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DIVERSE RURAL LIVELIHOODS IN EASTERN AFRICA FARMING SYSTEMS: CONCEPTS, MODELLING AND CHALLENGES IN INNOVATION ADOPTION AND VALUE CHAIN PARTICIPATION

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I dedicate this thesis to my beloved,
who supported me in this exciting and challenging adventure

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Abstract

Farming systems across Eastern Africa are characterized by a high level of complexity. On the one hand, recognizable patterns between farming systems, farmers, their aspirations and resource allocation strategies exist across the farms. On the other hand, farmers operate in highly diverse environments, both in biophysical and socio-economic terms. Diversity at household level arises from diversity in capital endowment, produce use, production objectives, knowledge, ethnic identity, lived experiences, management ability and risk orientation. Widening the perspective at regional level, diversity emerges in agroecology conditions, markets and local culture, shaping different land use patterns and agricultural management practices across regions. However, despite the occurrence of differentiated livelihood strategies as adaptative response to such diverse conditions, many interventions aimed at alleviating rural poverty and food insecurity underlie a *one-size-fits-all* policy strategy.

Against this background, the current doctoral thesis aims to inform the design and implementation of interventions and policies questioning how and why they are targeted towards particular farmers, communities or agro-ecologies, as well as how much room or flexibility they allow for adjustment and adaptation to suit its intended beneficiaries. The thesis investigates the impact of rural diversity in Eastern African farmers' decision-making process, analysing the drivers of technological innovation uptake among heterogeneous users, as well as their differentiated access to markets.

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INTRODUCTION

Over the last decades, many African countries have showed noticeable improvements in their economic performances. For example, the percentage of Africans living below international poverty thresholds fell from 60% to 40% between 1996 and 2018 (World Development Indicators, World Bank). Most countries have also showed advances concerning social indicators (e.g., higher school enrolment, lower child mortality rates and increased life expectancy (ibid.).

Among specific sectors, agricultural performances have particularly demonstrated the highest increments of any world region (Jayne et al., 2020). Notwithstanding these progresses, several aspects of the agricultural sector (e.g., yield for the main food crops) are not yet in line with advancements of other areas of the developing world. This is particularly true for Sub-Saharan and Eastern Africa countries (Jin et al., 2017), where the scenario of increasing population and substantial dependency on imported goods raises the need to speed up technological change aimed at agricultural productivity, develop value chains, and improve market access of rural households.

Several potential policy solutions have been developed and tested to tackle these issues. However, the development of appropriate interventions is still challenged by the complexity of rural contexts in these geographical areas, which are characterized by high levels of diversity between farming systems, between farms and between fields within farms (Ruben and Pender, 2004; Tittonell et al., 2010). Much of this diversity consists in differences in household socio-economic characteristics, agronomic strategies, environmental variability, and livelihood diversification strategies (Tittonell et al., 2010; Makate & Mango, 2017). Particularly, uneven resource endowments[1] have been proven to drive heterogeneous responses to technology adoption and to determine differentiated potentials in market access for smallholder farmers (Magruder, 2018; Montes de Oca Munguia et al., 202; Minh & Osei-Amponsah, 2021). In general terms, diversity is a crucial determinant of households' different responses towards any development support or policy initiative. Therefore, understanding diversity (its sources and consequences) is essential for designing successful policies and programmes.

The current thesis aims to analyse the impact of rural diversity in shaping the process of technological change and market access in East Africa. Technological change and market access are complex processes which have been widely investigated. Moreover, technological change and market access are strongly interconnected. They have been traditionally framed together as part of the linear TOT

[1] In the current thesis, resource endowment refers to factors external and internal to the farmer (Stoian et al., 2012): external factors include access to basic infrastructures and services, common pool resources and social stability, while internal factors focus on asset endowments, interests and power.

(transfer of technology) model, according to which agricultural research is assumed to be the principal source of farm-level innovation, which is transferred to farmers, increasing their productivity, and ultimately expanding their access to market (Deveaux et al, 2018).

Technology change and market access have been, and still are, at the core of development-oriented interventions and policies. They have been the subject of extensive theory building in their respective fields and have evolved over time into two predominant models: technology adoption and value chain participation, respectively. Despite the development of sophisticated framework for designing development interventions and impact evaluations, both fields have struggled to find effective solutions for governing the complexity and diversity of social, economic, and institutional environment in which smallholders are embedded.

In this frame, the current thesis aims to inform the design and implementation of interventions and policies accounting for questions about "how and why they are targeted towards particular farmers, communities or agro-ecologies and how much room or flexibility they allow for adjustment and adaptation to suit its intended beneficiaries" (Glover et al. 2016, p. 5). It investigates about the impact of rural diversity in farmers' decision-making process, analysing the drivers of technological innovation uptake among heterogeneous users as well as their differentiated access to markets. More specifically, the thesis aims to address the following three research questions:

RQ1: Which factors constrain smallholders endowed with less resources from benefitting from development interventions aimed at technological change and market access?

RQ2: Which factors constrain smallholders endowed with more resources from benefitting from development interventions aimed at technological change and market access?

RQ3: How does rural diversity impact the potential effectiveness for smallholders of development interventions and policies?

By answering to these questions, the thesis aims at providing insights to practitioners and policy makers for the design of interventions accounting for rural diversity in East Africa.

The reminder of this thesis unfolds as follows. Section 1 provides theoretical aspects and contextual geographical factors behind the concept design of the research. Particularly, Sub-section 1.1 elaborates on how the problem of rural diversity has been addressed in development thinking, focusing on both research and policy aspects. Sub-section 1.1.1 contextualizes the issue of rural diversity in East Africa countries, providing justification for the selection of the study sites. Sub-section 1.2 reviews main innovation adoption perspectives in agricultural research, while Sub-section 1.3 illustrates the multidimensional assessment of inclusive value chain development. Section 2 and

3 constitute the core of the current thesis and are presented as standalone research articles. More specifically, the first article addresses the problem of technology adoption by investigating East African farmers' decision making process, as concerns the exclusive or combined use of improved and local seed varieties, assuming that they perform complementary and sometimes overlapping functions. The second article adopts an asset-based approach to analyse the minimum conditions for smallholders' participation to the maize VC in Ethiopia, Malawi and Tanzania, accounting for the diversity of rural sites, as well as to investigate assets interdependences. Lastly, Section 4 discusses main findings of the thesis, elaborating on the answers to the three research questions (Sub-sections 4.1.1, 4.1.2, and 4.1.3), and deriving policy implications for future interventions directed to rural contexts in East Africa.

1. DIVERSITY IN EAST AFRICAN FARMING SYSTEMS: CONCEPTS AND CHALLENGES

1.1. Rural diversity in development thinking

Rural diversity has not always been a focus of development thinking. Different development theories, and policy frameworks/strategies arising therefrom, have come in succession after the II World War. They have not evolved in a unilateral way, but rather coexisted in time. Some have been adopted more widely, being advocated by more influential actors, while others remained relatively marginal. Nevertheless, major trends in development thinking can be recognized. In this sense, the development discourse has been shaped by the "issue attention cycles", a definition coined by Downs (1972) to emphasize the cyclical nature of issues that dominate public and academic debate. The existence of issue attention cycles in development thinking also reflects the different ways in which diversity has been perceived over time.

From a theoretical perspective, Pieterse (2011) traces back the emergence of "diversity" as a concern for development to the shift in the long-term trends in social sciences that occurred from nineteenth to twentieth century. Structuralist approaches considered social reality as determined by existing macro-structures. The structuralism method aimed to detect the common structure of widely different economic, social, and cultural forms. Early mainstream and alternative development schools of thought, such as Modernization and Dependency theories, have been strongly influenced by structuralism (Sheth, 1987). They focused on structural changes in the economy, the State, and the social system, and thus on universalistic and homogenizing recipes for success. The emergence and increasing impact of many contributions from distinct disciplines (e.g., existentialism in philosophy, new institutional economics in economics, and ethnomethodology in anthropology) have gradually led the dismissal of structuralist approaches in favor of more institutional and agency-oriented views, in the sense of people's capacity to influence social change (cf. Pieterse, 2011). In parallel, in the 1980s, development thinking became aware that existing development theories had not reached the expected success. Modernization strategies based on catching up with advanced countries started to be increasingly criticized for focusing on the experiences of Western Europe societies and for assuming that all countries of the world would generally follow the same path of progress and development (cf. Latouche, 1993). Top-down development approaches focusing on state-led industrial development and involvement in commodity markets through technology transfer and increased agricultural efficiency had been increasingly questioned for their limited success in

reducing rural poverty in large areas of the world (Long, 1990). In this critical moment, two opposite theoretical perspectives emerged. Neoliberalism, on one hand, focused on the central objective of economic growth, which should be market-led (Desai & Potter, 2013). National states should support privatization, liberalization, deregulation, and reduce market-distorting interventions (ibid.). On the other hand, instead, alternative development approaches pointed out that exogenous interventions, such as those deriving from international aid, might drive important structural changes. However, new questions started to raise on how external interventions interact with individuals and social groups to which they are addressed, and how they are mediated by these actors (Elwert & Bierschenk, 1988). According to Willis (2011), the recognition of the importance of social diversity for development thinking dates back to the emergence of these alternative approaches. In particular, postmodernist approaches in developing contexts focused on deconstructing categories assumed by previous development paradigms. Therefore, not all 'peasants' are the same nor all rural–urban migrants have the same experiences. Populations in developing countries are not homogeneous but rather diverse in social, spatial, and temporal terms. Postcolonialism approaches added a nuance to the recognition of such differences. They focused, in particular, on differences arising in contexts where colonization took place, dealing therefore with the hybrid material legacy of colonialism (cf. Willis, 2011).

This deviation from mainstream development theories brought broad changes in development thinking. Based on Pieterse (2011), the concern for differentiation and diversity have become a reality, and this entailed several implications.

First, from a methodological perspective, this implied a gradual shift towards interdisciplinarity, aimed at narrowing the gap between economic development and social and political development. Second, culture begins to constitute another dimension of development. From cultural diversity unfold the new concepts of human capital and capabilities. Cultural diversity is no longer seen as an obstacle towards modernization, but, instead, as a prospective informing the context-specific paths of socio-economic growth. Third, development thinking changed its unit of analysis. Early modern theories have focused on the nation. New approaches increasingly acknowledge the scalar nature of development. It encompasses local, microregional, national, macroregional, international, and global level of action. The last implication relates to the growing importance of intersectoral cooperation and harmonization among different actors on the international arena. State-led, market-led and societal-led approaches have come in succession supported by the most influential actors of the

international community. An intersectoral partnership is instead required to respond to the multidimensional and multiscale nature of development challenges.

New perspectives and approaches have emerged since the crisis of early development thinking, trying to make the most of the intense mainstream and alternative development theorizing. The increased importance of participatory and people-centered approaches could be interpreted as positive steps towards processes and definitions of 'development' accounting for diversity. Nevertheless, despite being criticized for neglecting the different ways in which markets work in developing countries and the factors that contribute to these differences (Brohman, 1995), neoliberalism remains to date the broad theoretical context which shapes much of international development policy (Hammouda, 2017). Moreover, the status of development in-field reflects the lag between researchers, funding agencies and practitioners and the ups and downs of learning and improvement in development practice. A clear example of that is represented by the legacy of early development theories. Modernization theory supported the transition of traditional society towards more technological and institutional advanced form of modern society. This evolutionary process involved commodity market integration and interventions based on vertical transfer of technology, knowledge, resources and organizational forms from developed world. In this sense, technological change has been interpreted as a driving force for increasing the potential role of smallholders in tropical countries in dynamic and increasingly globalized agri-food markets (Stoian & Donovan, 2012). Therefore, technology change and market access have been, and still are, at the core of development-oriented interventions and policies. They have been the subject of extensive theory building in their respective fields, and have evolved over time into two predominant models: technology adoption and value chain participation, respectively. Despite the development of sophisticated framework for designing development interventions and impact evaluations, many interventions continue to underlie a one-size-fits-all policy strategy (Ruben & Pender, 2004). Both technology change and market access models have been criticized for their poor understanding of the complexity and diversity of social, economic and institutional environment in which smallholders are embedded. In this sense, the deterministic and generalizing assumption that availability of technological innovations can lead to productivity increase and thus to increased market participation and food security appears to have maintained a certain influence. To a certain extent, low levels of innovations uptake and market participation, especially among diverse resources-endowed smallholders, remain beyond understanding. Nevertheless, in recent years, a strong plea for the development of theoretical

approaches and holistic methods able to account for diversity across farming systems has involved practitioners, academics and policy makers of different fields.

Some studies have suggested targeting interventions based on development domains based on some of the key elements that determine comparative advantage of different rural livelihoods, including agricultural potential, access to markets, and population density (Chamberline et al., 2006; Omamo et al., 2006). Targeting interventions based on development domains can guide commodity investment at a national level but does not provide insight into how best to reach diverse farm households. Other studies have suggested geographical targeting based on development pathways and directing interventions across sites that are comparable (Kristjanson et al., 2012). However, this approach has also been countered by other studies that have indicated that differences between households are greater than the differences between regions (ICRA, 2012), implying that rural households are heterogeneous irrespective of their geographical localities.

In this frame, the current thesis aims to inform the design and implementation of interventions and policies accounting for questions about "how and why they are targeted towards particular farmers, communities or agro-ecologies and how much room or flexibility they allow for adjustment and adaptation to suit its intended beneficiaries" (Glover et al. 2016, p. 5). It investigates about the impact of rural diversity in farmers' decision-making process, focusing on the drivers of technological innovation uptake among heterogeneous users as well as their differentiated access to markets.

1.1.1. Rural diversity in East Africa

Farming systems across Sub-Saharan and East Africa are characterized by a high level of complexity. On the one hand, scholars have highlighted "recognizable patterns between farming systems, between farmers, their aspirations and their resource allocation strategies across the farms" (Giller et al. 2011, p. 192). On the other hand, production systems and livelihood strategies of rural households in less-favoured areas are characterised by a wide diversity in terms of resource endowments, activity choice and the prevailing conditions for engagement in market exchange. According to Ruben and Pender (2004), diversity in these environments can be classified into three main categories: i. variability in biophysical conditions at plot/field level; ii. economic diversity among farm households; and iii. social diversity in community organisation at village and regional level. Nevertheless, such factors are strongly interrelated, raising the question on how to target policy and investments to maximize rural growth out of poverty, taking into consideration the vast diversity of development attributes.

As for the first diversity category (biophysical diversity), diversity in East African biophysical conditions can be observed within and among farms and across localities, leading to variable yield performances (Jin et al, 2017). One reason for variable productivity is diversity of soil-weather conditions. African farming environments are characterized by variable soil fertility conditions even at short distances, often referred to as soil fertility gradients (Buerkert et al., 2001). Rainfall and water availability also differ across different sites. Moreover, year-to-year and long-term trends in rainfall variability generate different impacts on mean crop yields in already different agroecological sites (Stuch et al, 2021). However, another important reason for variable productivity is the diversity of crop management strategies (Tittonell et al, 2010), which might counteract constraining biophysical conditions. These strategies, in turn, depend on a number of factors such as resource endowment, access of farmers to high-yielding varieties, fertilizers, and modern management technologies, production orientation and objectives - including food for subsistence and products for the market -, ethnicity, education, past experience, management skills and farmers' attitude towards risks (Crowley and Carter, 2000; Salasya, 2005; Jin et al, 2017).

These complementary factors have been, however, often overlooked. African governments have implemented a number of programmes for improving agricultural productivity, which have often generated poor results (Kansiime et al, 2018). For example, large variability in outcome of fertiliser use efficiencies has been reported in some African countries that have implemented agricultural input subsidies (Baltzer and Hansen, 2012; Chibwana et al., 2010). Similarly, government-led extension and advisory services in many African countries have been criticised for their failure to address the diverse farmers' needs and demands (Benin et al., 2007; Davis, 2008). In general, programs promoting efficient crop management practices in Africa have had mixed results, attributed to socio-economic and ecological variability within farming systems (Giller et al., 2011).

As for the second diversity category (economic diversity), East African rural households are also characterized by diversity in resource endowments (capital, land and labour) and access to markets and institutions (Makate & Mango, 2017). These factors are not only strongly interconnected, but also exert a reciprocal influence. The "sustainable livelihoods framework" (Scoones 1998) has contributed to a deeper consideration of such interrelations which have been extensively developed in further theory building. In its original formulation, this framework links specific households' assets endowments combination (inputs) to differentiated livelihood strategies (outputs) to diverse outcomes including income and employment, as well as to later wider framings, such as well-being and sustainability (Scoones, 1998; Donovan & Poole, 2013). Therefore, households with similar resource

endowments and opportunities do not always select the same portfolio of activities. Rooting on this theoretical background, asset endowment variability (natural, human, social, physical and financial assets) has been considered one of the most critical factors in determining market access (Stoian et al, 2012; Minh & Osei-Amponsah, 2021). However, farmers' strategies related to market (e.g., diversification away from food crop production into higher value cash crops) may be strongly influenced by unpredictable exogenous factors such as the existence of market imperfections (variable transaction costs and missing markets both for inputs and produce (De Janvry et al., 1991; Bellon & Hellin, 2019)), risks and insurance options (Fafchamps, 1992; Binswanger and Rosenzweig, 1986), and variable access to credit (Eswaran and Kotwal, 1986). In this context, diversification might play a crucial role for ex-ante risk management and for ex-post coping with adverse shocks (Ruben & Pender, 2004). Impact evaluation literature has also shown that diverse resources endowment has strongly influenced farmers' participation in development interventions in East Africa, and the contrasting results/benefits deriving therefrom (Deveaux et al, 2018). In particular, the early economic stream of adoption studies has emphasized role of diverse resources endowment for explaining the discontinuous rate of innovation adoption. Especially in uncertain market conditions, rural household tend to select diversified strategies for reducing income vulnerability, giving preference to technology choices that involve low sunk costs and permit a high flexibility in the allocation of their differentiated resources (Davies, 1996; Wale et al, 2005) and thus avoiding uncertainty regarding the expected returns.

However, later innovation models have emphasized the effects of diverse cultural and individual perceptions of an innovation on farmers' technology choices (Ruzzante et al, 2021), which leads us to the third diversity category in developing countries, namely diversity in social structure (social diversity). Community organisation in developing countries has been traditionally considered a critical issue for collective action, namely the possibility of individuals self-organizing to achieve collective benefits (Ostrom 1990, 1998). Communities are far from being homogenous unity. Instead, they greatly differ in terms of number of actors, as well as in the roles played by each of them based on social class, origin (old vs recent migrants) and ethnicity, leading to different organizational configurations (Makate & Mango, 2017). In context where formal structures, regulations, or policies that support markets are "absent, weak, or fail to accomplish the role expected of them" (Mair and Marti, 2009, p. 422), namely/conditions defined institutional voids (ibid.), diverse social ties enable the facilitation of mutual exchange and information sharing, which is used to develop marketplace skills and to compensate for challenges of low literacy (Viswanathan et al., 2008; Viswanathan et al.,

2012). Of significant importance are familial and friendships networks, which community members view as the most trusted sources for product information or business advice (Viswanathan et al, 2012). Even if existing groups bring the potential to do what governments and markets cannot, given that their members have crucial information about the context specific behaviors, capacities and needs of other members (Bowles & Gintis, 2002), their successfulness in each context cannot be given for granted. In such circumstances, entrepreneurship scholars and institutional theorists have shown how new options can be created through the recombination and transformation of the existing institutional configuration at hand (Schumpeter, 1934). For instance, these insights have increasingly informed interventions that focus on setting up multistakeholder initiatives, namely networks forums for action and learning in which different types of actors come together to address the issues of mutual concern (Cavatassi et al. 2011; Kilelu et al, 2013). These are generally considered flexible tools able to dynamically adapt to heterogeneous conditions and to evolve according to unfolding events (Schut et al., 2017; Devaux et al, 2018).

1.2. Beyond traditional approaches for modelling farmer decision making: the case of innovation adoption

Technological change has traditionally played a central role in development thinking. It is considered a strategic driver for boosting the productivity, sustainability and resilience of small-scale farming systems. (Evenson and Westphal, 1995). Technical advance has generated a variety of benefits in rural areas across most of the developing world. First, the application of improved technologies has strongly contributed to improvements in agricultural productivity and production, however with lower rate in East African countries (Fuglie et al, 2019). Second, technical advances in the agricultural have shown to generate higher increases in household incomes in comparison to technical improvements in other productive sectors, such as industry and services (Ivanic & Martin, 2018). This is particularly true in the case of East African countries (ibid.). Third, an increased use of technologies bears the potential to reduce inequalities in rural areas. For instance, innovations allow households to counteract resource limitations (e.g., land) by improving productivity (Makate & Mango, 2017)). Finally, technical innovations are acknowledged as a viable strategy to reach environmental sustainability by increasing factor productivity and thus reducing resources use (Vanlauwe et al, 2019).

To date, experimental evidence on adoption of agricultural innovations in developing countries have shown contrasting, and often disappointing results (Magruder, 2018; Macours, 2019; Ruzzante et al,

2021). This body of works highlights heterogeneity in adoption response, particularly due to differences in contexts, as well to innovation characteristics and traits. Moreover, the gains from adoption of innovative technologies have been much more limited in East and Sub-Saharan Africa (Macours, 2019). It is therefore crucial to shed light on possible constraints that may help explain the lack of adoption of promising technologies and/or of the benefits deriving therefrom.

From a theoretical perspective the last 70 years of research in the adoption of agricultural innovation in developing countries has generated a proliferation of insights. This resulted in a lack of convergence in the way adoption is defined, explained, and measured, causing agricultural extension and policy to rely on a body of literature that is often unable to provide clear recommendations on the variables or mechanisms that can be used to design interventions.

The bulk of the theoretical literature on agricultural technology adoption may be categorized into three main paradigms: the innovation-diffusion paradigm; the economic constraints paradigm; and the adopter-perception paradigm (Adesina & Zinnah, 1993; Negatu & Parikh, 1999; Ruzzante et al, 2021).

The diffusion of innovations theory is most strongly associated with Rogers' seminal "Diffusion of Innovations" (1962), which defined the field of innovation diffusion research. Rogers conceptualized the term innovation diffusion to define the level of innovation uptake at aggregate scale, for instance by region or by country, in contrast to the term innovation adoption. The latter is commonly used to represent the level of innovation uptake at farm level, and thus by individuals (Glover et al., 2016). The paradigm, in its original formulation, conceived the innovation as a technology package and the input of a linear diffusion process - i.e., invention – production – transfer – implementation – use - through which the new technology flows, eventually displacing and substituting existing techniques, artefacts and practices (Godin, 2006; Mica, 2013). The spread of technology within a society was depicted as a process of propagation (Glover, 2019) where the key factor was assumed to be disseminating information on the technology to the potential end users. The model has been criticized for ignoring the changes brought to the technology during its implementation and adaptation in diverse local contexts (Abrahamson, 2006).

