., Meinzen-Dick, R.S., Hellin, J. and Dohrn, S. (2009) 'Collective Action for Smallholder Market Access', *Food Policy*, vol. 34, no. 1, pp. 1–7.

Mizik, T. (2021) 'Climate-Smart Agriculture on Small-Scale Farms: A Systematic Literature Review', *Agronomy*, vol. 11, pp. 1096. https://doi.org/10.3390/agronomy 1106109

Montefrio, M. J. F. and Dressler, W. H. (2019) 'Declining Food Security in a Philippine Oil Palm Frontier: The Changing Role of Cooperatives', *Development and Change*, vol. 50, no. 5, pp. 1342–1372. https://doi.org/10.1111/dech.12443

Mutimura, M. and Ghimire, S. (2020) 'Brachiaria Grass for Sustainable Livestock Production in Rwanda Under Climate Change', *Handbook of Climate Change Management: Research, Leadership, Transformation*, pp. 1–17.

Mutenje, M., Kankwamba, H., Mangisonib, J. and Kassie, M. (2016) 'Agricultural Innovations and Food Security in Malawi: Gender Dynamics, Institutions and Market Implications', *Technological Forecasting and Social Change*, vol. 103, pp. 240–248. https://doi.org/10.1016/j.techfore.2015.10.004

Mwangi, M. and Kariuki, S. (2015) 'Factors Determining Adoption of New Agricultural Technology by Smallholder Farmers in Developing Countries', *Journal of Economics and Sustainable Development*, vol. 6, no. 5, pp. 208–216. ISSN 2222–2855

Nagothu, U.S. (2015) 'The Future of Food Security: Summary and Recommendations', In: Nagothu, U.S. (ed.) *Food Security and Development: Country Case Studies*. London: Routledge, p. 274.

Nagothu, U.S. (2018) *Agricultural Development and Sustainable intensification: Technology and Policy Challenges in the Face of Climate Change*. London: Routledge. ISBN 9781138300590.

Njarui, D.M.G., Gatheru, M. and Ghimire, S. R. (2020) 'Brachiaria Grass for Climate Resilient and Sustainable Livestock Production in Kenya', In: Leal Filho, W. et al. (eds.) *African Handbook of Climate Change Adaptation*. Cham: Springer Nature, pp. 1–22.

Njarui, D.M.G., Gichangi, E.M., Ghimire, S.R. and Muinga, R.W. (2016) *Climate Smart Brachiaria Grass for Improving Livestock Production in East Africa – Kenya Experiences*. Nairobi: Kenya Agricultural and Livestock Research Organization, p. 271. https://cgspace.cgiar.org/handle/10568/79797

Norton, G.W. and Alwang, J. (2020) 'Changes in Agricultural Extension and Implications for Farmer Adoption of New Practices', *Applied Economic Perspectives and Policy*. vol. 42, no. 1, pp. 8–20. https://doi.org/10.1002/aepp.13008

Obi, A. and Maya, O. (2021) 'Innovative Climate-Smart Agriculture (CSA) Practices in the Smallholder Farming System of South Africa'. Available at: https://www.mdpi.com/2071-1050/13/12/6848

Poulton, C., Kydd, J. and Dorward, A. (2006). Overcoming Market Constraints on Pro-Poor Agricultural Growth in Sub-Saharan Africa. *Development Policy Review*, vol. 24, no. 3, pp. 243–277.

Raj R. and Nagothu, U.S. (2016) 'Gendered Adaptation to Climate Change in Canal-irrigated Agroecosystems'. In: Nagothu, U.S. (ed.) *Climate Change and Agricultural Development Improving Resilience through Climate Smart Agriculture, Agroecology and Conservation*. New York: Routledge, pp. 259–278, ISBN: 978-1-138–92227-3.

Rockstrom, J. and Barron J. (2007) 'Water Productivity in Rainfed Systems: Overview of Challenges and Analysis of Opportunities in Water Scarcity Prone Savannahs', *Irrigation Science*, vol. 25, no. 3, pp. 299–311.

Scialabba, N. E. H. and Müller-Lindenlauf, M. (2010) 'Organic Agriculture and Climate Change', *Renewable Agriculture and Food Systems*, vol. 25, no. 2, pp. 158–169.

Scopel, E., Da Silva, F. A., Corbeels, M., Affholder, F. and Maraux, F. (2004) 'Modelling Crop Residue Mulching Effects on Water Use and Production of Maize Under Semi-arid and Humid Tropical Conditions', *Agronomie*, vol. 24, no. 6–7, pp. 383–395.

Verderosa, D. (2021) ‘New Hub Promotes Farmer Producer Organizations in India’. Available at: https://news.cornell.edu/stories/2021/09/new-hub-promotes-farmer-producer-organizations-india

Vohland, K. and Barry, B. (2009) ‘A Review of In Situ Rainwater Harvesting (RWH) Practices Modifying Landscape Functions in African Drylands’, *Agriculture, Ecosystems & Environment*, vol. 131, no. 3–4, pp. 119–127.

Wiggins, S. and Keats, S. (2013) ‘Leaping and Learning: Linking Smallholders to Markets’. Available at: https://workspace.imperial.ac.uk/africanagriculturaldevelopment/Public/LeapingandLearning_FINAL.pdf

Wijk, J., Vellema S. and van Wijk, J. (2010) *Institutions, Partnerships and Institutional Change: Towards a Theoretical Framework.* No. 009. Partnerships Resource Centre.

Wiyo, K. A., Kasomekera, Z. M. and Feyen, J. (2000) ‘Effect of Tied Ridging on Soil Water Status of a Maize Crop Under Malawi Conditions’, *Agricultural Water Management*, vol. 45, no. 2, pp. 101–125. https://doi.org/10.1016/S0378-3774(99)00103-1

World Bank (2007) *World Development Report 2008: Agriculture for Development*. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/5990

Woodhill, A.J. and van Vugt, S.M. (2011) ‘Facilitating MSPs: a sustainable way of changing power relations?’ In: *Guidebook for MSP Facilitation* (pp. 36–56). Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.