The central assumption of the economic constraints paradigm, also named the factor endowment model, is that new technology is developed in response to a resource scarcity and adopted because it increases efficiency or intensifies the use of resources, resulting in an improved production function (Glover, 2019). Potential users (i.e., farmers) are conceived as rational actors who maximize their utility by taking individual adoption decisions based on their resource endowment. Therefore, uneven

resource endowments lead to diversified patterns of adoption in a country/region (Hayami and Ruttan, 1985; Adesina & Zinnah, 1993). This model has been criticized for overlooking the effects of cultural and individual perceptions of an innovation (Ruzzante et al, 2021).

Lastly, the technology 'adopter perception' model expands factors considered to influence adoption decision. In particular, prospective adopters are still interpreted as rational actors who maximize utility, however embedded in specific agro-ecological, socioeconomic and institutional contexts (Negatu & Parikh, 1999, Ruzzante et al, 2021). These contextual factors determine the diverse perceptions of the characteristics of a technology by diverse potential users, ultimately influencing their differentiated adoption choices (Scoones & Thomson, 1994). The current study is generally based on the assumptions of this model (cf. Chapter 2).

The first two bodies of work have been strongly criticized. First, they conceive technologies as determined packages (the so-called *black box*) that can be successfully transferred across different locations (Glover, 2019; Mica, 2013). Second, technology adopters are conceived as passive users excerting a limited agency, and the process of innovation adoption confined to a relatively simple, largely individual, dichotomous yes/no, once-and-for-all and linear progression by which inferior existing materials, tools and/or methods become obsolete and are abandoned in favour of new, superior ones (Glover, 2019).

On the practitioners and policy side, many different models have been implemented in fields. The linear transfer of technology (TOT) model has been hugely influential and there is still a number of programmes which explicitly or implicitly recall its legacy (Glover, 2016; 2019). According to the model, technology is developed by formal research with the primary aim to raise productivity on farm and spread by extension agents to farmers, which ultimately choose to adopt it or not (ibid.; Mica, 2013). This simplified model has been criticised for its top-down approach where technological change is seen as a simple, merely technical process. The final success is determined by how innovations ‘diffuse’ and how technologies ‘transfer’ (and thus strongly recalling the diffusion theory).

Based on the crucial importance of “information transfer” for the process of innovation diffusion, the new Training and Visits system (T&V) have been strongly supported by the World Bank in the late 1970s (Hulme, 1992). It was however gradually dismissed due to its high implementation costs and low effectiveness (ibid.).

The Farming research (FSR) emerged in the 1980s. It focused on improving agricultural productivity through improved adoption of innovative farm technologies, as well as considering the contextual

cultural practices. In this sense, it was a first attempt to consider the complexity and diversity of farming systems, integrating their biological, economic and human dimensions (Budelman & Van Der Pol, 1992).

A stronger focus on farmers' diversity and agency emerged with farmer participatory research (FPR). It challenged the conventional technology transfer strategies of R&D which have proved to work poorly in complex and highly variable environments (Farrington & Martin, 1988). This approach assumes that the involvement of farmers in formal research can produce more effective results (Okali et al, 1994).

Agricultural Innovation Systems (AIS) expanded the perspective connecting the innovation systems thinking to agriculture. The model challenges the linear approach to R&D considering the context-specific relationships shaping each farming systems. In particular, the processes of technological change and innovation adoption are mediated by the interactions "among diverse actors, social and economic institutions, and technological and institutional opportunities" (Spielman, 2006, p. 41).

Technological change in agricultural systems is now broadly conceived as a "process that occurs through a confluence of multiple factors which combine to stimulate change in situ" (Wiggins et al, 2021). Many theoretical efforts from different fields have been devoted for overcoming the above-mentioned simplified model of technology adoption. Alongside these traditional narratives, only the AIS literature has made inroads into professional practice, while the theoretical debate may have not sufficiently contaminated field studies and intervention/policy design.

A striking example of this is the wide promotion of improved seeds in developing countries, which is the focus of our first case study. An extensive literature has analysed the intended process of technological change based on improved seeds adoption, which is recognized for its potential for enhancing smallholders' productivity and resilience. However, many studies/interventions employ a traditional vision of innovation adoption and diffusion, relying on simplified frameworks for analysis which overlooked smallholder's diversity (Glover 2019; Wiggins et al, 2021).

Until now, interventions aimed at enhancing the uptake of improved seeds in east Africa have shown ambiguous results. We posit that adoption itself it is not a valuable instrument for understanding smallholders' differentiated behaviours towards innovation/technological change. A research effort is needed for modelling farmer decision making in its complex dynamic nature and thus promoting different interventions/policies tailored to the needs, constraints and opportunities of their different intended users.

1.3. Towards operationalization of a multi-dimensional assessment: the case of inclusive value chain development

Policy makers, researchers and practitioners have long embraced market-based development approaches for achieving economic growth and poverty reduction in the development world. However, different approaches and policies have come in succession since the 1980s to date, underlying subsequent development paradigm (Stoian et al, 2019).

During the 1980s and 1990s, one of the core market-based development strategies focused on the engagement of private sector, including therefore investments at the micro level scale (Schulpen and Gibbon, 2002; Oyelaran-Oyeyinka, 2017). Two early strategies were non-traditional agricultural exports (NTAE) and SME development. The former sought to encourage smallholder engagement in newly expanding export markets for high-value agricultural products, often horticultural products (Balassa, 1990). The public sector provided subsidies, infrastructure development, and others means of support for export promotion, often directed at large-scale companies equipped to ship agricultural commodities to international markets (ibid.). SME development, in turn, and related discussions on microfinance and business development services (BDS), shifted the focus to small and medium enterprises with the expectation that the urban and rural poor would benefit from income-generating activities, either as business owners or as employees (Stoian & Donovan, 2020). Despite positive impacts in some cases (e.g., Hamilton and Fischer, 2003), the appropriateness of NTAE for smallholders attracted scrutiny. Among the critics raised, NTAE proved a viable strategy for farmers with sufficient asset endowments and prepared to take risks, for example in relation to horticultural production (ibid.). For most smallholders, however, benefits were limited in view of poor rural services and highly demanding regulatory and market requirements (Carletto et al., 2007). At the same time, after more than a decade of strong support to SME development, donors' interest started to decrease, with a shift in focus to microfinance services. During the 1990s and 2000s, expectations with regard to the poverty-reducing potential of microfinance ran high. An important role in the process accrued to microfinance institutions (MFIs), based on the strategy to facilitate access by the poor to finance, thus overcoming their lack of collateral and jump-starting their engagement in markets as small-scale traders, producers, or processors (Arrassen, 2017). The underlying rationale that even the poorest people could escape poverty by becoming entrepreneurs was strongly supported by donors, which made available significant amounts of money to be channelled to low-income households through MFIs (Hilson, et al, 2018). MFIs has however gradually faced strong pressure to become less dependent on donor funding leading to increases in their commercial orientation, and

thus charging higher interest rates to an increasingly urban clientele (Arrassen, 2017). MFIs popularity in funding agencies started then gradually to decline. In the late 1990s, donors and NGOs embraced the idea of business development services (BDS) to enhance the effectiveness of microfinance in spurring SME growth and development. Promoted heavily by bi- and multilateral funding agencies (e.g., USAID, World Bank, and UN agencies), BDS strategies emphasized the need to spur market development for specialized services which were non-financial in nature (e.g. management consulting, logistics support, and marketing services) (Stoian & Donovan, 2020). Such services were expected to support the building of business skills to run SMEs, including the capacity to access and manage rural finance (ibid.). However, BDS providers often found it difficult to offer cost-effective services that micro and small businesses would demand (and pay for), while at the same time reducing their dependence on donor support (Bear et al., 2003). Moreover, they were perceived as a too ambitious strategy, and proponents were criticized for lacking a fundamental understanding of how diverse markets actually function (Caniels et al., 2006). Donor interest quickly decreased and soon gave way to other priorities (ibid.).

In the past decades value chains have emerged as a concept of relevance for developing countries. "The value chain concept has been covered at length in the literature (Hainzer et al.,2018; 2019), and most simply refers to the full range of activities required to bring a product or service from production through to final consumption (Kaplinsky and Morris, 2001).

Although the terms value chain and supply chain are often used interchangeably, a supply chain focusses on the efficient integration of supply and production processes to reduce costs. In contrast, a value chain is a set of interrelated activities used to create greater value for its customers and therefore establishing a competitive advantage over other chains within the industry (Tarver, 2018). In utilising the term value chain as a way of creating a competitive advantage, practitioners and researchers have pursued the objective to map interactions in order to identify potential opportunities for smallholders. Therefore, VC was used to highlight "the actual and potential role of smallholders in tropical countries in dynamic and increasingly globalized agri-food markets" (Stoian & Donovan, 2020, p. 17-28) as opposed to traditional development approaches focusing on achieving growth through improved productivity and increased natural resources' management (Devaux et al.,2018).

Multidisciplinary theory building has evolved over time within several theoretical streams such as Global VC analysis (GVC), Social network theory (SNT), Supply chain management (SCM) and New institutional economics (NIE) (Trienekens, 2011). This trend coincided with a growing research of feasible approaches to pursue both economic and social outcomes to address poverty (Humphrey

& Navas-Aleman, 2010; Ricketts et al., 2014), also stimulated by the formulation of Millennium Development Goals (Stoian, et al., 2012).

This (was) gradually reflected in the adoption of value chain as a conceptual device by the development community (Neilson, 2014 and Donovan et al., 2015) and with the integration of value chain interventions in larger economic growth programme promoted by major international organizations (Cattaneo et al., 2010) as well as by national governments. Consequently, earlier market-based approaches imprinted by previous development paradigms "based on the premise of economic growth (e.g., modernisation theory) […] for developing non-industrialised countries in the Global South" (Stoian et al., 2019, p. 238), have been progressively dismissed in favour of, or evolved into, alternatives value chain development (VCD) approaches (Stoian & Donovan, 2020).

VCD interventions pursue the goals of tackling poverty by strengthening mutually beneficial linkages among chain actors (Hobbs et al., 2000 and Webber and Labaste). According to UNIDO (Riisgaard & Ponte, 2011), VCD are "positive or desirable change in a value chain to extend or improve productive operations and generate social benefits: poverty reduction, income and employment generation, economic growth, environmental performance, gender equity and other development goals". When targeting "marginalized actors in a value chain, such as smallholders, small-scale businesses, and landless laborers" (Stoian, et al. 2012, p. 9) such interventions might be also defined "inclusive VCD" approaches (Devaux et al.,2018). VCD They are not, however, immune to their own share of criticism.

Pro-poor VCD has both advocates and skeptics. The former argue that the most promising option for lifting rural people out of poverty, other than rural–urban migration, is linking poor farming households to lucrative markets through skills development and new institutional arrangements along the chain. Skeptics, on the other hand, regard VCD as unsuitable for working with the very poor, given its perceived emphasis on risk-taking and entrepreneurship, and the additional challenges faced by the very poor when responding to economic incentives (Fowler and Brand 2011).

In particular, despite a clear focus on poverty reduction, many value chain initiatives have been challenged for their inability to catch the heterogeneous nature of rural poverty, which includes diversified asset endowments, income flows, social embeddedness, and response capacity to shocks (Fowler & Brand, 2011). In 2012, Stoian and colleagues' seminal article have thus questioned the frequent underlying assumptions to VCD interventions, namely: smallholders "(1) have sufficient resources to effectively participate in VCD, (2) do not face substantial trade-offs when using these

resources, and (3) are able to assume higher risks when reinvesting capital and labor access to adequate resources" (ibid., p. 15).

A striking example of this are asset-based interventions, which are the focus of our second case study. Opportunities for smallholders to access lucrative market depends on their ability to provide stable supply of quality products. However, in turn, achieving such productive standards (or taking advantages of these opportunities) requires a threshold level of land, credit, inputs, technology, organization capacity, infrastructures, access to networks, technical advice and market information, (Devaux et al., 2018 p. 103), besides an enabling environment characterized by conducive market functioning, norms, regulations, policies and programmes (Donovan & Poole, 2013). The development discourse has thus increasingly focused on VCD interventions aimed at enhancing VC participation for asset-poor households, characterized by limited, or in many cases inexistent, surplus production for accessing the market (e.g., Stoian & Donovan, 2020).

In turn, interesting insights on the multidimensional challenge represented by unequal (heterogeneous) and/or poor asset endowment in development contexts have been provided by impact evaluation studies. A review of research papers analysing 14 VCD case studies in the context of international agricultural research (Devaux et al., 2018) indicates a clear relation between initial asset endowment and the distribution of benefits deriving from VCD interventions. In particular, VCD interventions have proved ineffective for participants falling in the lower and upper asset thresholds. On the one hand, asset-poor households may have insufficient resources for accomplishing the specialization efforts required to participate in dynamic VCs or be unwilling to assume the risks associated with the new trade-offs derived from a new allocation of their constrained resources. Moreover, the analysis of an intervention for the development of a taro VC in Nicaragua (Donovan & Pool, 2013), suggests that even when support is provided, for instance in the form of access to short-term credit to purchase agricultural inputs and labour, unexpected events such as productive losses or lack of buyers during peak productive season can lead to productive-related debts and thus resulting in the erosion of the pre-existing, limited, asset endowment. On the other hand, participants falling in the upper threshold have proved to benefit inconsistently from such interventions, being their participation in the market already successful. VCD interventions can benefit the poor. Between the lower and upper threshold smallholders can compensate potential shocks with existing assets. However, VCD interventions may not generate direct effects on the not targeted poorest group, for whom more benefits may therefore derive from alternative livelihood strategies as for instance

employment in production, processing, and marketing activities generated from VCD interventions or alternative/specific nonmarket-based interventions.

Interventions aimed at promoting VC participations should therefore account for the differentiated asset endowment of rural households, as well as for the differentiated livelihood strategies arising therefrom. The existing linkages between diversified asset combination and livelihood strategies has been widely investigated by the sustainable livelihoods framework (SLF) (Scoones, 1998) and the varied research, policy and project arising from this standpoint. The framework and its evolutions have looked at how the combination of livelihood assets (namely natural human, physical, social and financial capitals) owned by a rural household may generate diversified livelihood strategies (Scoones, 1998). This process is local and culture specific, and thus mediated by the social and institutional context in which smallholders are embedded (Ellis, 2000). The framework, though, has been criticized for overlooking the existing bi-directional linkages between markets and smallholders' livelihood strategies (Dorward et al., 2003). Since, then, many attempts have been made to integrate (more or less explicitly) the SLF with VC analysis, Global Value Chain analysis and VCD interventions design (e.g., Challies & Murray, 2011; Nelson & Shonk, 2014; Andriesse, 2018 etc.).

In general terms, the characterization of asset endowments raises many theoretical and methodological issues (Donovan & Stoian, 2012). One of this issue concerns how assets are built or eroded over time by rural households. According to Donovan & Stoian (2012), this is particularly relevant considering the dynamic nature of capitals and the existence of flows across them. One capital can be converted in one another, for example when savings (financial capital) are converted in agricultural tools (physical capital). More importantly, flows can lead to feedback loops, either positive or negative. Participation in cooperatives (social capital) can facilitate smallholders' access to training in integrated pest management (human capital) which in turn leads to savings in agricultural inputs to be reinvested in machinery, storage or processing facilities (physical capital), with consistent enhancement on production quality and thus earnings. These can, in turn, potentially increase smallholders' initial asset endowment.

Triggering such processes has been one of the core strategies of VCD interventions. The contribution of development interventions to household asset building and how initial asset endowment evolves in response to interventions, have been therefore investigated to determine their effects on smallholders' participation in the targeted VCs (e.g., Donovan & Poole, 2013 and Donovan & Poole, 2014). Based on these considerations, there is the need to formulate holistic methods which accounts for rural diversity and thus progress beyond the formulation of standardized framework to determine

priorities for policy and VCD interventions. New approaches should be primarily able to address two main constraints to the design and implementation of effective policies and VCD interventions: heterogeneity within site and heterogeneity across sites.

2. LOCAL AND IMPROVED SEEDS ARE COMPLEMENTS AND NOT ALTERNATIVES. EVIDENCE FROM EAST AFRICA

Abstract

Policies for developing countries encourage the use of improved crop varieties to enhance production and counteract adverse climate/agroecological conditions.

Improved varieties never completely replace local varieties, complementing instead the existing genetic pool with new traits meeting farmers' production/consumption needs, while adapting to growing and marketing conditions.

This paper investigates East African farmers' behaviour, as concerns the exclusive or combined use of improved and local varieties, assuming that they perform complementary and sometimes overlapping functions. We further analyse the role of market imperfections in determining the interdependence between marketing and consumption functions, as well as in terms of varieties' use.

Farmers' decision making is conceptualized as a sequence of two strategic choices, namely the inclusion of improved varieties and the subsequent maintenance or displacement of the extant pool of local varieties. We used a two steps Sequential Logit model to investigate the motivations behind each decisional knot, sampling 10 crops and 1.615 households in Ethiopia, Malawi and Tanzania.

The use of improved and local varieties reveals a combination of multifaceted decisions by sampled farmers. Adoption is particularly influenced by households' vulnerability[2], by poorly conducive institutions and by specific barriers to the access of improved seeds. Once improved varieties are adopted, distance from the market and level of market orientation play a central role. Local and improved varieties play different and sometimes overlapping functions, e.g., consumption and marketing functions, which are interdependent under conditions of market imperfections.

Understanding motivations behind varieties' choices might drive policies supporting farmers to access to their preferred varieties (improved, local or both), thus leading to more profitable marketing choices and satisfying specific consumption preferences. Our findings can inform effective variety development and diffusion, as well as legal frameworks preserving the coexistence of formal and informal seed systems, thus delivering the whole pool of varieties chosen by farmers.

[2] The term "vulnerability" in the context of this manuscript refers to the inability to respond to the external shocks (e.g., drought), trends (e.g., resource stocks), and seasonal variations (Bebbington, 1999).

2.1. Introduction

Reduction of food insecurity in Sub-Saharan Africa (SSA) remains a top priority on the development agenda as 240millions people are estimated to be currently undernourished (FAO et al., 2020). Promoting the diffusion of modern technologies to reduce food insecurity, such the smallholder's adoption of improved crop varieties, represents one of the interventions that authorities traditionally carry out in order to increase food supply.

The extensive literature on adoption of improved crop varieties by smallholder farmers in Sub-Saharan Africa reports contrasting results: some report widespread adoption (Alene et al, 2009), while others show low rates of adoption and low use of complementary innovative farm technologies (Kijima et al, 2011; Branca & Perelli, 2020). Literature has often analyzed the process of improved varieties adoption as a dichotomous choice (Sumberg, 2016): Traditionally, conditions of technological change, e.g., the advent of modern varieties, have been claimed to lead to two different scenarios: the scientific and traditional knowledge collide and take two isolated paths; or the scientific knowledge prevails over the traditional one, which is gradually dismissed. (Howes & Chambers, 1979). This reflects a common theoretical interpretation of technology adoption in small-scale farming systems as a dichotomous switching process from traditional materials, tools and methods to innovative and sometimes superior ones (Glover et al, 2016). This vision has frequently led to classify prospective technology adopters merely into two exclusive categories: adopters and non-adopters. However, several studies highlight the multifaceted behaviors of households when facing strategic choices related to the use of improved or local seeds (Bellon & Hellin, 2011). Farmers maintain in many cases a pool of crop varieties, most of them local, and incorporate in this pool some improved varieties (Bellon et al, 2006; Dedeurwaerdere & Hannachi, 2019; Perales et al, 2003) More specifically, this strategy is implemented both at interspecific and infraspecific level. As for interspecific diversity, smallholder farmers might take on partial adoption behavior, namely the use of improved or local seeds for different crops in the same farming system, due to, inter alia, the heterogeneous access to improved seeds for minor and major crops. In fact, in most African countries farmers use diverse seeds varieties and relate to diverse seed systems for different crops: commercial seeds for exotic vegetables; seeds from national commercial chains for maize; local semi-commercial sources for groundnut; and farm-saved seeds for staple crops like sorghum, millet and beans (Louwaars & de Boef, 2013). As for infraspecific diversity, different varieties may cover different roles; improved and local seeds use can thus fall on the same crop based on the idea of crop multi-functionality. Briefly, improved varieties have been reported to play a commercial function while

local varieties to play a subsistence function responding to food security and cultural preferences needs (Bellon & Hellin, 2011). Farmers, indeed, employ multiple selection criteria and ask for multiple traits able to respond to the structural heterogeneity of their needs (Adesina & Baidu-Forson, 1995; Edmeades et al, 2004; Bellon, 1996). Crop varieties can therefore be interpreted as a bundle of multiple traits or attributes (Wale et al, 2005; Edmeades et al., 2008), representing not only a source of food and income, but also means to fulfill latent meanings such as cultural identity and social status, as well as being a safety net for the household (Perales et al, 2005).

By recognizing the limitations of considering seeds adoption as dichotomous switching process, this study examines smallholders decision-making process for the inclusion of improved varieties, maintenance or displacement of local varieties in three Eastern African countries (Ethiopia, Malawi and Tanzania). More specifically, this study aims to identify functions do improved and local varieties play in East African subsistence farming system and the role of markets in determining varieties' adoption motivations. The underpinning assumption behind this work is that in subsistence farming systems, with market access imperfect and costly[3], agricultural decisions of the households strictly depend on their consumption habits, while farmers may adopt improved and or local varieties according the final use of the crop, namely, self-consumption and or market sales. Similarly, the coexistence on farm of local and improved varieties can be explained on the differentiated uses that they are simultaneously/individually able to address. This situation has been already verified in semi-commercial farming systems in Mexico, where the analyses of farmers' choice to use maize hybrids or landraces demonstrated that the former are also planted for self-consumption and the latter for commercial purpose (Bellon & Hellin, 2011).

The novelty of this paper lies on the detailed analyses of the diversified subsequent choices that farmers make in relation to seed innovation adoption for a number of crops simultaneously present in the farming systems, complemented by a multi-country, multi-crop analysis. To this regard, this paper also offers a novel theoretical framework for a better understanding of the farmers' decision to adopt improved varieties in subsistence farming system. Grounded on the dynamics of crops infraspecific diversity at farm level elaborated by Bellon (1996), the framework aims to clarify the

[3] Market imperfections alter households' consumption and marketing decisions due to difficulty access to input and outlet for their produce, determining a higher recourse to self-consumption. Traditionally, this has been associated to the selection of local varieties. Thus, in these conditions, varieties selection, consumption and commercialization have been hypothesized to be interdependent (Bellon & Hellin, 2011).

multi-functionality of crop infraspecific diversity and the connected implications in terms of interdependent production and consumption decisions of the household.

2.2. Theoretical framework

Farming systems are complex and diverse adaptive systems subject, particularly in developing countries, to increasing climate variability and shocks. The stock of genetic diversity embedded within the system influences its adaptive capacity to respond to these alterations (Acheampong et al, 2018). Farmers' behavior ultimately determines the genetic diversity of a geographical site affecting the evolutionary forces pressing on genetic plant populations; Each site is characterized by a set of traits selected by the whole farming community over the years, integrated by the technological changes — and thus by new traits — brought by external interventions. In turn, the site supplies the variety traits from which each farmer makes his/her own variety choice over time[4] (Smale et al, 2001). Nevertheless, within the same site farmers make different choices and tend to give preference to different attributes, according to specific individual selection criteria. Based on Smale et al (2001), farmers choose crop varieties selecting the combination of attributes able to better "address production constraints, assure consumption preferences and satisfy specific market requirements". Nordhagen et al (2017) extended those factors to four broad categories of concerns: marketing; culture, exchange, and status; environment and risk management; and culinary/consumption. While a core of these concerns is typical of most subsistence farming systems, some others are more specific and determined by the peculiar features of each household. Farmers use therefore multiple criteria to simultaneously address the unique combinations of concerns which characterize them. The number of selection criteria used by farmers in a particular area has been positively associated with the level of diversity in farmers' fields (Teshome et al, 1999).

Nevertheless, the bulk of the scholarly literature that analyze varieties adoption has increasingly underscored the importance of crops traits, and thus farmers' concerns, in determining farmers' decisions. Differently, our study draws its conceptual framework on the dynamics of crops infraspecific diversity at farm level elaborated by Bellon (1996) that analyzed the process of

[4] Notably, the crop variety traits or attributes are the performance characteristics of the plant varieties that include both the production capacity of the plant and the consumption attributes of the product (Edmeades et al, 2008). Such bundle of traits may include production characteristics, such as disease and pest resistance, high yielding, early maturity and adaptability to harsh environments (Manu–Aduening et al, 2006); and consumption characteristics, such as taste, color and subjective importance farmers place on seeds (Wale et al, 2005).

inclusion, elimination and maintenance of crop varieties in the household's farming systems. Bellon (1996) based its analysis on five assumptions:

(1) Farmers have a set of concerns, which include important issues related, among others, to consumption (e.g., cultural preferences, taste) and marketing (e.g., productivity, storability);

(2) Farmers access to a pool of varieties, each of them characterized by different attributes able to respond to farmers' concerns[5];

(3) Through the direct use of each variety and the indirect knowledge gained by neighbors' experiences, experimental field, etc., farmers are aware of each of the varieties' attributes and are able to link them to their concerns;

(4) Farmers evaluate each variety based on the capacity of its attributes to respond to the considered concern. Each variety can be therefore ranked and compared to others;

(5) Eventually, farmers associate each concern with the best variety.

According to Bellon (1996), different cases may occur. In a steady situation, the variety pool maintained by farmers consists of varieties ranking higher than others in terms of capacity to respond to farmers' concerns. When a single variety is not enough to address a specific complete set of farmers' concerns, more than one variety is maintained to address this set through the complementarity of their attributes. However, when a variety scores higher than another for the same subset of concerns, displacement occurs, leading to the elimination of the second one. An extreme scenario is represented by the existence of a variety scoring higher than all others for all the concerns expressed by a farmer, in which case it eliminates them all. Lastly, if a new variety scores higher than the others for a subset of concerns, but lower for another subset of concerns, it is included without displacement of other varieties.

In the current study, we have implemented Bellon's framework applied to the specific farmers' decision-making process taking place when they access to improved varieties assuming an initial condition in which only local varieties are used.

Farmers' decision-making is here intended as a sequence of two strategic choices, namely the decision to adopt an improved variety and the subsequent maintenance or displacement of the extant pool of local varieties, corresponding to the two following decisional knots illustrated in Fig. 1:

To illustrate, in the first *knot / adoption choice,* farmers access a new improved variety and compare it with the pool of cultivated local varieties. Farmers evaluate improved variety' attributes and

[5] This study assumes a simplified version of the framework, only targeting the properties related to local or improved varieties categories

compare the performances of improved and local varieties in addressing their concerns. When the attributes of the improved variety are not better able to address all or at least a subset of farmers' concerns in comparison to the existing local varieties, farmers continue to solely use the extant pool of local varieties. This situation finds correspondence in the first output of Fig. 1 (grey triangle "Farmers maintain extant local varieties pool"). Otherwise, the improved variety is included in the farming system, either exclusively or in combination with the existing local varieties depending on the second farmers' strategic choice (2nd knot). This first step of the decision-making process allows to capture the propensity of farmers to innovation adoption.

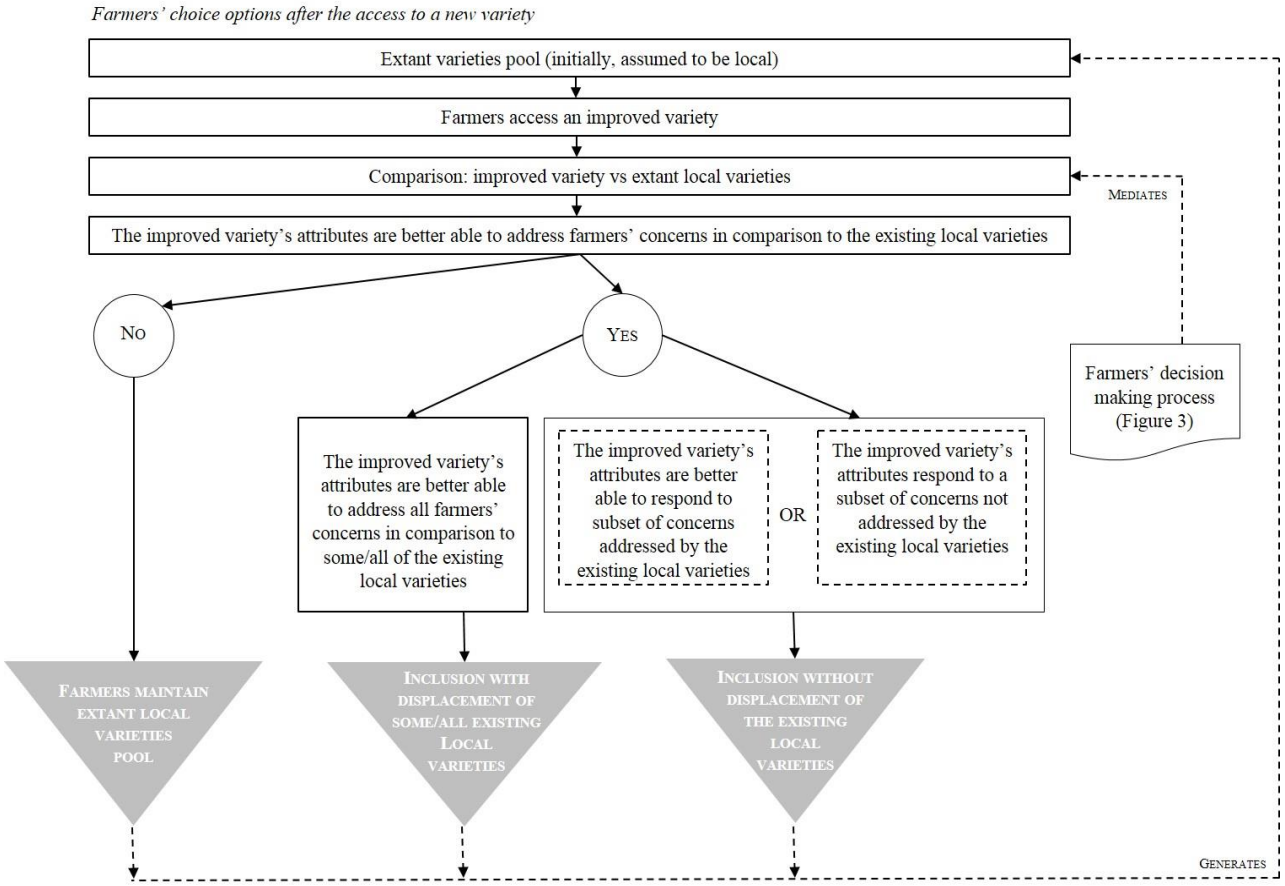

Figure 1. Dynamic of crops infraspecific diversity at farm level based on the analyses of the process of inclusion, elimination and maintenance of improved and local varieties, own source.

The second adoption choice of the decision-making process (*second knot / adoption choice*) focuses on the adopters of improved varieties, which face the decision to maintain or to displace the existing local varieties (second and third triangles in Fig. 1, respectively). When improved varieties

outperform existing local varieties in addressing all farmers' concerns, local varieties are displaced, determining a final condition of exclusive use of improved varieties (grey triangle "Inclusion with displacement of some/all existing local varieties"). On the contrary, when the two varieties complement each other in responding to farmers' needs, local varieties are maintained, leading to a final condition of coexistence of local and improved varieties (grey triangle "Inclusion without displacement of the existing local varieties").

This two-steps decision making process underlies the dynamic evaluation process described by Fig. 2. It gathers the interconnections between varieties' perceived attributes and level of diversity that occurs in a particular area, based on the capacity of the different varieties to satisfy farmer's economic and non-economic individual concerns. According to Bellon (1991; 1996) farmers' concerns can be classified into: agro-ecological (e.g., climatic condition and soil type); management (e.g., availability of fertilizer and labor, cultural practices); and use (e.g., yield, storage resistance, appropriateness for market taste and/or consumption). Farmers' concerns arise as a result of the constant interplay of farmers' socio-economic characteristics and the policy and working environment characterizing the farming system they belong to (Wale et al, 2005), thus determining specific farmers' concerns profiles. Each individual attribute preference system corresponds to the concerns profile of a specific farmer. The attributes preference system of each farmer can be either farmer-specific for each included attribute, or include attributes shared also with other farmers (in Figure 2, attributes are represented by the triangles). The selection of attributes is based on farmers' capacity to address specific farmers' concerns. Farmers' preferences for variety attributes result in their varieties selection, since farmers value varieties by considering the bundle of attributes that each variety embeds. Figure 2 illustrates how varieties embedding different bundles of attributes are selected depending on linked farmers' attributes preference systems that, in turn, result from farmers' concerns profiles. Ultimately, collective farmers' decisions on varieties will determine the level of crop diversity in the farming system.

In our framework, interacting antecedent factors of farmers' concerns have been extended to the following categories of factors: Household specific factors, Economic and Financial Factors, Institutional Factors, Physical Factors, Technological Factors and Social and Human Factors. Being the focus of our analysis subsistence and semi-subsistence farming systems, farmers' concerns categories have been restricted to that of the output use: marketing and consumption. Particularly, even though this is not always true, in the study areas farmers' output uses are almost exclusively self-consumption and commercialization. By means of three example profiles, Figure 2 highlights

how different attributes preference systems composition, arising from different farmers' concerns profiles, translate into different or overlapped decisions for local and improved varieties. Specifically, attributes of profile n.1 find an exclusive match with the local variety. This represents the case of the exclusive use of local variety (first grey triangle in Fig. 1). Profile number 2 and 3 present an overlap in their attribute preferences. Whilst Profile n.3's preferences are exclusively addressed by a single variety (the improved one), Profile n.2's composition requires the use of both improved and local varieties to satisfy its preferences. The first case represents the exclusive use of improved varieties. In the hypothesized decision-making process, this would correspond to the adoption of improved varieties with displacement of local varieties (second grey triangle in Fig. 1). The second case represents instead the combined use of improved and local varieties, corresponding to the inclusion of improved varieties without displacement of the existing local varieties (third grey triangle in Fig. 1). In this simplified representation is however possible to note how different varieties can still address the same concerns and hence playing overlapping functions. This is the case of profiles number 1 and 3 that include in Figure 2 respectively a vertically and horizontally striped red triangle. We can imagine that they share a common concern, as for instance a consumption concern (red). However, this concern might be addressed by different consumption attributes (e.g., taste (vertical) and cultural (horizontal) meanings), and hence leading to different varieties' use decisions. Infraspecific diversity is thus shaped by farmers' concerns and perceived varieties performances. Nevertheless, farming systems are not fixed entities, but rather dynamic environments subjected to countless interactions able to alter the antecedents of farmers' concerns and, as a consequence, farmers' concerns. For instance, development-oriented interventions, the advent of new technologies or the increased integration in the market can lead to contrasting impacts. Specifically, as this study focuses on concerns related to the output use (consumption and marketing) (Figure 2), market dynamics are crucial. This is particularly true in subsistence farming systems, where market participation plays a critical role in shaping the cultivated diversity. High transaction costs reduce the convenience for farmers and traders in either selling or buying the produce, leading to missing markets. In addition, from a producer point of view, a limited market participation constraints output marketability while from a consumer point of view, it drastically narrows consumption options. The general effect is a recourse to self-consumption especially when dietary preferences are culturally determined. Considering the critical role of market imperfections in subsistence and semi-subsistence farming systems, consumption and marketing strategies can be considered interdependent in addressing farmers' decision on varieties use (Taylor & Adelman, 2003).

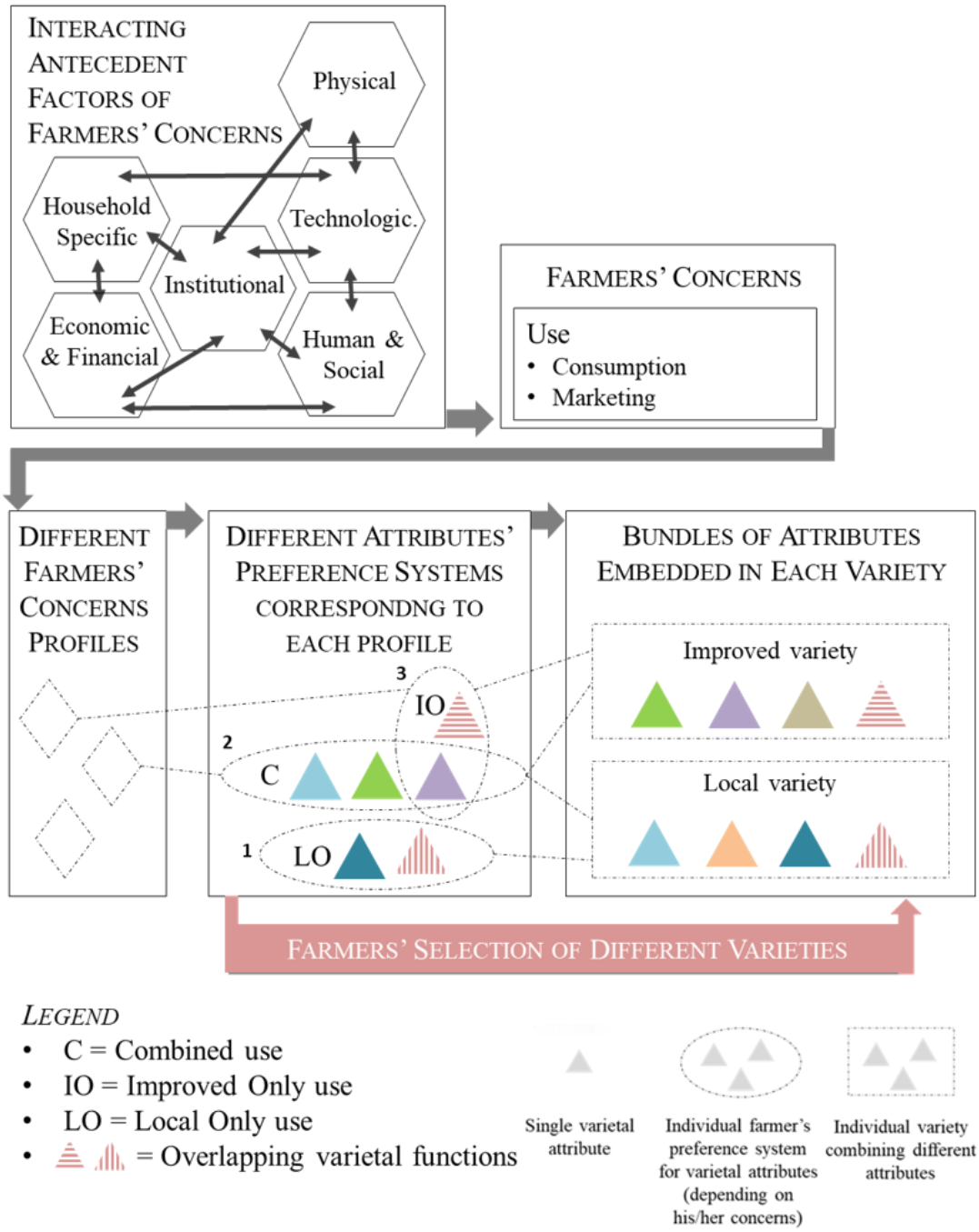

Figure 2. Farmers' decision-making in relation to improved and local varieties' use. Own elaboration based on from Bellon (1996) and Wale et al (2005).

2.3. Empirical framework

The purpose of the current investigation is to analyze the motivations underlying farmers' multifaceted behaviors with relation to varieties use, accounting for the unique combinations of individual and shared concerns faced by each household. To this aim, we have conceptualized a

decision-making process based on two subsequent decisions: i.) to include or not improved varieties to the extant local varieties pool and ii.) to maintain or to displace local varieties once that the improved varieties are adopted. We assume a decision-making process based on the comparison of varieties attributes. We also assume that each of the subsequent decision is based on the capacity of the selected variety to better address farmers' concerns through the attributes that the varieties themselves embed.

A Sequential Logit approach was implemented (Van de Ven and Van Pragg, 1981; Malorgio et al., 2013) in order to analyze empirically farmers' decision-making process, under the assumption that farmers face choices concerning varieties use sequentially over time.

According to the adopted conceptual framework, farmers' decision-making is treated as a two steps decision-making process, under the hypothesis of an initial condition (Time 0) where exclusively local varieties are in use: i) *Time 1* - the choice to include or not a new improved variety; and ii) *Time 2* – the choice to include the improved variety with or without displacement of the extant pool of local varieties (Figure 3).

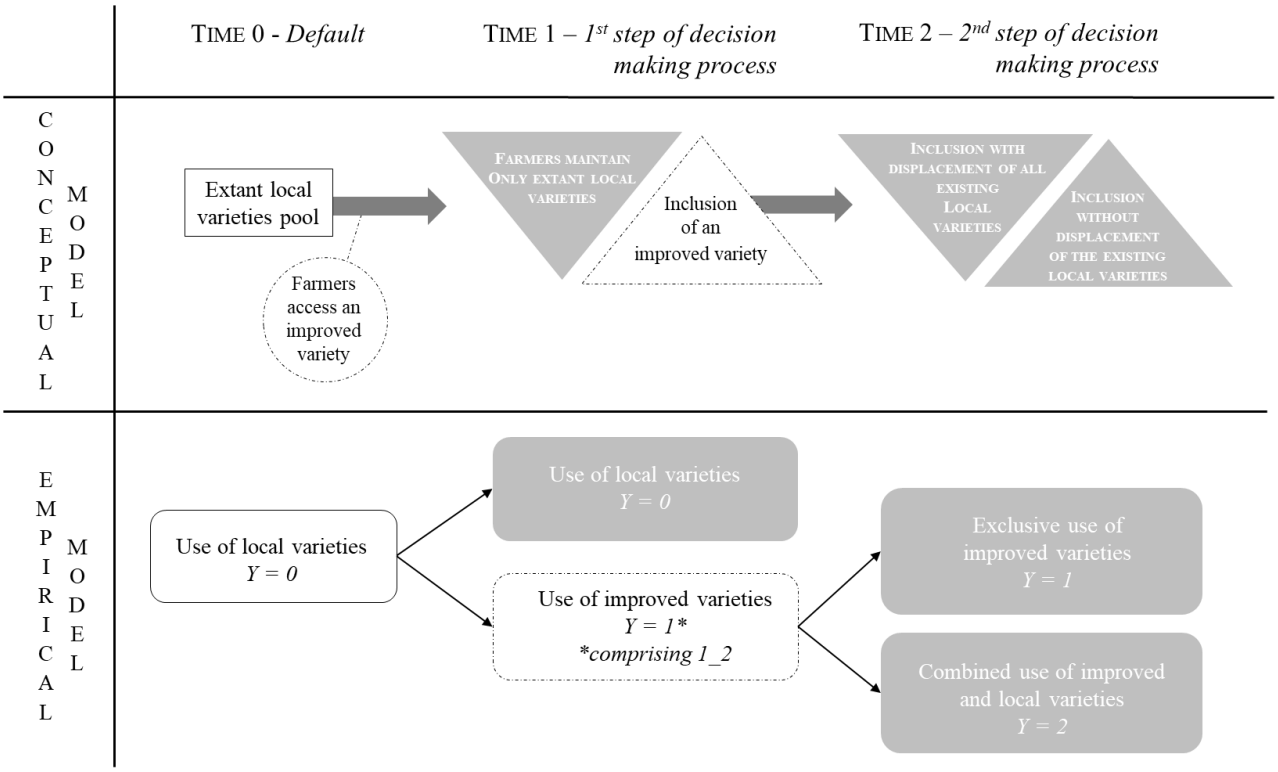

Figure 3. Correspondence between the conceptual and empirical model, Own source

The empirical operationalization of the decision-making process leads to three potential technology bundles that a farmer could choose: i. local varieties only; ii. improved varieties only; or iii. both types of varieties (corresponding to the grey triangles of Fig. 4, conceptual model).

Farmers are expected to select the bundle which maximizes their expected utility (Dorfman, 1996). For each-*c* crop, the expected utility conditional on the use of a particular technology bundle is represented by $U_{c,i}(V_i, \mathbf{z})$ where V_i denotes the *i*th variety bundle and **z** a vector of all the information used to calculate expected utility (Household specific factors, Economic and Financial Factors, Institutional Factors, Physical Factors, Technological Factors and Social and Human Factors). In the function $U_{c,i}(V_{c,i}, \mathbf{z})$ are implicitly included the profit, cost, and risk impacts of the varieties decisions. The farmers' problem is summarized in:

$$\text{choose } V_{c,i}\text{: } V_{c,i} = \text{argmax}[U_{c,i}],\ i=0,1,2 \qquad (1)$$

By convention, in the analysis variety bundle zero represents no adoption of improved seeds, hence, the exclusive use of local varieties. Indeed, in our empirical model, the use of local varieties in the farming system occurred in two different states: farmers' initial condition before accessing new improved varieties and farmers' final condition after accessing new improved varieties and displacing them. Lastly, variety bundle one represents the exclusive use of improved varieties and variety bundle two the coexistence of improved and local variety.

Choices for each step of the decision-making process, interpreted in the empirical model as the probability to adopt specific strategies, are determined by Household specific factors, Economic and Financial Factors, Institutional Factors, Physical Factors, Technological Factors and Social and Human Factors (Fig. 2). The result of each step, hence the dependent variable $\{Y_i\}$, is interpreted as a qualitative random variable, since the subject of this analysis is a set of choices. It can assume three levels: 0, 1 and 2 (corresponding to the grey rectangles of Fig. 4, empirical model). The *h-th* farmer's initial condition before accessing new improved varieties (*Time 0*) is assumed to be limited to the use of local varieties (Y=0). From this starting point he/she can move forward the *inclusion* of improved varieties ($Y\neq0$) or not (Y=0), in which case he/she *maintains* the sole local varieties (*Time 1*). Thus, the first step of the analyses captures the propensity of farmers to adopt the innovation, estimating its determinants factors. The subsequent choice (*Time 2*), given the *inclusion* of improved varieties ($Y\neq0$) relates to the exclusive use of improved varieties (Y=1) or the combined use of local and improved varieties (Y=2). This second step focuses on the propensity and determinants to the

displacement of local varieties and to the *inclusion* of improved varieties *without the displacement* of local ones.

We explain the above mentions two-step-choices using two different binary models. They include two latent stochastic variables, L^* and I^*, representing the propensity to choose and use local and improved varieties, respectively. Since they are not observable, the model considers instead two dichotomous variables expressing farmer's choices:

$$L_{h,c} = \{1 \text{ if } L^*_{h,c} > 0; \quad 0 \text{ if } L^*_{h,c} \leq 0) \text{ and}$$
$$I_{h,c} = \{1 \text{ if } I^*_{h,c} > 0; \quad 0 \text{ if } I^*_{h,c} \leq 0) \tag{2}$$

From now on the new outcome can be read as: $Y_{h,c}$=0 when $I_{h,c}$=0 and $L_{h,c}$=1; $Y_{h,c}$=1 when $I_{h,c}$=0 and $L_{h,c}$=1 and $Y_{h,c}$=2 when $I_{h,c}$=1 and $L_{h,c}$=1. Explanatory variables and unobservable variables are used to explain the farmer's strategy:

$$L_{h,c}^{*} = \boldsymbol{z}_1'\beta_1 + u_h \quad h = 1,2 \ldots . n_1 + n_2 + n_3 \tag{3}$$

$$I_{h,c}^{*} = \boldsymbol{z}_2'\beta_2 + e_h \quad h = 1,2 \ldots . n_2 + n_3 \tag{4}$$

z_1 and z_2 represent k_1 and k_2 matrix of known factors influencing the decisions, and β_1 and β_2 represent k_1 and k_2 vectors of unknown parameters, and the error terms follow a bivariate normal distribution: $\begin{bmatrix} u \\ e \end{bmatrix} \sim (N,0)$, with $\sum = \begin{bmatrix} 1 & . \\ \rho & 1 \end{bmatrix}$

The selected model allows to overcome the dichotomous approach to innovation adoption, and thus to confound the simplicity of the adoption concept. Different methods have been developed so far to add precision and nuance to the study of adoption (cfr. intensity of adoption in Arslan et al., 2014, partial adoption and dis-adoption in Moser and Barrett, 2003 and Neill and Lee, 2001). The great advantage of this model arises from the possibility to explain the structure of farmers' decision-making process considering the complete combination of potential choices that may be taken. It thoroughly matches the conceptual framework proposed, generating insights into the dynamic innovation adoption process that is richer and more informative than given by other popular econometric models.

2.4. Study Context and Data

The analysis was conducted using data from a household-level survey carried-out in 2018 in five sites in three countries: the two districts Meta and Kombolcha in Oromia region in Ethiopia; the Lindi district in Lindi region in Tanzania; Dedza district in the Central region and Mzimba district in the Northern region of Malawi. Study sites even if are located in three different countries, they overall share some similarities for representing subsistence farming systems of SSA characterized by smallholders farmers, with limited access to productive inputs and financing. On the other hand, they cover widely different cultural and agro-environmental conditions, leading to the opportunity for an inclusive analysis of the farmers motivations to adopt improved seeds. In the Districts have conducted several focus group discussions (FGDs) with small-scale producers and relevant actors along the value chain (e.g. policy makers, agrodealers, processors, extensionists and traders) in February 2018. To some of those actors were given in-depths interviews. More in detail, Kombolcha district within the Oromia Region of Ethiopia, comprises lowland, mid-altitude and highland agro-ecologies with altitude ranging from 1400 to 2400 meters above sea level. Kombolcha district receives a mean annual rainfall of 600 – 900 mm. Meta district is also represented by lowland, mid-land, and highland agro-ecologies with altitude ranging from 1200 to 3140 meters above sea level. Livelihood of most of the population in the two selected districts (>90%) is based on smallholder farming where integrated crop-livestock production is practiced and sorghum, maize, pulses, potato are the major crops. Mzimba District of Malawi is characterized by a mid-altitude (1000-1200 m asl), sub-tropical ecosystem, while Dedza District is a higher altitude (1200 – 1600 meters above sea level) district along the Rift Valley. Both districts are mainly settled by smallholder farmers farm with land size an average less than 2 ha of land, with approximately half of all calories consumed by rural households come from their own food production (Dorward & Chirwa, 2011). The typical cropping pattern of smallholders in both sites has been maize as the dominant staple crop, and other crops grown at low density including tobacco, sweet potatoes and groundnut (Ellis & Manda, 2012). Finally, as concerns the selected site in Tanzania, Lindi District, much of the area lies at an altitude of less than 300 m above sea level and it is characterized by infertile sand soil (Martin et al., 1997). The typical farming systems include cassava/sorghum and cashew/cassava/coconut -based farming systems, while the overall population is characterized by a higher than average poverty prevalence.

Within the five districts, the analyses were conducted using data from a household-level survey carried-out in 2018. The survey provided information about demographic and socioeconomic characteristics of households, crop production systems and practices used, seed accessibility,

membership in agricultural associations, access to extension and advisory services, access to agricultural inputs and credit. A sample of 1,965 households were randomly surveyed on the basis of census lists. Multi-stage Sampling procedure was used to obtain efficient and consistent estimates of the target population: first, the relevant population of farmers adopting target sustainable agriculture practices in each selected country was identified; second, clusters representing lower administrative units (e.g., regions, districts, villages, wards) were selected; third, households to be interviewed have been randomly selected. The surveys were carried out in accordance with the ethics requirements. Permission to carry out the surveys was obtained by the regional, district and village authorities. All the anonymous participants were made aware of the objective of the survey for whose purpose permitted the use of the information provided.

2.5. Results

2.5.1. Household and crops characteristics

Summary statistics of the variables which were used in the Sequential Logit analysis are presented in Table 1.

The study revealed that most of the household are headed by males (83%). Their average age was about 44 year and on average they reported to have spent in school from about 3 years in Ethiopia to 6 years in Malawi. The average family size of the sampled households was 3.9 while average hired labor was about 47 days per season.

The survey confirms that access to credit and services in this area is strongly constrained. Nearly a third of respondents reported to have had access to a loan (27%) or to extension and advisory services (30%), with, however, values considerably below the overall average in Tanzania (9% and 7%, respectively). In general, a very small proportion of households (5%) was able to access to seed subsidies, indicating that the existing seed subsidy programs in the three countries lack of proper implementation. Instead, the use of complementary agricultural inputs displays again differentiated trends across the three countries. While almost half of respondents reported to use fertilizers in Ethiopia and Malawi (55% and 44%, respectively), the percentage drops to 14% for Tanzanian households, whose use of pesticides (57%) is however consistently above the overall average (28%). Thus, although 89% of the surveyed households declared to perceive the effects of the climate change, their capacity to choose an increased intensity of input use as adaptation strategy is still limited.

The degree of market orientation, with an average 33% of overall produce sold, is not uniform across the region. In particular, in Tanzania the marketed production reached a percentage of 64%, probably

facilitated by a shorter distance from the nearest market (1.5 Km) in comparison to the whole sample (7.8 Km). Only 20% per cent of farmers come from households in which at least one member has membership in a farmer association. This last factor, when interpreted in conjunction with the low access to extension services and credit is able to depict a clear picture of a generalized low endowment of public assets and services, which are therefore expected to negatively influence the adoption decisions.

Survey identified overall 43 different crops, of which we included in the analyses 10 crops selected as cultivated by at least 100 households. The selected crop were beans, cashewnut, cassava, cowpea, groundnut, khat, maize, potato, sorghum and soybean. Observations which did not include the type of variety selected, were removed. Table 2 reports for each crop and for each country, the number of households cultivating that crop, the average total production and the average cultivated land.

Unsurprisingly, maize was cultivated by the largest number of households (1.367). Indeed, Sub Saharan Africa accounts for 15.7% of maize produced worldwide (Pingali 2001), which also represents 45% of the share of calories from all staple cereals in Eastern and Southern Africa (Shiferaw et al, 2011). Maize frequencies are followed by sorghum (447), beans (409), groundnut (343), potato (341), soybean (321), khat (273), cashewnut (271), cowpea (145) and cassava (109). In line with the low level of market orientation intercepted (30%), results confirm that on average smallholders cultivate primarily food crops such as maize, sorghum and beans to meet (even if not exclusively) subsistence requirements. However, results differ across the countries.

Sorghum and potato frequencies are particularly relevant in Ethiopia (76% and 80% of the overall sample, respectively). With respect to sorghum, this can be explained in view of the fact that Ethiopia is the center of origin of this crop (Mekbib, 2008), which represents a dominant staple crop in many areas of the country. Potato has increasingly become an important food and cash crop in the country, also due to potato research programs implemented by the Government since the mid-1970s (Tadesse et al, 2017). Khat is cultivated exclusively in Ethiopia by 273 respondents. Its high frequencies are justified by the fact that it is one the three major cash crops in the area, contributing to an estimated 13.4% of national export earnings (Megerssa et al, 2014). Lastly, 179 Ethiopian respondents reported to grow bean, the most important food legume in Ethiopia (Tigist et al, 2020).

Table 1. Key characteristics of farming households

Variables	Description	Sample (obs. 1590)		Ethiopia (obs. 612)		Malawi (obs. 646)		Tanzania (obs. 332)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Household Specific Factors									
HH Head Gender	Gender of the household head (0=male; 1=female)	0,17	0,37	0,08	0,26	0,26	0,44	0,15	0,36
HH Head Age	Age of the Household Head	43,6	14,32	39,2	11,08	44,8	15,4	49,4	15
HH Head education	Number of years spent in school by the Household Head	4,63	4,05	3,25	3,62	6,39	4,08	3,73	3,45
HH Size	Number of household members living permanently on the compound other than household head (HH)	3,9	1,9	4,53	1,94	3,67	1,81	3,19	1,67
Hired Labour	Number of days/season	47,1	118,2	91,1	172,5	19	45	20,8	48,5
Economic and Financial Factors									
Credit	Acces to credit in the last 12 months (0=no; 1=yes)	0,27	0,44	0,34	0,48	0,28	0,45	0,09	0,29
Market Orientation	Percentage of the overall produce sold	0,33	0,32	0,26	0,28	0,24	0,26	0,63	0,34
Institutional Factors									
Seed Subsidy	Access to subsidy in the last 12 months (0=no; 1=yes)	0,05	0,22	0,02	0,14	0,1	0,3	0,01	0,08
Market Distance	Approximate distance to the nearest trading market/urban centre (Km)	7,8	6,18	5,33	2,38	13,3	5,55	1,58	1,81
Physical Factors									
Wheather Change	Change in weather pattern experienced in the past five years (0=no; 1=yes)	0,89	0,31	0,97	0,16	0,87	0,34	0,79	0,41
Technological Factors									
Fertilizers	Fertlizer use in the last 12 months (0=no; 1=yes)	0,42	0,49	0,55	0,5	0,44	0,5	0,14	0,35
Pesticides	Pesticide use in the last 12 months (0=no; 1=yes)	0,28	0,45	0,16	0,37	0,25	0,43	0,57	0,5
Social Capital Factors									
Extension	Access to extension services for crop production in the last 12 months (0=no; 1=yes)	0,3	0,46	0,38	0,49	0,34	0,47	0,07	0,25
Group Participation	Membership in agricultural associations (0=no; 1=yes)	0,2	0,4	0,12	0,33	0,27	0,44	0,2	0,14

The importance of maize in Malawi is particularly relevant in comparison to the other countries as well as in comparison to the national statistics. Historically, this crop is highly supported by the national Farm Input Subsidy Program (FISP). However, in the study sites maize is grown by almost 98% of the sampled households, and thus considerably above the national average (70.8%) presented

by the Malawi National Statistics Office (NSO) for the 2015/2016 agricultural season (Zavale et al, 2020). However, 98.2% of national households are reported to consume this staple crop (ibid.). These results could be explained by the relative lower market orientation of the Malawian study sites (only 24% of produce sold) in comparison to the overall sample (33%). In contrast to Ethiopia, the most important legumes grown in Malawi extend beyond beans (cultivated by 230 households) to soybean and groundnut. 240 households reported to grow groundnut, while soybean is almost exclusively cultivated in this country by 320 households. Soybean expansion is promoted by the Government as a differentiation strategy to contrast the generalized dependence of the agricultural sector from maize and tobacco (GoA, 2015). Moreover, both crops are also targeted for integration in maize-legume cropping systems under conservation agriculture (Ngwira et al, 2020).

Cashewnut is the most important cash crops in southern Tanzania, which accounts for about 2% of global production (Mitchell & Baregu, 2012). This is confirmed in the Tanzanian study site where cashewnut is the most popular crop, cultivated by 81.6% of households. These data contribute to explain the relative higher market orientation of Tanzanian household in comparison to the rest of the sample. In this study site maize is cultivated by about 48% of farmers, slightly below the national average of 60% (USAID, 2010). This is probably due to the complementary relevance of sorghum in this area, grown by 102 households. According to Simtowe & Mausch (2019), sorghum cultivation decision would "respond to changes in relative market prices compared to maize". As opposed to the other countries, legumes cultivation in Tanzania includes cowpea, grown almost as much as groundnuts (by 135 and 103 households, respectively). Tanzania also presents the highest frequency for cassava cultivation (85.2% of the overall sample). Recent studies show that this crop is perceived as more tolerant in comparison to other staple crops to harsh climate and environmental extremes by farmers in the coastal area of Tanzania (Mbwambo & Liwenga, 2020).

Table 2. Total production and area planted for plant species grown by farm households in Ethiopia, Malawi, and Tanzania

Crops	Ethiopia			Malawi			Tanzania		
	obs.	Total prod. (Kg)	Area (m^2)	obs.	Total prod. (Kg)	Area (m^2)	obs.	Total prod. (Kg)	Area (m^2)
		Mean	Mean		Mean	Mean		Mean	Mean
Beans	179	141.8	764.1	230	91.61	7647.4	0	-	-
Cashewnut	0	-	-	0	-	-	271	1005	5237.6
Cassava	0	-	-	16	1631	3571.3	93	303.5	5982.6
Cowpea	8	91.25	654.75	2	25	1015.5	135	157.3	7763.2
Groundnut	0	-	-	240	190.3	2282.7	103	241.4	5887.6
Khat	273	42.97	1357.4	0	-	-	0	-	-
Maize	571	504.8	1781.1	636	1051	42610	160	190.6	6062.6
Potato	274	1430	2575.4	67	607.9	2873	0	-	-
Sorghum	340	385.5	1140.4	5	10	809.2	102	139.7	5397.3
Soybean	1	-	-	320	155	2813	0	-	-

Source: Own elaboration

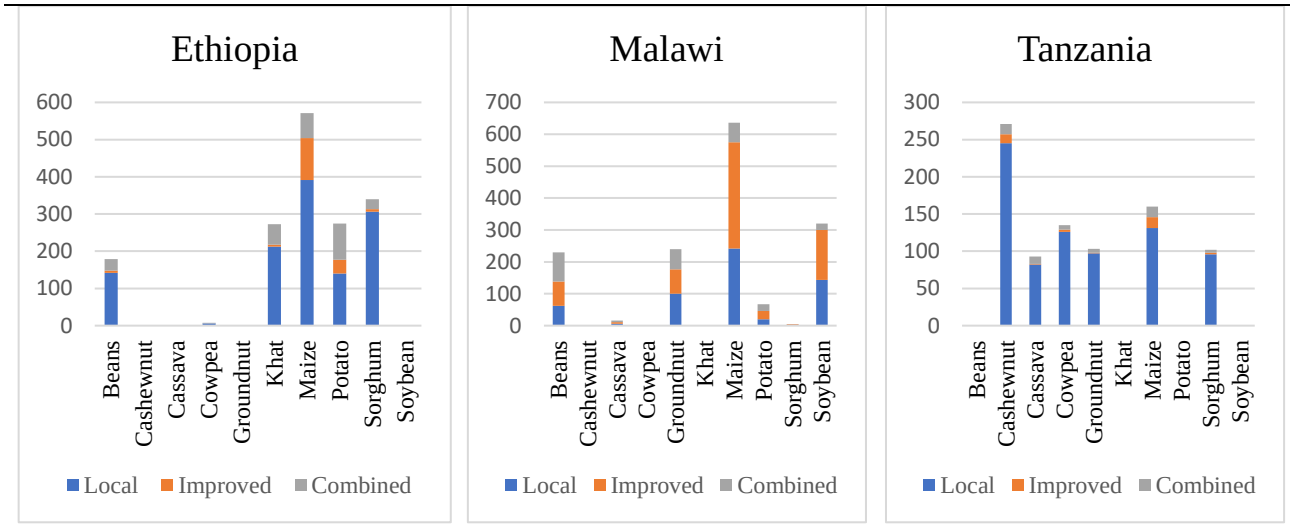

Figure 4. Number of farm households cultivating each plant species and variety in Ethiopia, Malawi and Tanzania. (Source: Own elaboration)

2.5.2. Adoption estimates

The 1st step of the sequential logit model investigates i) the motivations behind the inclusion of improved varieties to the extant pool of local varieties and ii) the motivations behind the exclusive use of local varieties. Results provide different alternative interpretations. On the one hand, we look at the role of the variables in determining the adoption of improved varieties. We can therefore seize

useful indications about the barriers to improved varieties adoption. On the other hand, we look at farmers' specific preferences for the attributes of local varieties. Despite the well-known constraints to the access and use of improved varieties in East Africa, it must be also considered that the exclusive use of local varieties can potentially arise from the specific preferences of farmers for their bundle of attributes. This idea adds a different nuance to the results interpretation: explanatory variables not only represent the barriers to innovation adoption, but also the factors supporting the active choice to exclusively use the local varieties. An in-depth interpretation of results in this respect is elaborated in the discussion section.

The 2nd step of the sequential logit focuses on the behaviors of adopters. It analyzes: i) the motivations behind the exclusive use of improved varieties and ii) the motivations behind the combined use of improved and local varieties. Accordingly, results can also be read as the motivations behind the displacement or maintenance of local varieties.

Results are illustrated in Table 3. They are discussed in by category group of independent variables in the following subsections. As discussed earlier, farmers concerns were elicited in the empirical analysis by means of the following categories of variables: a) Household specific factors, b) Economic and Financial Factors, c) Institutional Factors, d) Physical and Technological Factors and e) Social and Human Factors. Finally f), remainder sources of farmers concerns that are strictly country and crops specific have been included in the analysis as fixed factors.

Table 3. Results of the sequential logit uptake model: 1) Use of improved varieties (1_2) rather than only local varieties (0). 2) Use of a combination of local and improved varieties (2) rather than only improved

Variables	0 vs 1_2				1 vs 2			
	Regression results				Regression results			
	Coef.	S.E.	*z*		Coef.	S.E.	*z*	
Household Specific Factors								
HH Head Gender	-0.348	0.140	2.49	**	-0.290	0.204	-1.43	
HH Head Age	0.002	0.004	0.51		0.004	0.006	0.61	
HH Head Education	0.036	0.014	2.49	**	-0.054	0.022	-2.46	**
HH Size	0.090	0.030	3.00	***	0.035	0.041	0.85	
Hired Labour	-0.005	0.001	3.90	***	0.003	0.001	2.27	**
Economic and Financial Factors								
Credit	0.152	0.116	1.31		0.158	0.161	0.98	
Market Orientation	1.810	0.245	7.37	***	0.781	0.310	2.52	**
Institutional Factors								
Seed Subsidy	0.600	0.216	2.78	***	0.140	0.341	0.41	

Market Distance	-0.045	0.013	3.39	***	-0.034	0.021	-1.66	*
Country[1]								
Physical Factors								
Land Cultivated	-0.022	0.018	1.23		0.055	0.028	1.97	**
Yield	0.000	0.000	2.47	**	0.000	0.000	0.08	
Weather Change	-0.282	0.189	1.49		0.331	0.255	1.30	
Technological Factors								
Fertilizers	-0.198	0.104	1.90	*	-0.152	0.157	0.97	
Pesticides	0.051	0.125	0.41		0.236	0.177	1.33	
Crops[2]								
Human and Social Factors								
Extension	0.394	0.122	3.23	***	0.264	0.175	1.51	
Group Participation	-0.032	0.148	0.21		-0.223	0.209	-1.06	
[1]Country								
Malawi	1.624	0.173	9.40	***	-0.695	0.242	-2.87	***
Tanzania	-1.804	0.291	6.19	***	0.206	0.388	0.53	
[2]Crop								
Cashewnut	-0.929	0.294	3.16	***	-1.887	0.542	-3.48	***
Cassava	-0.254	0.349	0.73		0.077	0.547	0.14	
Cowpea	-1.056	0.354	2.98	***	-0.406	0.775	0.52	
Groundnut	-0.441	0.154	2.86	***	-0.278	0.229	-1.22	
Khat	-0.500	0.165	3.03	***	0.694	0.485	1.43	
Maize	-0.012	0.118	0.10		-1.872	0.205	-9.13	***
Potato	0.482	0.164	2.95	***	-0.541	0.254	-2.13	**
Sorghum	-1.267	0.186	6.82	***	-0.336	0.389	0.86	
Soybean	-0.480	0.127	3.79	***	-2.249	0.272	-8.27	***
Constant	-1.087	0.326	3.33	***	0.214	0.516	0.41	

Note: Significance levels (***p < 0.01, **p < 0.05, *p < 0.10).

Source: Own elaboration

a) Household specific factors

Looking at the results for the first step of the model, female-headed households are less likely to adopt improved varieties and to use exclusively local varieties. This is consistent with previous studies reporting that adoption decisions are positively associated with access to resources rather than with gender attitudes per se. Due to socio-cultural values and norms, men in general have greater access to resources such as land, credit etc. and are thus more likely to adopt new technologies (Mignouna et al, 2011; Obisesan, 2014). Other studies argue that female-head households place in general more attention to household consumption needs and tend for this reason to favor local varieties (Wang et

al, 2017). This hypothesis rests on the assumption that local varieties embed consumption attributes considered superior by farmers. Household head gender is non-significant in the second step of the analyses, meaning that the gender of improved varieties adopters does not influence the decision to maintain or to displace local varieties once the improved varieties are introduced in the farming system.

The role of household head age has been investigated by many authors, although reporting mixed evidence. In the analyses the variable is non-significant in any of the steps.

Consistently with Mignouna et al. (2011), the education level of households' heads increases improved varieties adoption. Education promotes the ability of farmers to better process and use the information, particularly about technology adoption. The education level appears to influence the choice of adopters to displace the existing local varieties in the second step.

Local varieties are generally considered to be more labor demanding (Ouma et al, 2002). Smaller household size is generally reported to positively influence the adoption of improved varieties, since their use can constitute a labor-saving strategy. However, in the 1st step of the estimation, smaller households are more likely to exclusively cultivate local varieties. This result can partially be counterbalanced by a higher presence of hired labor in these households. Other studies, as for instance Mignouna et al (2011), suggest that bigger household size may favor the adoption of improved varieties, counterbalancing the increasing demand of labor during the process of technology inclusion. This is a possible interpretation for our results, only extensible, however, to the category of new adopters potentially existing in the sample. In the second step of the analysis the variable is non-significant.

The presence of hired labor, being able to complement the labor force in the more demanding cultivation of local varieties, is positively associated with the exclusive use of these varieties in the 1st step of the model. It has, however, a significant positive effect in the combined use of improved and local varieties.

b) Economic and financial factors

Access to credit has been reported to support technology adoption by many authors (e.g. Mohamed & Temu, 2008). However, the variable is non-significant in both steps. This might be due to the general low level of access to credit in the study sites.

Market orientation is significant at both steps of the analyses. Since market orientation is complementary to the degree of self-consumption[6] , results concerning this variable provide many different interpretations. Looking at the first step, a higher level of market orientation positively affects the adoption of improved varieties, whilst its counterpart, a higher orientation to self-consumption, determines the exclusive use of local varieties. These findings seem to confirm the traditional hypothesis by which improved and local varieties play two distinct functions in the farming systems: increased productivity and thus commercialization, and traditional subsistence, respectively (Bellon & Hellin, 2011). The behavior of adopters analysed by the second step, however, deconstructs this simplified interpretation. One would expect that increasing market orientation levels would lead to local varieties displacement. Results show an opposite trend, where a higher degree of market orientation is significantly associated with the combined use of improved and local varieties. Accordingly, the exclusive use of improved varieties, and hence the displacement of local varieties, is significantly associated with higher level of self-consumption. Improved and local varieties play multiple and sometimes overlapping functions, whose interaction will be further examined in the last section.

c) Institutional factors

As expected, access to seed subsidies positively affects the adoption of improved varieties in the first step, providing financial access to improved seeds. Its impact is non-significant in the second step.

Market distance can be considered a proxy measure of access to market (Wang et al, 2017). As market is the place to purchase inputs and sell outputs, households with more convenient and less costly access to a market would have a greater potential level of adoption, holding constant all other factors. (Salasya et al, 1998). This variable is significant both at the first and the second step of the estimation. As expected, it constitutes a barrier to the adoption of improved varieties. This result reaffirms the key role played by market imperfections, in particular the existence of high transaction costs, in daunting the process of technology adoption. Interesting insights are provided by the results of the second step, although their interpretation requires further cautious considerations in combination with results related to other variables, as for instance the level of Market Orientation. Distance from the market is negatively associated with the combined use of improved and local varieties. This might

[6] Even though this is not always true, in the study areas farmers' output uses are almost exclusively self-consumption and commercialization. Therefore, the variable "market orientation" was built as a percentage of total produce complementary allocated to these two use categories.

mean that proximity to the market guarantees an easier access to improved seeds and complementary technologies, favoring the process of adoption. Adopters closer to market, though, do not displace local varieties. This could potentially indicate that local varieties are maintained to fulfill consumption needs. However, a conjoint interpretation of Market Distance and Market Orientation results, supports the hypothesis that local varieties are maintained by adopters to be sold in the proximate markets.

d) Physical and technological factors

Results from this section display a general low level of significance.

Farm size, only significant in the second step, impacts positively the combined use of improved and local varieties. As reported by Uaiene et al (2009), farmers with large farm size adopt a new technology as they can afford to devote part of their land to try new technology unlike those with less farm size.

Yield is positively associated only with the adoption of improved varieties. It confirms to be one of the dominant reasons of improved varieties popularity (Wang et al, 2017).

Despite the use of improved varieties is perceived by farmers as a preferential approach to face climate variability and change (Lipper et al, 2014), it doesn't appear to shape farmers' decision-making process. Indeed, the variable related to the perceived change of weather pattern in the last five years is non-significative. Looking at the descriptive statistics it comes as no surprise. Despite a generalized high perception of the climate change effects, farmers' capacity to choose an increased intensity of complementary agricultural inputs as adaptation strategy remain limited.

Availability and application of fertilizers has shown a positive influence on the adoption of improved varieties (Wang et al, 2017). However, the analysis shows a negative impact on improved varieties adoption, favouring the use of local varieties. This might be influenced by the low use of agricultural inputs in the study sites. Moreover, the study targets different crops including legumes, notably nitrogen fixing crops with lower nutrient requirements. The interpretation of a single result for the whole crops selected appears in this specific case particularly controversial.

Pesticides are non-significant in both steps of the model, probably due to their generalized low use across the three countries.

e) Human and Social factors

The analysis reports a positive impact of the Extension and Advisory Services with regard to the adoption of improved varieties. Many authors have already evidenced the positive relationship between extension services and technology adoption (Mignouna et al., 2011; Uaiene et al, 2009). Extension services are in fact able to counterbalance the negative effect of lack of years of formal education in the overall decision to adopt some technologies.

Results show that group participation doesn't have a significant relation to the adoption decision. To this regard, literature reports contrasting results. Belonging to social networks, including among others, cooperatives and farmers' organizations, might play an important role in the adoption process, facilitating access to information about new technologies (Mmbando & Bayegunhi, 2016; Wossen et al, 2017; Konja, 2021). However, it has been noted that in the presence of free-riding behaviours, social group can impact negatively the adoption process (Obayelu et al, 2017). New insights are provided by the recent meta-analysis of agricultural technologies adoption conducted by Ruzzante and colleagues (2021), where the effect of membership in groups has been found small on average and highly variable between the analysed studies.

f) Country and Crops fixed effects.

Country effects results need to be interpreted with the respect to the reference country (Ethiopia). Looking at the first step of the analyses, we can therefore affirm that in Malawi there is more use of improved varieties than in Ethiopia whilst in Tanzania there is more use of local varieties than in Ethiopia. Looking at the second step of the analyses, we can further note that in Malawi it is more common to exclusively use improved varieties than the combined use of improved and local varieties, in comparison to Ethiopia. The coefficient for Tanzania is non-significant, instead.

As for the countries, results related to the crops need to be interpreted in comparison with a reference crop, in this case bean. The reference crop was selected based on its importance for food and nutrition security in the area. Cash crops were therefore excluded. Maize, despite being the most important staple crop in the area, was also excluded to avoid unreadable results arising from its prominent weight in the sample. Looking at the first step of the analyses, for the entire list of crops is more common the use of local varieties than for beans (except for potato). However, coefficients for maize and cassava appear non-significant. Looking at the second step of the analysis, for maize, cashewnut, and soybean there is more exclusive use of improved varieties than the combined use of improved and local varieties, in comparison with beans.

2.6. Discussion and conclusions

Results of the empirical model provided extensive information on the complex structure of farmers' decision-making process concerning variety choice and use. The differentiated decisions taken by farmers in relation to varieties use clearly show that crop infraspecific diversity in the study sites is highly functional to address simultaneously different farmers' use concerns. In line with the study conducted by Bellon and Hellin in Mexico (2011), results confirm the hypothesis that local and improved varieties play different and sometimes overlapping functions in the analyzed farming systems, as for instance consumption and marketing functions. This implies the existence of a heterogeneous system of attribute preferences informing farmers' decision-making process. The analyses did not look explicitly to individual attribute preference systems, but instead used the provided framework to interpret the emerging dynamics.

More specifically, outcomes allow to define three farmers' profiles: namely users of only local varieties resulting from the first step of the decision-making process; the other two profiles, namely users of improved varieties that displace or maintain local varieties, constitute a sub-classification of general adopters resulting from the second step of the decision making process. Results enable to define the characteristics of farmers and of the surrounding institutional, economic and natural environment associated with each variety choice investigated.

Looking at the first step of the decision-making process, *household choosing to solely use local varieties* are more likely to be female headed, with lower level of education. These households are generally also characterized by lower size and are surrounded by a weak institutional environment. In fact, they do not access to extension and advisory services and to input subsidies and are unable to access the distant market infrastructure. These characteristics imply that besides a difficult access to agricultural inputs, these households lack of enough resources and are probably more risk adverse, which results in a lower propensity to innovation adoption. Indeed, this emerging adoption path shares common features with the general dynamic of technology adoption in developing countries. Nevertheless, their prevailing orientation to self-consumption suggest that their choice to solely use local varieties might be also influenced by the prevalence of this use concern over the others. The implication would be that for non-adopters, local varieties embed superior consumption attributes in comparison to improved ones. This hypothesis is partially confirmed by in-depth interviews conducted in the sites at the time of data collection. For instance, farmers in Malawi affirmed that maize local varieties were preferred for consumption due to the better rendering in the milling process, allowing to produce a higher quality porridge in comparison to improved varieties. Nonetheless, our

study analyses ten different crops in three countries, and this interpretation cannot be generalized to the entire sample. The current investigation, supported by the infield research activities, underpin the hypothesis that vulnerable household with little access to market value more income stabilizing/survival maximizing attributes embedded in local varieties to address concerns related either to input access or consumption needs. However, the analysis performed is not able to assign a weight to these two factors based on their relative importance for each crop in each study site.

Consequently, improved varieties adopters, in opposite to exclusive local varieties' users, are more likely to be headed by males with higher education level. A more conducive institutional environment also appears to be a key element in the adoption decision. In fact, these household are more likely to access to subsidies and to extension and advisory services. Their proximity to the market suggests that neither input access nor market outlets represent a barrier to technology adoption, which is in fact confirmed by their higher level of market orientation. It is possible to affirm that besides the easier market access, their adoption choice is linked to a better resources' endowment; therefore, for these farmers, improved varieties embed income maximizing attributes suitable to the market, as for instance higher yield and marketability (Wale et al, 2005).

Results reveal that the two subcategories of adopters resulting from the second step of the estimation are not a homogeneous category, but rather diverge in their characteristics, external conditions and therefore strategies and behaviors. Within the general category of adopters, *adopters who abandon local varieties* are more likely to have a relative higher distance from the market and to be less market oriented. These households are generally led by a more educated household head. They are able to overcome constraints related to inputs access, implied by their distance from the market, in comparison to the general category of adopters. This might indicate a higher enterprising spirit, access to research or development programs, or simply the key role played by the access to input subsidies. Moreover, adopters who use only improved varieties are relatively less market-oriented than those who maintain local varieties; therefore, they display a higher share of self-consumption, while continuing to sell a certain amount of produce. This might appear a contradiction with respect to results of the first step, where local varieties seemed to be those playing consumption functions; based on this, one would expect the exclusive use of improved varieties in the second step to be associated with higher market-orientation levels. The latter is more true if one considers that the households of the present category have higher distance from the market; for them, commercializing a higher share of their produce could be a reward for transaction costs incurred to reach the market. However, data collected infield highlighted a more complex dynamic in place. Farmers distant from the market, but

having high entrepreneurial abilities, can afford to sell a small share of their produce instead of the total amount. To illustrate, interviews in Lindi District (Tanzania) revealed that small producers are able to sell a little amount of produce in distant market by using two different strategies. In the first strategy, an enterprising farmer coordinate the aggregation of the small produce of farmers in the area and the provision to national enterprises. In the second strategy, small groups of farmers aggregate produce, rent a truck and sell it at Dar es Salaam market thanks to an intermediary in contact with international exporters. This example confirms the idea resulting from the first step that improved varieties embed attributes that farmers recognize as suitable to the market and contributes to justify the consumption use of improved varieties emerged from the second step of the analysis. Based on this, a distinct path starts to emerge: improved varieties play distinct functions in the farming systems, a commercial one and a consumption one.

The last described behavior includes *farmers maintaining local varieties after the inclusion of improved varieties* and hence combining improved and local varieties in the farming systems. Compared to the general category of adopters, these household are characterized by largest extension of land cultivated, by a relative higher proximity to the market and by a higher level of market orientation. Households with larger land size are more likely to maintain higher infraspecific diversity. It is thus possible to state that the decision to maintain the local varieties is determined by concerns related to the output use. More importantly, significant variables for this decision suggest that these concerns relate to the marketing use. Local varieties are maintained by adopter farmers to play a commercial function. Results of the first and second step provide thus evidence that as for improved varieties, also local varieties play both consumption and commercialization functions in the farming systems.

In line with these findings, it is worth noting that adopters who maintain local varieties are characterized by what can be cautiously described as having more favorable household specific, physical, economical and institutional conditions. The strong implication would be that interventions directed to eliminate direct and indirect barriers to improved varieties adoption wouldn't lead necessarily to the detriment of local varieties. Instead, as local varieties use is also perceived as a viable livelihood strategy rather than a second-best solution, their maintenance can be considered an active choice. As Bellon et al (2020, p. 7) have argued, "increasing crop diversity seems to open market opportunities for farmers, while still providing a substantial contribution to self-consumption".

The extensive results produced, and their interpretation, suggest important differentiated policy implications. First, interventions are needed to overcome barriers to the general innovations adoption and specifically to support the access to improved varieties seeds and complementary technologies. These interventions encompass this specific purpose but would also act on the general vulnerability conditions intercepted for non-adopters' households. An example for that would be interventions aimed at women empowerment and at providing better access to education. Interventions addressed to strengthen the institutional environment would be also crucial in this context. The qualitative research showed that existing agricultural policies in the three countries are potentially conducive in their intercepted strategies. However, policy instruments lack of proper implementation, mainly due to insufficient funds. This is the case of input subsidies and extension and advisory services. Specific interventions should also target the enhancement of market infrastructures whose lack acts both on input access and produce's outlet. This level of intervention is intended for creating the preconditions for smallholder farmers to take active unrestricted decisions tailored to their heterogeneous specific needs and preferences, with great impact in terms of food and nutrition security.

Second, results suggest important implications for breeding priority development. Actions to develop new varieties should not assume desirable attributes without considering the multiple functions played by each crop and variety in the farming systems, and the related preferred attributes in relation to each function, whether they represent marketing or consumption functions. Thus, integrating knowledge on the varieties functions in the farming systems and the farmers' attribute preferences is crucial not only to promote agrobiodiversity conservation in vulnerable areas, but also to satisfy effective differentiated needs not addressed by existing varieties and to support the best variety choice and use for smallholder farmers. A detailed analyses of crop attributes preferences was beyond the scope of this study, but it may be highly relevant for setting breeding priorities and for some policy decisions and could be therefore addressed in further research.

Third, the study provides useful indications to the global governance policy for seed systems development. Our results suggest the importance to promote legal and policy frameworks not confined to incentivize only the formal seed systems which supply seeds for improved varieties. In fact, the relevance of this study relies on the evidences provided with regard to the profitable market opportunity that many local varieties represent for smallholder farmers in East Africa. Besides their potential great impact on food and nutrition security, the maintenance of the whole pool of varieties chosen by farmers plays a considerable role in preserving the infraspecific diversity in the analysed

sites, with a significant collateral advantage in terms of conservation of agricultural biodiversity on-farm.

Limitation to this study consists in the poor knowledge of smallholder farmers in relation to the provenience of their seeds. This might have affected their answers about the definition of the seed type used. While this study has provided aggregated multi-country, multi-crop results, further studies should provide a better understanding of the specificity of each crop and sites and their interactions in determining farmers seeds adoption decision.

3. DIVERSITY MATTERS. UNDERSTANDING SMALLHOLDERS' MARKET ACCESS IN EAST AFRICA

Abstract

According to the United Nation Industrial Development Organization (UNIDO, 2011), inclusive value-chain development (VCD) can be defined as a "positive or desirable change in a value chain to extend or improve productive operations and generate social benefits: poverty reduction, income and employment generation, economic growth, environmental performance, gender equity and other development goals". Inclusive VCD interventions should account for several challenges constraining the participation of smallholder farmers to value-chains. Limited access to land, technology and inputs, inadequate knowledge of the market functioning, insufficient access to credit and extension services, combined with more general problems of poor infrastructures, often prevent smallholder farmers from accessing profitable market opportunities. In addition, these critical conditions vary widely between sites and within sites at household level, thus calling for interventions based on holistic methods accounting for rural poor diversity. To account for these challenges, the current study is based on the definition of "*value-chain readiness*" (VCR), namely the ability of households to meet the *minimum conditions for participating in the VC*. More specifically, according to these authors, farmers should reach minimum conditions for a set of external and internal factors: external factors include "access to basic infrastructures and services, common pool resources and social stability", while internal factors focus on "asset endowments, interests and power". Particularly, smallholders' initial asset endowment (natural, human, social, physical and financial assets) is one of the most critical factors in determining market access and the distribution of benefits resulting from VCD interventions. The current study analyses the minimum conditions for smallholders' participation to the maize VC in Ethiopia, Malawi and Tanzania, accounting for the diversity of rural sites. This was done by adopting an asset-based approach to assess farmers' potential to access the market and investigate *assets interdependences*, namely the existence of flows and feedback loops across assets in the process of asset building and erosion. We have conceptualized a participatory multidimensional VCR definition for each of the analysed sites, assessed the diverse minimum conditions to participate in the selected VC by means of a quali-quantitative assessment method and investigated available and potential policies and instruments for a feasible implementation of an inclusive VCD. Besides contributing to the literature on VC inclusiveness, the relevance of the current study resides on the provision of empirical results and effective policy indications able to foster the participation of smallholder farmers in more inclusive VCs.

3.1. Introduction

Value chain (VC) development interventions have become an imperative part of rural development strategies in Africa (Hainzer & Brown, 2019) to work towards agricultural growth and poverty reduction (Donovan et al, 2015; Stoian et al. 2012; Humphrey and Navas-Aleman, 2010 and Ricketts et al., 2014). VC participation entails a number of challenges for smallholders. Limited access to land, technology and inputs, inadequate knowledge of the market functioning, insufficient access to credit and extension services, combined with more general problems of poor infrastructures, often prevent smallholder farmers from accessing profitable market opportunities (Devaux et al, 2018). Even when these conditions are met, improved market access can be constrained by a difficult and uncertain market environment, as well as by the lack of effective policies and incentive schemes, or the failure in their implementation.

As academics and practitioners have highlighted, poor rural households share common constraints. Yet at the same time, these conditions manifest themselves varying in intensity and impacts within and between sites, posing few conceptual and practical barriers to successful VC interventions. On the one hand, evidence suggests that within sites "many value-chain initiatives treat poor rural households as a uniform stakeholder group with the same response capacity" (Stoian et al, 2012, p. 82) rather than considering their differentiated livelihood strategies and asset endowment and, therefore, differentiated potentials for accessing the market. On the other hand, empirical research has shown that "identical policies have different effects among individuals with the same observed characteristics living in different contexts, because of unobserved differences between populations" (Devaux et al, 2018, p. 118). The use of standardized frameworks to implement and evaluate VC interventions ignoring the context-specific nature of value chains has thus attracted increasing criticism (e.g., Creevey et al., 2011**).** Based on these considerations, the success of interventions aimed at smallholders' participation in VC requires the development of holistic methods able to capture rural poor diversity. In particular, a call for the operationalisation of methods to assess whether rural households meet the minimum conditions for participating in the VC was explicitly formulated by several authors (Stoian et al, 2012; Devaux et al, 2018 and Donovan & Stoian, 2012). To account for these challenges, Stoian et al (2012) introduced the notion of "value-chain readiness" (VCR). According to these authors, value chain readiness is the ability of households to meet the minimum conditions for participating in the VC. More specifically, farmers should reach minimum conditions for a set of external and internal factors: external factors include "access to basic infrastructures and services, common pool resources and social stability" (ibid., p. 82), while internal

factors focus on “asset endowments, interests and power” (ibid., p. 82). Particularly, smallholders’ initial asset endowment (natural, human, social, physical and financial assets) is one of the most critical factors in determining market access and the distribution of benefits resulting from VC interventions (Devaux et al, 2018). Therefore, there is now a widespread agreement on the need to adopt asset-based approaches to assess farmers’ potential to access the market (ibid., Stoian et al, 2012, Donovan & Stoian, 2012 and Donovan & Poole, 2013). Furthermore, one of the critical issues in identifying the minimum asset thresholds for accessing the market is the presence of asset interdependences, namely the existence of flows and feedback loops across assets when the variation of one asset determines changes in another asset (e.g., reduced natural capital due a natural disaster can erode farmers’ financial capital and, consequently, the health and nutritional status of the household). Notably, how assets relate to one another is strongly, however not exclusively, determined by local dynamics. Asset interdependencies reflect much of environment in which smallholders are embedded, being themselves influenced by the above-mentioned internal and external factors “access to basic infrastructures and services, common pool resources, social stability, and by the dimensions of interests and power”.

Based on these considerations, the overall objective of the current study is to analyse the minimum conditions for smallholders’ participation to agricultural value chains in Eastern Africa. Particularly, the study will focus on the maize VCs in Ethiopia, Malawi and Tanzania, accounting for the heterogeneity across and within rural sites. This will be done by addressing the following three specific research objectives:

• Exploring the critical assets to participate in the selected VCs, their interdependences and thus the existing heterogeneity across sites (RQ1);

• Understanding the minimum endowment of assets to successfully participate in the selected value chains in each site (RQ2);

• Investigating available and potential policies and instruments for a feasible implementation to enhance smallholders’ VC participation (RQ3).

To address these objectives, the impact of rural diversity on smallholders’ value chain participation was investigated in 4 sites in Ethiopia, Malawi and Tanzania. In the study, we considered that VC participation requires a minimum level of initial asset endowment, which determines value-chain ready farmers and not value chain ready farmers. Furthermore, the study is grounded on the assumption that smallholders’ asset endowment is influenced by the process of asset building/erosion (“assets’ interdependencies”). Since asset interdependencies are context specific dynamics, the

analysis supports the adoption of policies / interventions acting on interdependent critical assets, rather than focusing on single capitals.

These dynamics will be explored for maize VC. Despite being a crop widely investigated in East Africa, maize makes a great case for this analysis. It is the most important food crop consumed in Eastern Africa (Kornher, 2018), but it is also widely sold into differentiated market channels (local, national, regional and international markets). This is well represented in the selected study sites where maize is either a local or global value chain.

A mixed quali-quantitative method combining Causal-Process Observations and Data-Set Observations will be used. Asset endowment and asset interdependences will be investigated by means of multivariate analysis using a dataset of 1.590 households in the three Eastern African countries. Results will be combined with statistic methods and information about context and market access pathways collected in-field during Focus Group Discussion, Multiactor Platform Meetings and Key Informant interviews. A participatory method will be used to analyse the effectiveness of existing policies in supporting smallholders' market access and suggest policy changes.

Besides the attempt to bridge the gap on operative methods for the VC-readiness assessment, the novelty of the current study resides on the provision of cross-country empirical insights on the role of assets and assets interdependencies in determining smallholders' market access. The extensive results produced, validated by means of across methods and data triangulation, provide country-specific differentiated indications for the design of policy/interventions tailored to value chain ready farmers and not value chain ready farmers. They bear therefore the potential for effectively fostering smallholders' participation in more inclusive VCs in each of the analysed sites.

3.2. Theoretical background

Despite their potential and their clear focus on poverty reduction, many VC initiatives fall short of catching the heterogeneous nature of rural poverty, which includes diversified asset endowments, income flows, social embeddedness, and response capacity to shocks (Fowler & Brand, 2011). In their seminal article, Stoian et al. (2012) have questioned the frequent underlying assumptions to VC interventions in developing countries. Based on these assumptions, smallholders "(1) have sufficient resources to effectively participate in VCs, (2) do not face substantial trade-offs when using these resources, and (3) are able to assume higher risks when reinvesting capital and labor access to adequate resources" (ibid., p. 15). This is the base for the authors' plea to the development community to account for the external and internal minimum conditions smallholders need to reach

for participating in specific value chains. The authors associate external factors (basic infrastructures and services, common pool resources and social stability) and internal factors (asset endowments, interests and power) to the concept of "Value Chain Readiness" (Stoian et al., 2012). Accordingly, value chain interventions are called to distinguish between *value chain ready farmers*, namely those provided with the minimum conditions of external and internal factors, and *non-value chain ready farmers*. Smallholders' diversity thus calls for differentiate interventions tailored to value chain-ready and not value chain ready household conditions. In particular, market-based interventions are needed for enhancing market access of value-chain ready farmers. Conversely, nonmarket-based interventions prove necessary to build the minimum asset thresholds for not-value chain ready farmers participation in the market (e.g., "customized technical assistance and training to build human and social capital, rehabilitation of natural capital where eroded, investments in basic infrastructure and services, and resolution of land-tenure conflicts where they exist" (Stoian et al., 2012, p.88).

The approach used in the current study to distinguish between farmers ready and non-ready to participate in value chain takes specifically into consideration assets endowments. Previous studies have shown that achieving market supply standards demands a threshold level of certain assets, such as land, credit, inputs, technology, organization capacity, infrastructures, access to networks, technical advice and market information (Devaux et al., 2018 p. 103), as well as an enabling environment characterized by conducive market functioning, norms, regulations, policies and programmes (Donovan & Poole, 2013). This *asset-based approach* can effectively address the problem of the distribution of benefits deriving from VC interventions in developing countries. Farmers holding different levels of asset endowment require tailored based value chain interventions to achieve level specific objectives. To illustrate, those having lower asset endowments might benefit from interventions aimed at building assets demanded for value chain product specialization, while minimizing the vulnerability risk associated to such an effort. Consistently, a review of research papers analysing 14 value chain development case studies in the context of international agricultural research (Devaux et al., 2018) has proven that such interventions are often ineffective for participants falling in the lower asset thresholds. Asset-poor households may have insufficient resources for accomplishing the specialization efforts required to participate in dynamic VCs or be unwilling to assume the risks associated with the new trade-offs derived from a new allocation of their constrained resources. Moreover, the analysis of an intervention for the development of a taro VC in Nicaragua (Donovan & Pool, 2013), suggests that even when support is provided, for instance in the form of access to short-term credit to purchase agricultural inputs and labour, unexpected events such as

productive losses or lack of buyers during peak productive season can lead to productive-related debts and thus resulting in the erosion of the pre-existing, limited, asset endowment.

An option to distinguish between value chain ready and not-ready farmers is therefore the adoption of interventions aimed at promoting VC participations that account for the differentiated asset endowment of rural households. Nevertheless, the characterization of asset endowments raises many theoretical and methodological issues (Donovan & Stoian, 2012). Particularly critical is how assets are built or eroded over time by rural households. According to Donovan & Stoian (2012), this is particularly relevant considering the dynamic nature of capitals and the existence of flows across them. One capital can be converted in one another, for example when savings (financial capital) are converted in agricultural tools (physical capital). More importantly, flows can lead to feedback loops (from now on, *asset interdependencies*), either positive or negative, eventually building or eroding assets. Participation in cooperatives (social capital) can facilitate smallholders' access to training in integrated pest management (human capital) which in turn leads to savings in agricultural inputs to be reinvested in machinery, storage or processing facilities (physical capital), with consistent enhancement on production quality and thus earnings. These can, in turn, potentially increase smallholders' initial asset endowment.

Triggering positive feedback loops in asset interdependencies has been one of the core strategies of value chain development interventions and various studies have investigated their connections with participation in VCs (e.g., Donovan & Poole, 2013 and Donovan & Poole, 2014). However, literature so far has fallen short to consider that complex and diversified economic contexts have different influences on assets, thus leading to context specific asset interdependencies. More specifically, as noted by Dorward et al. (2003), smallholders are interconnected with markets at different scales and they are directly and indirectly dependent on the broader economy, beyond the boundaries of the value chain. Therefore, the analysis of the access to a specific value chain cannot overlook the diversity of economic contexts across different sites, making a *sic et simpliciter* transposition of asset interdependencies. Understanding smallholders' asset endowment and asset building/erosion requires therefore to consider the wider context in which smallholders operate.

Based on these considerations, our contribution to ongoing discourse on value chain development approaches relates to the analysis of the minimum conditions for smallholders' participation to selected VCs in East Africa using an asset-based approach. We consider asset endowment and asset interdependencies to be critical elements for understanding smallholders' market access within and across sites. Therefore, the current study emphasizes the relevance of asset-based approaches to build

and determine priorities of policies and value chain development interventions. To do so, we focus on the potential of the analysis of asset endowments and asset interdependencies to provide a better understanding of the *heterogeneity across and within sites* targeted by VC interventions and policies.

3.3. Conceptual framework

This section clarifies the conceptual approach used in the current study used to design and interpret the empirical analysis. It describes how heterogeneous asset interdependencies and levels of asset endowments influence, respectively, VC readiness across and within sites. Particularly, these two patterns are illustrated in Figure 5 and Figure 6.

First, as mentioned in Section 2, the existence of asset interdependencies implies the need to consider smallholders' asset endowment in its dynamic nature and relation with the broader economic environment. In Figure 5 are outlined different configurations of asset endowments and enabling conditions (i.e., bundles) required to participate in a targeted VC in different sites. Different sites are characterized by a bundle consisting of varied combinations of spare assets/enabling conditions (single circles included in a coloured shape), and/or assets/enabling conditions interdependencies (circle sets grouped in coloured shapes). (Assets and enabling conditions that are not relevant to influence market access are not included in any coloured shape.). In Figure 5, this leads to varied combinations of coloured shapes in different sites, resulting in a simplified representation of the bundles as piles of coloured rhombuses. Interdependencies imply that different capitals/enabling conditions are interconnected in some ways. This may depend on the fact that building/erosion processes for these capitals are interconnected in a uni- or bi/multi-directional way. Building a specific asset can lead to build another/others. The reverse relation is possible, but it is not necessarily true. Moreover, in a wider vision, such interconnections may also imply the existence of a latent phenomenon acting simultaneously on both independent building/erosion processes. Lastly, we have assumed that VC participation is determined by a minimum level of assets owned by smallholders. However, VC participation itself acts on asset building/erosion and asset interdependencies. There are thus infinite potential arrows with different directions connecting such elements, leading to a complex network of circular, simultaneous causal relations. This might be explained in view of the fact that we consider how assets are built and eroded, and how they relate to one another, to be determined by the direct and indirect interactions with the proximate and wider environment in which smallholders are embedded. For these reasons, we posit that asset interdependencies represent unobservable, context specific processes. Exploring such processes may enhance the understanding

of rural *heterogeneity across sites*. Indeed, impact evaluation studies have revealed that identical policies have shown "different effects among individuals with the same observed characteristics living in different contexts, because of unobserved differences between populations" (Devaux et al., 2018, p.118). Therefore, we aim to analyse asset interdependencies across sites to achieve a twofold purpose: 1.) provide evidence on unobserved dynamics. This will allow to analyse the effectiveness of existing policy instruments to act on the combination of critical assets identified through interdependencies, rather than focusing on single capitals; 2) provide evidence on the context specific nature of interdependencies. As a consequence, interventions/policy change towards a fluid assembly of coherent intervention/policy packages will be considered. Intervention/policy packages bear the potential to better adapt to context specificity, to act on the identified critical assets/asset combination more flexibly and thus to be tailored to heterogeneous conditions.

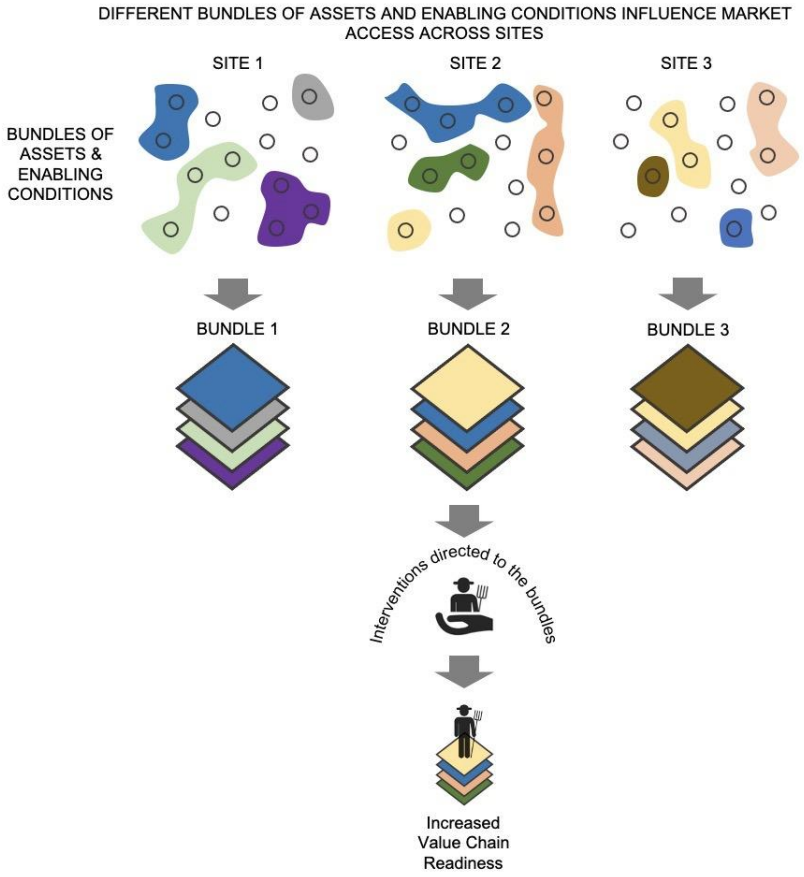

Figure 5. Asset interdependencies and value chain readiness across sites, Own elaboration

Second, asset endowments differ among smallholders within the same site, leading to a differentiated capacity and potential for participating in a target VC. Figure 6 summarises how, within a site and for the access to a target value chain, smallholders have different asset / enabling conditions levels. Consistently with Figure 5, site specific bundles are represented with coloured rhombuses. However, in each site, each household is endowed with a specific level of the assets / enabling conditions that build the rhombuses. We assume that participating in a specific VC requires a minimum level of each asset / enabling condition, that is to say *being VC ready*. Consistently with the fact that VCs are "heavily embedded in complex social, cultural, and business networks" (Hainzer et al., 2019, p. 375), a specific definition of value chain readiness needs to be provided for each VC and for each site. In Figure 2, the full completion of these minimum levels by VC ready farmers is represented with bundles whose rhombuses are coloured with full saturation and perimeters. Instead, rhombuses to which are associated assets / enabling conditions diverging from the one required or completely lacking are represented by the transparent rhombuses; dashed rhombuses are assigned to farmers that completely lack a standalone asset / enabling condition (in Figure 5, spared circles in coloured shapes) or all the elements that contribute to an interdependency (in Figure 5, circle sets grouped in coloured shapes). From the Figure, it emerges that *heterogeneity within a site* is determined by the presence of VC ready and not VC ready farmers; furthermore, among the former, households with different VC ready levels can be distinguished. Therefore, enhancing VC participation requires a deep understanding of asset endowment diversity for designing market-based interventions tailored to consider all these categories.

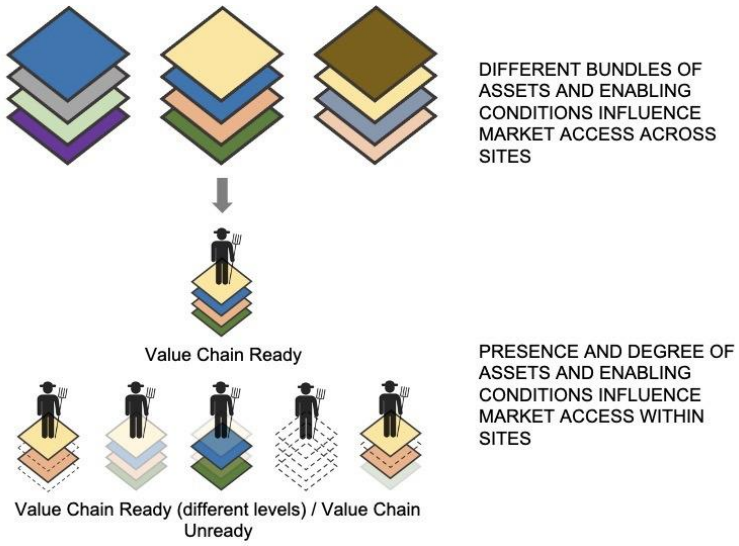

Figure 6. Asset endowments and value chain readiness within site, Own elaboration

3.4. Materials and methods

3.4.1. Empirical approach and data sources

For analysing smallholders' participation in maize VC in 5 sites in Ethiopia, Malawi and Tanzania, a participatory, mixed quali-quantitative method was used, accounting for within and across sites heterogeneity. Our methodology is rooted in the impact evaluation stream of research. However, this is not the purpose of our investigation. Instead, our analysis is located upstream of a potential VC intervention and can be assimilated to a context analysis for designing VC interventions, built up on impact evaluation findings.

In this context, theory-based approaches, based on ex-ante theorization of pathways through which assets are expected to influence a specific outcome (VC participation) and *vice versa* (White, 2007), have proved to provide valuable evidence. This is the case of analyses based on the theory of change (e.g., the framework provided by Stoian & Donovan, 2012) used for impact evaluation of VC development interventions on asset building and VC participation. However, the exclusive use of causal chain approaches, assuming a linear, deterministic process (White, 2009), does not serve our purpose. As pointed out in the previous section, initial asset endowment and asset interdependencies are the result of unobservable context specific dynamics. Therefore, the analysis of initial asset endowments and interdependencies and their role in shaping VC participation needs to be extended to the hardly mappable smallholders' interactions with the wider economic environment.

For this reason, we propose an approach combining Data-Set Observations (DSO) and Causal-Process Observations (CPO) (Brady et al., 2006). The former relates to the use of dataset comprising observations and variables. The latter includes information on contexts, processes or dynamics that may be used for exploring/interpreting causal relations (ibid.). In this study, both types of information were exploited for between methods[7] and data source triangulation[8], in order to enhance the understanding of complex phenomena in place and validate our findings (Patton, 1999 and Carter et al., 2014).

As for DSO, the analysis used data from a household-level survey carried-out in 2018 in 5 sites in 3 countries: the two districts Meta and Kombolcha in Oromia region in Ethiopia; the Lindi district in

[7] Between (or across) methods triangulation can be used for cross validation when distinct and independent methods are congruent and provide the same conclusions (e.g., DSO and CPO) (Jick, 1979);

[8] According to Carter et al. (2014, p.545), "Data source triangulation involves the collection of data from different types of people, including individuals, groups, families, and communities, to gain multiple perspectives and validation of data" (e.g., Focus Groups Discussions (FGDs) and in-depth individual (IDI) interviews).

Lindi region in Tanzania; the Dedza district in the Central region and the Mzimba district in the Northern region of Malawi. The survey provided information on demographic and socioeconomic households' characteristics, crop production systems and practices, membership in agricultural associations, access to extension and advisory services, access to agricultural inputs, credit and market participation. A randomized sample of 1,965 households was surveyed on the basis of census lists. A multi-stage sampling procedure was used to obtain efficient and consistent estimates of the target population.

As for CPO, different data sources were used: i. 3 Focus group discussions (FGDs) with small-scale producers, policy makers, agrodealers, processors, extensionists and traders conducted in January and February 2018 in Ethiopia, Malawi and Tanzania; ii. In-depths interviews to key informants in January and February 2018 in the 5 study sites; and iii. 3 Multi-actor Platform (MAP) meetings involving relevant actors of the value chain (small-scale producers, farmer's organizations, public sectors, NGOs, private organizations and SME) held in the 3 countries in March 2020).

3.4.2. Data analysis

The first step of this study was the specification of variables to adequately represent smallholders' assets by means of a literature review. As Donovan & Poole (2013) have pointed out, the identification of smallholders' assets is far from straightforward and no 'gold standard' can be used to this purpose. Therefore, we have prioritized indicators which have proved relevant, particularly in VC impact evaluation studies.

Assets include natural, human, social, physical, financial capital and enabling environment.

The variables selected to quantify the different asset endowment are the following:

i. *Natural capital:* natural capital includes natural resources and services that smallholders rely on for agricultural production and income generation by means of resource collection (Pandey et al., 2017 and Sharaunga & Mudhara, 2021). In this study therefore was given priority to the productive domain, considering 3 subsets of variables: productive capacity (variables: total land area, area under crop production, topography and yield), soil fertility (variable: use of fertilizers) and water availability (variable: use of irrigation) (Donovan & Poole, 2013);

ii. *Human capital:* human capital embraces the set of skills, knowledge, personal and social characteristics influencing the capacity to work and thus generate economic outcomes (Khalili et al., 2015). Considering the importance for our analysis of smallholders'

interactions within and outside the selected VC, we have considered Au and colleagues' categorization into general human capital and task specific human capital (Au et al., 2008). General human capital relates to generic knowledge and competencies built through professional experience and education, which can be transferred across different economic activities (variable: household head education). Task specific human capital focuses on knowledge built on education and professional training/experience. We have focused on knowledge, capacities and skills for VC related activities in vulnerable contexts (variables: access to extension, use of soil management practices and use of adaptation strategies to weather change) (Donovan & Stoian, 2012).

iii. *Social capital:* Smallholders are embedded in social networks which strongly influence their livelihood. Social capital embraces participation in groups (variable: membership in groups) and characteristics of such interactions. Therefore, it also refers to trust and reciprocity within and across networks of individuals, households and communities (Ellis, 2000). Moreover, a specific correspondence can be found between social capital and horizontal coordination of the VC (Andriesse, 2018). Data limitation did not allow to consider trust within smallholders' communities. We have thus focused on the role of trust in uncertain and vulnerable environments characterized by information asymmetry (e.g., on prices, quality standards etc.) (Troger et al., 2018). In this context, trust has shown to mediate business relations that shape chain organization (ibid.). It can provide to smallholders information about the reliability of suppliers and buyers (Buskens, 2006). We have therefore used the variables quality problems found with agricultural inputs as a proxy of trust towards suppliers, and delayed/absence of payment for sale of agricultural produce as a proxy of trust towards buyers.

iv. *Physical capital:* In this study, physical capital is interpreted as tools, equipment and infrastructure that influence production and determine market opportunities (Sharaunga & Mudara, 2020). We have therefore included, by means of a Multiple Correspondence Analysis (MCA), 3 physical capital dimensions: technological and non-technological productive assets (Asfaw et al., 2019) and communication/transportation assets (Jendoubia et al., 2020). The list of variables considered are reported in Table 2. and 3. Moreover, we have included the use of pesticides.

v. *Financial capital:* Financial capital includes resources with the potential to originate supplemental capital when reinvested (Meikle & Liew, 2018). The variables used in the

study are formal/informal credit (Patnaik, 2019) and household income (Jendoubia et al., 2020).

vi. *Enabling environment:* Literature interprets the mentioned five capitals in many different ways. This has led to a certain degree of overlapping among the variables selected to describe them (Quandt, 2018). Particularly relevant is the case of variables concerning access to basic services and infrastructures. To illustrate, the variable distance to a paved road is included by Erenstein et al. (2010) into the Physical capital. Other authors include it in the Social capital, as it also represents access to communication facilities (Katungi et al., 2007), or a proxy of access to buyers and services (Chamberlin & Jayne, 2013). Following Donovan & Poole (2013), we have created the new dimension *Enabling Environment* - including the variables distance from a paved road, distance from the market, access to subsidy and access to storage facilities -, to address the presence of such kind of controversial variables.

Table 4. Description of assets

Variables	References
Natural capital	
Land cultivated (Ha)	Quandt et al, 2018; Kuang et al., 2020
Landholding (Ha under shared tenant)	Donovan & Poole, 2013
Topography (0=plain, 1=other)	Donovan & Poole, 2013
Fertlizers (0=no, 1=yes)	Donovan & Poole, 2013
Irrigation (0=no, 1=yes)	Asfaw et al., 2019
Human capital	
HH head education (years)	Quandt et al, 2018
Extension (0=no, 1=yes)	Quandt et al, 2018
Soil management practices (0=no, 1=yes)	Donovan & Poole, 2013
Weather adaptation strategies (nr. of strategies adopted)	Donovan & Poole, 2013
Social capital	
Group (0=no, 1=yes)	Quandt et al, 2018
Quality problems with providers (0=no, 1=yes)	Troger, 2018
Payment problems with buyers (0=no, 1=yes)	Troger, 2018
Physical capital	
Non-technological productive assets (MCA index)	Asfaw et al., 2019

Technological productive assets (MCA index)	Asfaw et al., 2020
Communication/transportation assets (MCA index)	Jendoubia et al., 2020
Pesticides (0=no, 1=yes)	Murugani & Thamaga-Chitja, 2017
Financial capital	
Credit (0=no, 1=yes)	Patnaik, 2019
Income (local currency)	Jendoubia et al., 2020
Enabling conditions	
Subsidy (0=no, 1=yes)	Donovan & Poole, 2013
Road distance (Km)	Donovan & Poole, 2013
Market distance (Km)	Donovan & Poole, 2013
Lack of storage facilities (0=no, 1=yes)	Donovan & Poole, 2013

Table 5. List of variables for physical productive assets

Productive assets	Modality
Water pump	(0=no, 1=yes)
Irrigation equipment	(0=no, 1=yes)
Machete	(0=no, 1=yes)
Sickle	(0=no, 1=yes)
Spade shovel	(0=no, 1=yes)
Hoe	(0=no, 1=yes)
Spray pump	(0=no, 1=yes)

Source: Own elaboration

Table 6. List of variables for other physical assets

Other assets	Modality
Radio	(0=no, 1=yes)
Telephone	(0=no, 1=yes)
Tv	(0=no, 1=yes)
Motorcycle	(0=no, 1=yes)
Bicycle	(0=no, 1=yes)

Source: Own elaboration

The identification of variables representing assets was followed by the analysis of asset interdependencies. We assume asset interdependencies to be context specific unobservable phenomena, able to explain the different asset building/erosion processes across sites and thus, ultimately, the differentiated role of asset endowment for VC participation across the different study sites. In terms of data-set observations, our principal tool was Exploratory Factor Analysis (Mair, 2018), a multivariate statistical technique for isolating emergent dimensions, as the purpose of the

analysis was primarily exploratory and not aimed at validating theory-based models. Due to its capacity to reveal latent patterns in complex data sets, this technique was selected to allow the emergence of expected and unexpected patterns (White, 2009). Therefore, in comparison to other methods, the advantage of Factor Analysis is to overcome a strictly causal chain approach, which would miss the unintended effects object of this study.

3 separated Exploratory Factor Analysis were performed on the selected asset variables for Ethiopia, Malawi and Tanzania. The diverse components emerged represent country-specific asset interdependencies.

A systematic comparison was conducted to observe arising differences across countries. Using a Causal-Process Observation approach, results of the multivariate analysis were thus combined for interpretation and validation with information collected during Focus group discussions, Key-informant interviews, Multi-actor platform meetings and secondary data.

Factor analyses' indexes were further combined with descriptive statistics to determine the level of asset endowment for smallholders accessing/not accessing the market in each country. Critical assets for VC readiness were selected by members of Multi-actor Platform, representing the main VC actors. We have therefore iterated among theory, quantitative data and field-collected information to draw validated results by means of across methods triangulation.

A participatory approach was also used for assessing the effectiveness of existing policies/instruments. Multi-actor Platform members were involved to select relevant policies/instruments acting on the most critical asset dimensions intercepted. Actors were asked to evaluate policies/instruments' effectiveness, limits and potential changes needed to enhance smallholders' VC readiness and participation.

3.5. Results

3.5.1. Asset endowment and asset interdependencies

Asset endowment and interdependencies were analysed in several steps.

Summary statistics of the variables used are presented in Table 7, 8 and 9.

Table 7. Descriptive statistics of assets, Ethiopia

Variables	Maize producers (obs.566)		Not selling Maize (obs. 542)		Selling Maize (obs. 24)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Natural capital						
Land cultivated (Ha)	0.39	0.26	0.38	0.29	0.47	0.21
Landholding (Ha under shared tenant)	0.22	0.40	0.22	0.41	0.13	0.34
Topography (0=plain, 1=other)	0.07	0.26	0.07	0.26	0.07	0.25
Fertlizers (0=no, 1=yes)	0.54	0.50	0.53	0.49	0.75	0.44
Irrigation (0=no, 1=yes)	0.38	0.49	0.38	0.48	0.30	0.46
Human capital						
HH head education	0.68	0.77	0.66	0.75	0.92	1.05
Extension (0=no, 1=yes)	0.38	0.49	0.38	0.49	0.41	0.50
Soil management practices (0=no, 1=yes)	0.96	0.19	0.96	0.20	1.90	0.00
Weather adaptation strategies (nr. of strategies adopted)	2.02	0.97	2.00	0.95	2.33	1.30
Social capital						
Group (0=no, 1=yes)	0.12	0.32	0.12	0.32	0.20	0.28
Quality problems with providers (0=no, 1=yes)	0.60	0.49	0.60	0.49	0.63	0.49
Payment problems with buyers (0=no, 1=yes)	0.25	0.43	0.26	0.44	0.08	0.28
Physical capital						
Non-technological productive assets (MCA index)						
Technological productive assets (MCA index)						
Communication/transportation assets (MCA index)						
Pesticides (0=no, 1=yes)	0.16	0.37	0.16	0.37	0.13	0.33
Financial capital						
Credit (0=no, 1=yes)	0.35	0.48	0.35	0.48	0.29	0.46
Income (local currency)	1677.15	1927.19	1658.19	1916.59	2105.20	2152.85
Enabling conditions						
Subsidy (0=no, 1=yes)	0.00	0.09	0.00	0.00	0.09	0.00
Road distance (Km)	1.59	1.50	1.61	1.51	1.20	1.41
Market distance (Km)	5.36	2.38	5.34	2.38	5.75	2.34
Lack of storage facilities (0=no, 1=yes)	0.21	0.41	0.22	0.41	0.08	0.28

Table 8. Descriptive statistics of assets, Malawi

Variables	Maize producers (obs.641)		Not selling Maize (obs. 371)		Selling Maize (obs. 270)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Natural capital						
Land cultivated (Ha)	0.87	0.66	0.78	0.62	1.00	0.70
Landholding (Ha under shared tenant)	0.93	0.20	0.93	0.23	0.94	0.17
Topography (0=plain, 1=other)	0.03	0.17	0.03	0.17	0.03	0.18
Fertlizers (0=no, 1=yes)	0.44	0.49	0.44	0.49	0.45	0.50
Irrigation (0=no, 1=yes)	0.07	0.26	0.07	0.19	0.09	0.29
Human capital						
HH head education	1.10	0.64	1.07	0.63	1.15	0.66
Extension (0=no, 1=yes)	0.33	0.47	0.29	0.45	0.40	0.49
Soil management practices (0=no, 1=yes)	0.86	0.34	0.85	0.36	0.89	0.31
Weather adaptation strategies (nr. of strategies adopted)	2.29	0.93	2.19	0.92		
Social capital						
Group (0=no, 1=yes)	0.27	0.44	0.20	0.40	0.35	0.44
Quality problems with providers (0=no, 1=yes)	0.28	0.45	0.30	0.46	0.25	0.43
Payment problems with buyers (0=no, 1=yes)	0.06	0.25	0.03	0.17	0.11	0.32
Physical capital						
Non-technological productive assets (MCA index)						
Technological productive assets (MCA index)						
Communication/transportation assets (MCA index)						
Pesticides (0=no, 1=yes)	0.25	0.43	0.18	0.38	0.34	0.47
Financial capital						
Credit (0=no, 1=yes)	0.28	0.45	0.27	0.44	0.30	0.46
Income (local currency)	26305.00	3818.50	24001.70	3708.68	29470.00	3951.08
Enabling conditions						
Subsidy (0=no, 1=yes)	0.16	0.37	0.15	0.36	0.17	0.38
Road distance (Km)	13.34	10.67	12.40	10.24	14.61	11.06
Market distance (Km)	13.30	5.54	13.44	5.58	13.11	5.50
Lack of storage facilities (0=no, 1=yes)	0.03	0.15	0.03	0.16	0.02	0.14

Table 9. Descriptive statistics of assets, Tanzania

Variables	Maize producers (obs.169)		Not selling Maize (obs. 154)		Selling Maize (obs. 15)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Natural capital						
Land cultivated (Ha)	0.30	0.25	0.29	0.24	0.43	0.28
Landholding (Ha under shared tenant)	0.07	0.24	0.07	0.24	0.07	0.25
Topography (0=plain, 1=other)	0.00	0.00	0.00	0.00	0.00	0.00
Fertlizers (0=no, 1=yes)	0.11	0.31	0.11	0.32	0.06	0.25
Irrigation (0=no, 1=yes)	0.04	0.19	0.03	0.19	0.07	0.26
Human capital						
HH head education	0.65	0.59	0.65	0.59	0.60	0.51
Extension (0=no, 1=yes)	0.09	0.29	0.07	0.27	0.26	0.45
Soil management practices (0=no, 1=yes)	0.88	0.32	0.87	0.33	0.93	0.26
Weather adaptation strategies (nr. of strategies adopted)	1.62	0.73	1.61	0.73	1.80	0.77
Social capital						
Group (0=no, 1=yes)	0.20	0.40	0.17	0.38	0.40	0.50
Quality problems with providers (0=no, 1=yes)	0.35	0.48	0.35	0.48	0.34	0.42
Payment problems with buyers (0=no, 1=yes)	0.53	0.50	0.53	0.50	0.53	0.52
Physical capital						
Non-technological productive assets (MCA index)						
Technological productive assets (MCA index)						
Communication/transportation assets (MCA index)						
Pesticides (0=no, 1=yes)	0.48	0.50	0.48	0.50	0.48	0.51
Financial capital						
Credit (0=no, 1=yes)	0.11	0.31	0.10	0.31	0.13	0.35
Income (local currency)	495990	89813.27	473992	88934.9	721830.7	98786.29
Enabling conditions						
Subsidy (0=no, 1=yes)	0.05	0.22	0.05	0.22	0.00	0.00
Road distance (Km)	7.82	4.55	7.89	4.56	7.20	4.58
Market distance (Km)	1.63	1.68	1.67	1.65	1.30	1.33

Lack of storage facilities (0=no, 1=yes)	0.11	0.33	0.12	0.33	0.06	0.26

Analyses were carried out using STATA version 15. Outcomes highlight common patterns and differences across the three countries. For instance, on average, the wide majority of interviewed households uses soil management practices (96%, 86% and 88% in Ethiopia, Malawi and Tanzania, respectively). Other variables instead are more heterogeneous among countries. Examples of this are the access to extension and advisory services and the group participation. Around one third of respondents access to extension and advisory services in Ethiopia and Malawi, while the percentage drops to 9% in Tanzania. Likewise, Tanzania displays a lower rate of group participation (only 9%) in comparison to Ethiopia (12%) and Malawi (33%).

Two MCA analysis were carried out to reduce the two sets of selected variables for the dimensions of physical productive assets and other physical assets. Table 4. and 5. illustrate their results.

Table 10. Multiple Correspondence Analysis (Physical productive assets)

Dimension	Principal inertia	Percentage	Cumulated percentage
Dim. 1	0.339491	84.72	84.72
Dim. 2	0.000821	2.05	86.76
Dim. 3	0.000002	0.01	86.77
Total	0.040074	100.00	--

Source: Own elaboration

Table 11. Multiple Correspondence Analysis - Variable's contribution (Physical productive assets)

Variable		Dim. 1	Dim. 2
Water pump	0	0.009	**0.018**
	1	0.115	**0.239**
Irrigation equipment	0	0.000	**0.015**
	1	0.008	**0.287**
Machete	0	**0.095**	0.058
	1	**0.088**	0.054
Sickle	0	**0.112**	0.006
	1	**0.117**	0.006
Spade shovel	0	**0.122**	0.002
	1	**0.125**	0.002
Hoe	0	**0.157**	0.027
	1	**0.032**	0.006

Spray pump	0	0.001	**0.021**
	1	0.018	**0.259**

Source: Own elaboration

For physical productive assets, (Table 4.), the first axis alone (Dim. 1) explains more than 84% of the total inertia, while the explanatory power (Dim. 2) reduces to 2.05% and 0.01%, respectively, for the second and third axis (Dim 2. and 3.). The four variables showing high correlation with Dimension 1 (Table 5.) consist of basic productive tools. This Dimension was thus labelled *Non-technological productive assets*. The three variables more correlated with Dimension 2. represent instead more advanced tools and equipment. Dimension 2 can be therefore interpreted as *Technological productive assets.* Consistent with Asfaw et al. (2019), both dimensions appear also meaningful to the analysed context.

Table 12. Multiple Correspondence Analysis (Other physical assets)

Dimension	Principal inertia	Percentage	Cumulated percentage
Dim. 1	0.041765	96.51	96.51
Total	0.043275	100.00	--

Source: Own elaboration

Table 13. Multiple Correspondence Analysis - Variables' contribution (Other physical assets)

Variable		Dim. 1
Radio	0	**0.094**
	1	**0.154**
Telephone	0	**0.121**
	1	**0.077**
Tv	0	**0.010**
	1	**0.155**
Motorcycle	0	**0.009**
	1	**0.163**
Bicycle	0	**0.068**
	1	**0.149**

Source: Own elaboration

The MCA structure for other physical assets is elegantly unidimensional (Table 13), with Dimension 1 explaining itself more than 96% of the total inertia. The five variables considered well relate to Jendoubi et al.'s communication gadgets and transportation vehicles indicators (2020). In this context, however, transport and communication facilities are interpreted as fundamental instruments for

maintaining social and business relations and facilitating information transfer. They may therefore be well represented by a single dimension, which we have labelled *communication/transportation assets*.

Each dimension generated by the two MCAs has a greater potential explanatory capacity and can be represented as a continuous numerical scale which was used for the following Factor Analyses.

Data were further analyzed with 3 exploratory Factor Analysis (FA) for Ethiopia, Malawi and Tanzania, respectively, using variables described in Table 1. and MCA indexes. FAs are useful for extracting dimensions that synthesize the information of strongly correlated variables from the original variables. They were thus used for deriving assets interconnections patterns and measures. The primary approach used was maximum likelihood with Varimax rotation. We selected three five-factor models as the best fit for all the three countries. All eigenvalues exceeded unity (Table 14). In Ethiopia, the combined factors account for 44.52% of the variance, while in Malawi and Tanzania 44.27% and 47.05%, respectively. Factor loading matrices represent the correlation between the extracted components and the original variables and help to understand the component meaning (Table 9, 10 and 11). Loadings <0.40 are not displayed, for clarity.

Table 14. Eigenvalues and total variance explained, Ethiopia, Malawi, and Tanzania

	Rotated Sum of Squared Loadings										
	Ethiopia			Malawi				Tanzania			
Factor	Eigenvalue	% of Variance	Cumulative %	Factor	Eigenvalue	% of Variance	Cumulative %	Factor	Eigenvalue	% of Variance	Cumulative %
Factor 1	2.27	10.82	10.82	Factor 1	2.18	9.91	9.91	Factor 1	2.33	11.08	11.08
Factor 2	2.08	9.88	20.71	Factor 2	2.08	9.47	19.38	Factor 2	2.08	9.89	20.97
Factor 3	1.75	8.34	29.05	Factor 3	1.99	9.04	28.42	Factor 3	1.98	9.44	30.41
Factor 4	1.68	8.01	37.06	Factor 4	1.77	8.03	36.45	Factor 4	1.84	8.76	39.17
Factor 5	1.57	7.46	44.52	Factor 5	1.72	7.82	44.27	Factor 5	1.65	7.88	47.05

Source: Own elaboration

Table 15. Rotated component matrix for factor analysis, Ethiopia

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Land cultivated					
Landholding				**0.7761**	
Fertilizers					**0.6587**
Irrigation				**0.6283**	
HH education	**0.8351**				
Extension	**0.5239**		0.4215		
Soil.man.pract.					

Wx.adapt.strat.	**0.9732**				
Group			**0.4721**		
Suppliers probl.				**0.4615**	
Buyers probl					
Non-tech prod. ass.		**0.5947**			
Tech. prod. Ass.		**0.8183**			
Comm/transp ass.		**0.5805**			
Pesticides					**0.4264**
Credit					
Income		**0.5383**			
Subsidy					
Market distance			**-0.7050**		
Road distance			**-0.6183**		
Lack storage					**-0.5588**

Source: Own elaboration

Table 16. Rotated component matrix for factor analysis, Malawi

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Land cultivated				**0.6438**	
Landholding					**-0.4885**
Topography					**0.6590**
Fertilizers					
Irrigation					**0.7572**
HH education			**0.7002**		
Extension	**0.8116**				
Soil.man.pract.			**0.5929**		
Wx.adapt.strat.	0.4245		**0.8275**		
Group	**0.7858**				
Suppliers probl.					
Buyers probl					
Non-tech prod. ass.					
Tech. prod. Ass.					
Comm/transp ass.				**0.7252**	
Pesticides					
Credit	**0.4550**				
Income				**0.5615**	
Subsidy					

Market distance		**0.8584**			
Road distance		**-0.8820**			
Lack storage					

Source: Own elaboration

Table 17. Rotated component matrix for factor analysis, Tanzania

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Land cultivated	**0.6470**				
Landholding					
Fertilizers				**0.8485**	
Irrigation					**-0.4423**
HH education		**0.8486**			
Extension		**0.4825**			
Soil.man.pract.					**0.5959**
Wx.adapt.strat.		**0.9738**			
Group	**0.6840**				
Suppliers probl.			**0.7384**		
Buyers probl			**0.5539**		
Non-tech prod. ass.					
Tech. prod. Ass.	**0.5047**				
Comm/transp ass.	**0.5845**				
Pesticides	**0.4791**				
Credit					
Income	**0.6233**				
Subsidy				**0.7581**	
Market distance					
Road distance					**0.6598**
Lack storage			**0.7393**		

Source: Own elaboration

Across the three FAs' structures common patterns have emerged, complemented by country specificities.

Table 18. Summary of FA results, Ethiopia, Malawi and Tanzania

Ethiopia				
Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
HH education	Non-tech prod. ass.	Group	Landholding	Fertilizers
Extension	Tech. prod. Ass.	Market distance	Irrigation	Pesticides

Wx.adapt.strat.	Comm/transp ass.	Road distance	Suppliers probl.	Lack storage
	Income			

Malawi

Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Extension	Market distance	HH education	Land cultivated	Landholding
Group	Road distance	Soil.man.pract.	Comm/transp ass.	Topography
Credit		Wx.adapt.strat.	Income	Irrigation

Tanzania

Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Land cultivated	HH education	Suppliers probl.	Fertilizers	Irrigation
Group	Extension	Buyers probl	Subsidy	Soil.man.pract.
Tech. prod. Ass.	Wx.adapt.strat.	Lack storage		Road distance
Comm/transp ass.				
Pesticides				
Income				

Source: Own elaboration

In particular, Human capital emerged as a unique factor across the three FAs (Factor 1, 3 and 2 in Ethiopia, Malawi and Tanzania, respectively). It explained the greatest amount of variance in Ethiopia (10.82%), while accounting for 9.04% in Malawi and 9.89% in Tanzania. The clustering of variables turned up identical in Ethiopia and Tanzania (Household head education, Extension and Weather adaptation strategies) while in Malawi Extension was substituted by Soil management practices. The latter was eliminated from the overall factor solution for Ethiopia. Its failure to load meaningfully may be partly a function of lack of variability in response. Indeed, the percentage of respondents adopting Soil management practices in Ethiopia is 96.11%. In Tanzania, instead, this variable meaningfully grouped with Irrigation (-) and Distance from road (Factor 5). Soil management practices have been reported to improve resilience to drought (Brooks & Loevinsohn, 2011). It may be assumed that in remote areas, rainfed agricultural systems rely on such practices to improve resistance to extreme weather events.

Unsurprisingly, total income and physical assets have clustered together in the three FAs, albeit across several factors. Traditionally, physical assets have been considered as indicators of living standards and have been used to construct wealth indices as an alternative to income and consumption expenses (Howe et al, 2008). However, not the full set of physical assets loaded in the three FAs. Income, Non-technological productive assets, Technological productive assets and Communication/transportation

assets have emerged as a unique factor in Ethiopia (Factor 2, 9.88% of total variance). In Malawi, Income and Communication/transportation assets clustered with Land cultivated (Factor 4., 8.03% of total variance). In Tanzania, a similar pattern, however more complex, emerged. Income, Technological productive assets and Communication/transportation assets clustered together with Land cultivated, Pesticides and Groups (Factor 1, 11.08% of total variance).

Road distance and Market distance clustered together in two over three FAs. The two variables loaded on one independent factor in Malawi (Factor 3, 9.09% of total variance) while in Ethiopia they clustered with the variable Group (Factor 3, 8.43% of total variance).

In addition, a number of across sites differences emerged.

In Ethiopia, besides the outlined factors, two further dimensions emerged. Factor 4 (8.01% of total variance) grouped two natural capital variables: Landholding and Irrigation. A fifth Factor (7.46% of total variance) emerged with 3 variables, Fertilizers, Pesticides and Lack of storage facilities.

In Malawi, greatest amount of variance was explained by Factor 1, including Extension, Group and Credit (9.91% of total variance). A fifth factor emerged clustering the following natural capital variables: Lanholding, Topography and Irrigation (7.82% of total variance).

In Tanzania, the two variables targeting trust (Suppliers problems and Buyers problems), grouped with the variable Lack of storage (Factor 3, 9.44% of total variance). Unsurprisingly, a strong correlation emerged for Fertilizers and Subsidy, grouped in Factor 4 (8.76% of total variance).

For clarity, qualitative results of FGDs, key informants interviews and MAP meetings will be presented per country.

Ethiopia

Results of the Focus Group discussions with maize VC actors and key informants' interviews have been used to create a foundation for understanding maize VC in Meta and Kombolcha District. The FGD evidenced that Maize producers in the two districts are mainly smallholder farmers. There are about 60,000 smallholder farm households in Meta District and about 32,000 in Kombolcha district. Input providers supply a diverse range of inputs to producers. Inputs are provided by different suppliers. Research institutes (e.g., Haramaya University and Fedis Agricultural Research Center provide to farmers in the two districts with improved and/or farmer-preferred maize and other agricultural technologies. NGOs (including CARE-Ethiopia) also provide improved seeds and other inputs for farmers. Agricultural Offices at different levels (district and zone), in collaboration with cooperatives, supply fertilizers, seeds, and other agro-chemicals for farmers. There are no input subsidies in Ethiopia. Input sales are invariably done on cash basis. Based on input regulations, seed

sellers/producers need to have Certificate of Competence (COC) to engage in selling seeds. Producers choose inputs based on their own interest supported by recommendations from research institutions and the Office of Agriculture. Cooperative members comprise exclusively smallholder farmers. The volume of production collected is variable across cooperatives and districts, however being minority share for maize. In the two districts, there are both primary cooperative and Cooperative Unions. They play a relevant role in providing inputs and facilitating market for outputs. Produce is bought from member and non-member farmers and sold it further to wholesalers and exporters. Relationships between cooperatives and buyers related to terms of contract, price arrangements and credit systems are all well arranged with little prospect of undesirable effects such as defaulting. Storage losses have been reported to range between 3-5%. As maize production is not sufficient to meet demand of the local consumers, distant traders fetch more maize from western and central parts of the country. The maize brought from distant places in the country is further sold to other wholesalers, retailers, and consumers. Relationships of traders with buyers, in terms of contract, price arrangements and credit systems are well arranged. Sales are done invariably on cash basis. Storage losses at the traders' level have been reported to be about 3%. Maize wholesalers buy the crop from distant markets and traders, mostly from western and central parts of the country, and sell it to retailers and consumers. Maize sold by retailers to local consumers is bought from farmers, national traders and wholesalers.

During the MAP meeting, members clearly highlighted two main factors for farmers successfully participate in the maize VC. The first is physical capital. In particular, farmers are reported to have low access to agricultural equipment, tools and inputs, with direct effect on productivity and ability to meet the existing demand. Second, skills and knowledge were reported as a critical issue. Indeed, MAP members evidenced the risky nature of the agriculture sector (dominantly rainfed) which required investment in promoting a sustainable intensification of crop production. Moreover,

MAP members were also asked to select policy instruments with the highest potential for acting on farmers' participation in maize VC. Instruments/strategies selected by Map members were Generation, dissemination, and scaling up of technologies, included in the Agricultural Growth Program in the Growth and Transformation Plan (GTP I and II) and Building professional capacities and skills of extension workers, included in the National Agriculture Policy. For the former, MAP participants recognized a low level of implementation. This is mainly due to the limited capacity (capital, physical, and human) of institutions to generate and scale-up technologies, in the inefficient linkage among relevant actors involved in generation, dissemination, and scaling-up of technologies and in weak extension system to disseminate technologies. A clear need for harmonization of the

selected measures is therefore required. In particular, Ethiopia's Agricultural Extension Services should operate through adoption and adaptation of improved technologies by delivering market-oriented, demand-driven and pluralistic extension services. The strategy comprises 9 pillars which include enhance agricultural knowledge and information systems, enhance client oriented and multi actor's advisory extension service, facilitate market linkage, enhance VCs development, enhance institutional arrangements, coordination and linkages among key agricultural development partners, among others. Nevertheless, the main barrier to the Strategy implementation remains the enabling environment in which extension operates. It consists of limited material and financial capacity, professional dissatisfaction/lack of interest from extension workers themselves and lack of incentive mechanisms for moral boosting. Moreover, critical areas such as inputs, market access and credit, strongly constraint extension and agriculture production (Abate et al., 2015). To overcome those critical factors, an attempt to redesign a comprehensive strategy is in place to align policies related to agriculture system and business environment to the national extension strategy.

Malawi

FGD discussion and key informants interviewed revealed that in Mzimba and Dezda District, farmers are exclusively small-scale farmers. Crops produced include: maize, groundnuts, bambara nuts, millet, pigeon peas, sorghum and tobacco. Maize traditional varieties are locally used as a source of food while hybrid maize is regarded for commercial purposes. Farmers are also engaged in secondary activities such as beekeeping and poultry farming Despite the establishment of a floor price for maize established by Government, FGD participants stated that Government fails to monitor its application. Three categories of input providers operate in the area: companies that produce their own marketed inputs, companies exclusively focused on inputs trade and mixed producer-trader companies. Agro-dealers sell seeds, fertilizers, pesticides and herbicides to farmers and cooperatives. Agro-dealers work in collaboration with extension agents. Extension agents provide technical assistance to farmers and help to define inputs required, which are supplied by agro-dealers together with technical advice about their use. To become an authorized agro-dealer, a business license is required. Illegal behaviours like dilution of chemicals and labels alteration are reported for agro-dealers by farmers. A subsidy system (FISP – Farm input subsidy program) is in place to increase access to high quality seeds and fertilizers. According to FGD members, it reaches around 35% of farmers. Two different categories of millers exist: small and big. Small millers are mainly local, and process traditional maize varieties produced by farmers for self-consumption. In the study area there are 9 small millers. Big millers are not generally located in production areas and mainly correspond to International traders

(e.g. Bakhressa). Traders in the area can be classified into three categories: Local traders, national (small and big) traders and international traders. Local traders buy raw material from local smallholder farmers. National (small and big) traders buy products from local traders and sell them to both international traders and processors. International traders include three main competitors (e.g., ETG, RAB and Farmer's World). They manly buy grains from big traders. These companies are part of the Grain Traders and Processor Association (GTPA). Some of them provide inputs to farmers and trade different crops for domestic and international markets. Maize is stored in warehouses in Lilongwe to be then addressed to national and international market. In some cases, they work in collaboration with local NGOs to supports product quality enhancement, trading and knowledge sharing at farm level. Also, few of them provide mechanised services to companies, farmer groups and commercial farmers. These companies also supply Governmental maize stock. Seven cooperatives operate in the area. They have an average size of 50-100 members while the biggest one has 245 members. They provide farmers with storage facilities. Cooperatives buy grain from their members and sell it to big traders from Lilongwe and Blantyre. Raw material is processed by different industries specialized either in agro-processing including food fortification (in collaboration with Government and international organizations in malnutrition alleviation programmes) or in processing a diverse range of livestock feeds.

Results of Multiactor Platform meeting provided interesting insights into the most important requirements for farmers' participation in maize VC. Most important factors were recognized in sufficient natural capital. Most farmers in the area traditionally rely on maize monocropping, with decrease of fertility and resilience to weather changes. A specific reference was made to the importance of land size, which is reported to be very low in the study sites, making farmers' competition with existing larger companies unfair. To this extent, extensionists and cooperatives highlighted their joint effort in encouraging farmers' group to form cooperatives. Cooperatives play distinct role in the areas. Cooperatives are now engaged in value addition in collaboration with public extensionists, including looking for available grants to enhance mechanization. Moreover, being the number of potential buyers for selling maize in the area wide, cooperatives play an intermediation role with buyers. Informal agreements exist. However, during peak season, buyers are reported to attempt new price bidding. Cooperatives have an easier communication with different buyers and may therefore contract the better price based on their high production offer and extended business relations. Farmers reported the crucial role of credit for enhancing productivity and quality standards. Cooperative representatives highlighted the role of cooperative in facilitating access to credit for

members. MAP participants agreed that cooperatives may play a major role in linking farmers with Village Savings and Loans program. Moreover, the Government should make efforts to engage big companies in providing loans by formalizing specific agreements between farmers and buyers.

MAP members were required to select policy instruments with the highest potential for acting on farmers' participation in maize VC. Instruments/strategies selected by Map members were Strengthen farmer organizations and Establish an appropriate stakeholder and policymaker representation and coordination body to develop value chains, included in the National Agriculture Policy. They were considered potentially highly effective, however with a low implementation level. More specifically, even if farmers' organization have the potential to facilitate access to loans and input subsidies, to provide extension services and storage and processing facilities, as well as to link smallholders with the market, their presence and their coordination with other stakeholders needs to be increased. MAP members highlighted the need to put in place mechanisms encompassing all the players in the agricultural chain starting from providers and ending to buyers. They also stated that the recent District Agriculture Extension Services (DAES) established at District level could serve this coordination purpose, however requiring a greater recognition and empowerment by the Government.

Tanzania

Results of the Focus Group discussions with maize VC actors and key informants' interviews have been used to create a foundation for understanding maize VC. Results indicated that in Lindi District most farmers belong to the category of smallholders. Medium and large-scale farms exist, however they are generally led by organisations such as NGOs and Churches. In the district, Farmers grow different crops besides maize (e.g., cashew nuts, groundnuts, cow pea, sesame, pigeon pea, sorghum, cassava, green gram). Maize, despite being widely cultivated, is mainly considered a staple crop while cashew nut represents the most relevant cash crop, for whom the district is the most important national production centre. Farmers source agricultural inputs from around 50 agro-dealers in the whole Lindi region, registered in an association. To become an authorized agro-dealer, different business licenses are required. Agro-dealers pay different registration fees and permits to sell pesticides, vet/livestock inputs and fertilizers. Instead, selling seeds does not require any license. Fertilizers and improved seeds are subsided under National Agricultural Input Voucher Scheme (NAIVS). Local agro-dealers could be appointed as distribution agents for subsidised inputs, however, in most cases, they do not meet the required standards. Subsidised inputs are therefore more commonly distributed by agro-dealers from outside the District. This strongly constraints subsidies' access and particularly disincentives those who can afford to buy otherwise.

Despite around two grain mills exist in each village for de-hulling maize and process grain into flour, farmers do not process maize for the market, but only for self-consumption.

Maize surpluses are sold to different market channel, through local traders, companies' agents and international traders. Some cases were reported where farmers managed to aggregate raw material, arrange a truck and sell their produce in Dar-es-Salaam market with no intermediation. Local traders buy maize from local farmers and from Agricultural Marketing Cooperative Societies (AMCOS). However, local traders highlighted that maize quantity and quality are unstable, and many times fail to reach the required standards. At the same time, farmers recognized the great opportunity arising from selling to AMCOS. However, small producers reported to be unable to sell to AMCOS. Sometimes, local traders buy from local farmers through an intermediary, a local farmer able to aggregate farmers' production. Production is then stored in AMCOS warehouses before being addressed to Mtwara or Dar-es-Salaam. It was pointed out by both farmers and local traders that no formal agreements are generally subscribed. However, the traded volume is formally declared to the District Local Government Authority (LGA) in order to calculate the levy to be charged. Raw maize is then addressed to big companies, local markets and independent brokers in Dar-es-Salaam. Independent brokers handle only partially maize, being more focused on sesame, yellow grain, pigeon pea, green bean and groundnut, whose local supply better meet required quality and quantity standards. Maize is then sold to international companies or addressed to international markets.

Around 20 big companies operate in Tanzania (e.g. ETG, Maviga, Olam, Metl). These companies can be classified as international traders, but, in few cases, their business also include some processing. International traders buy from individual farmers, from groups of farmers or from independent brokers in Dar-es-Salaam. In the first case they reach small-scale farmers through their own agents or through individual local middlemen, who are generally farmers. In the second case, contracts are signed with groups of farmers able to aggregate raw material and to arrange trucks to Dar-es-Salaam,

Most of the companies have branches and warehouses in different areas of the country. Transport from farms to warehouses is arranged by the companies but paid by farmers. Raw material and processed products (e.g., feeding for livestock) are then addressed either to national or international markets. Traders participating in the FGD highlighted that maize trade is characterized by uncertain conditions. Since the 1990s Tanzania has decreased the role of the government control on the economy and progressively moved to a more liberal trade policy. Tanzania has aligned its import-export regulation with the East Africa Community (EAC). Members share a common external tariff

and internal tariff on maize have been abolished (Fapda, 2014). However, Tanzanian government has banned the exportation of maize on several occasions to ensure an adequate domestic food supply and to stabilize internal prices. The market uncertainty and the effects of the ban have affected farmers' and traders' access to international markets. All FGD participants also highlighted the critical role of intermediation for market access in the area. A good tarmac road connects Lindi to Dar-es-Salaam, and also to Mtwara port. However, there are poor road from the villages to the main road. This strongly constraints farmers' access to the market. As a result, many farmers only rely on intermediary's visits to sell their produce, strongly reducing prices at the farm gate.

Multiactor Platform meeting involving VC actors was a crucial moment to analyse the pathways through which farmers access maize VC and the existing constraints and opportunities. MAP members ranked the most important requirements for farmers participating in the maize VC. Equally important factors were considered sufficient land, productive capitals and skills and knowledge to enhance the quantity and quality of production. As already highlighted maize is produced by most farmers, but mainly for self-consumption. Another point of relevance refers to social capital. Besides the need for an increased access to farmers group and cooperatives, MAP members highlighted the importance of building more trustworthy relations with business partners. In the study sites, Maize production is linked to domestic, regional and external markets. As highlighted, each of them includes a high number of intermediation actors. MAP members indicated that the number of potential buyers for selling maize in the site is wide, however, smallholders mainly sell their produce individually to middlemen or directly to consumers. In the latter case, farmers are generally reached by middlemen, or make a first contact with them based on neighbours' or family's experience. These are generally regular long-lasting relationships where informal socialisation and being fair in negotiation play a major role. However, MAP members also highlighted that quite often farmers incur in cheating behaviours. In particular, price setting appears unfair, due to lack of market information on the part of farmers, and in many cases middlemen's word is not kept in relation to agreed prices. Moreover, were also reported frequent irregular or incomplete payments by buyers.

Furthermore, MAP members were required to select policy instruments with the highest potential for acting on farmers' participation in maize VC, which were *Agricultural production market oriented (including standard and quality in agricultural marketing developed and harmonized by the Government, in collaboration with other stakeholders)* included in the Agricultural marketing policy and *Availability of cooperative officers, field officers and field extension officers ensured,* included in the Cooperative development policy. Despite their potential effectiveness, the implementation

level for these two measures were considered by MAP members very low. In particular, for the former, implementation level varies across crops. For maize however, MAP members highlighted that a certain degree of trade with neighboring countries has been developed. However, maize is sold through differentiated channels, which are accessed by different categories of farmers. Only a small proportion is able to comply with export quality standards, and this should be considered. A policy change is therefore needed for making channels' standard explicit and formulate clear differentiated strategies for different farmers. A strong investment in education to farmers is required and an investment to improve the availability of market information to farmers and communication between parties would be also beneficial. MAP members highlighted that agricultural Universities could take a pivotal role in this assignment, facilitated by the Government. This would require a harmonization effort with the measure *Availability of cooperative officers, field officers and field extension officers ensured,* which is challenged by the insufficient availability of financial resources for increasing the inefficient supervision and distribution of the available officers and enhancing their employment rate which does not match with the actual demands.

3.6. Discussion and conclusions

The study provides extensive results on the maize VC participation in the three sites. Common patterns have emerged, as well as differences across and within sites. Maize is a crop widely cultivated in the study sites, however, except for Malawi, predominantly for consumption purpose. The study highlights the general poor asset endowment of farmers across sites, either participating or not in the VC. However, results allow to draw some considerations for enhancing VC participation in the study sites.

In relation to Ethiopia, the current maize demand is unmet by local farmers. This highlights the importance of interventions aimed at enhancing farmers' production and participation to market. Physical capital was considered one of the major challenges to that extent by MAP members. In this sense, results of the FA are consistent with MAP members opinion. Factor 2 clustered together total income and all the physical assets. As highlighted, physical assets are commonly used as a proxy for household income. Therefore, their correlation appears coherent. Looking at descriptive statistics, results of indicate that normalized FA scores for this factor are higher for farmers selling maize with respect to not sellers (0.27 versus 0.28). Also, the use of pesticides and fertilizers clustered with lack storage facilities in Factor 5. Normalized FA values for farmers selling maize are again higher in comparison to not sellers (45 vs 0.52). Nevertheless, we cannot state causal inference between the

higher value for the intercepted factors for farmers accessing the market and market access itself. For instance, a higher endowment of physical assets and a higher income are certainly a driver supporting the specialization effort required to participate in the VC. However, impact evaluation studies have shown that to a certain extent such conditions may be also influenced by market participation itself (Donovan & Poole, 2014). Temporal precedence of the cause is hard to establish. For this reason, our analysis strongly relies on across method validation, and, in particular, on qualitative data collected infield. Factor 1 clustered household head education, extension and use of weather adaptation strategies. These results are consistent with previous studies highlighting the strong casual relation between both household head's education and extension access and the adoption of climate-smart agricultural practices (e.g., Branca & Perelli, 2020). Also in this case, normalized FA scores for this factor are higher for farmers selling maize with respect to not sellers (0.32 versus 0.37). Across methods validation provide evidence that not value chain ready farmers in the study sites require specific interventions aimed at enhancing productive tools and skills and knowledge. According to MAP members, this should be mediated by an improved role played by extension and advisory services which could serve as a linkage among relevant actors involved in the generation, dissemination, and scaling-up of technologies.

In Malawi, MAP members highlighted the importance of natural capital for farmers be able to participate in the VC. Natural capital variables dispersed in different dimensions in the FA and provide interesting insights into how assets relate to each other, in particular, with regard to Factor 3 and 4. Factor 4 clustered land cultivated, total income and communication/transportation assets. This is not surprisingly. Sampled households are, on average, 13.3 km distant from the market and from a paved road. Communication and transportation assets may be useful to overcome challenges derived from distance, including access to inputs, services and market information. As highlighted for Ethiopia, correlation between income and physical capital can be considered coherent. Looking at descriptive statistics, results of indicate that normalized FA scores for this factor are higher for farmers selling maize with respect to not sellers (0.31 versus 0.25). Factor 3 clustered HH education, adoption of soil management practices and weather adaptation strategies. As highlighted for Ethiopia, results are consistent with literature (e.g., Branca & Perelli, 2020). Also in this case, normalized FA scores for this factor are higher for farmers selling maize with respect to not sellers (0.56 versus 0.58). MAP members have also selected the crucial role of social capital, in particular with reference to the role of cooperatives. Indeed, the variable membership in group clustered in the principal dimension emerged from the FA, also including access to extension and advisory services. This dimension

expresses the importance of the social network by which farmers access important services, and highlights the existing interconnections among social, human and financial assets. In this sense, higher values related to social network can be observed for farmers participating in the market (0.38 for farmers selling maize vs 0.31 for not sellers). Interventions aimed at enhancing maize VC participation in Malawi should therefore consider specific interventions aimed at not value chain ready farmers, displaying a lower level of education and productive skills. Also, not value chain farmers should be encouraged to engage in groups, and especially cooperatives, which according to FA results and MAP members are a potential driver for accessing extension and credit. Moreover, cooperatives may help enforcing the existing law on privileged access to land for poorest farmers.

A strong connection with the analysed policies can be therefore highlighted. In this sense the existing District Agriculture Extension Services (DAES) could effectively drive a change in the coordination mechanism along the VC, serving as platform of exchange among VC actors. This could serve as an in-field harmonization effort across the two measures analysed.

In relation to Malawi, MAP members highlighted the importance of natural capital for farmers be able to participate in the VC. Natural capital variables dispersed in different dimensions in the FA and provide interesting insights into how assets relate to each other, in particular, with regard to Factor 3 and 4. Factor 4 clustered land cultivated, total income and communication/transportation assets. This is not surprisingly. Sampled households are, on average, 13.3 km distant from the market and from a paved road. Communication and transportation assets may be useful to overcome challenges derived from distance, including access to inputs, services and market information. As highlighted, physical assets are commonly used as proxy for household income. Therefore, their correlation appears coherent. Looking at descriptive statistics, results of indicate that normalized FA scores for this factor are higher for farmers selling maize with respect to not sellers (0.31 versus 0.25). Factor number 3 clustered HH education, adoption of soil management practices and weather adaptation strategies. These results are consistent with previous studies highlighting the strong relation between household head's education and adoption of climate-smart agricultural practices (e.g., Branca & Perelli, 2020). Also in this case, normalized FA scores for this factor are higher for farmers selling maize with respect to not sellers (0.56 versus 0.58). MAP members have also selected the crucial role of social capital, in particular with reference to the role of cooperatives. Indeed, the variable membership in group clustered in the principal dimension emerged from the FA, also including access to extension and advisory services. This dimension expresses the importance of the social network by which farmers access important services, and highlights the existing interconnections among

social, human and financial assets. In this sense, higher values related to social network can be observed for farmers participating in the market (0.38 for farmers selling maize vs 0.31 for not sellers). Nevertheless, we cannot state causal inference between the higher value for the intercepted factors for farmers accessing the market and market access itself. For instance, higher land size, a higher endowment of physical assets and a higher income are certainly a driver supporting the specialization effort required to participate in the VC. However, impact evaluation studies have shown that to a certain extent such conditions may be also influenced by market participation itself (Donovan & Poole, 2014). Temporal precedence of the cause is hard to establish. For this reason, our analysis strongly relies on across method validation, and, in particular, on qualitative data collected infield.

Interventions aimed at enhancing maize VC participation in Malawi should therefore consider specific interventions aimed at not value chain ready farmers, displaying a lower level of education and productive skills. Also, not value chain farmers should be encouraged to engage in groups, and especially cooperatives, which according to FA results and MAP members are a potential driver for accessing extension and credit. Moreover, cooperatives may help enforcing the existing law on privileged access to land for poorest farmers.

A strong connection with the analysed policies can be therefore highlighted. In this sense the existing District Agriculture Extension Services (DAES) could effectively drive a change in the coordination mechanism along the VC, serving as platform of exchange among VC actors. This could serve as an in-filed harmonization effort across the two measures analysed.

In Tanzania, a slightly different pattern emerged. In particular, a clear correlation emerged among land cultivated, physical productive assets, the use of pesticides, membership in groups and income (Factor 1). We find this result particularly interesting. In particular, higher normalized values for this factor can be observed for farmers selling maize in comparison to farmers not selling maize (0.36 vs 0.27). We find this result particularly interesting, especially in combination with Factor 3, grouping problems with providers and buyers and lack of storage facilities. First, the fact that variables traditionally associated with wealth (income, land and physical asset) positively correlate with participation in groups, provide insights on how assets are built in the area. A low percentage of farmers participate in groups and cooperatives, however, results indicate that there might be a relation between group participation and physical asset endowment, and, in general better conditions in terms of land cultivated and ability to generate income. This might be interpreted as a low ability of cooperatives and groups to engage small-scale farmers, indicating the role of groups and cooperatives

as a potential driver for effectively enhance farmers' access to physical assets and pesticides, towards an increase of productivity and quality of production. Factor 3, related to problems with providers and buyers and lack of storage facilities is peculiar in Tanzanian sites. Maize VC is strongly fragmented in the area, where connections with buyers overlap over different market channels. Farmers display a high average distance from the market and are thus subjected to complex relations with different intermediaries. In this sense, as highlighted for Malawi, groups and cooperative could be a viable opportunity for challenging this difficult business relationships. Another important option would consist in an increased role played by Multiactor Platform, which could be a forum of exchange and to face conflicts among the VC different actors. As highlighted by MAP members, the importance of knowledge and skills for VC participation is confirmed by normalized FA scores for Factor 2, higher for farmers selling maize with respect to not sellers (0.38 versus 0.34). Factor 2 includes household head education, extension and strategies of adaptation to weather change. Interventions aimed at increasing VC participation for not VC ready farmers, should therefore focus on low land availability, low endowment of physical assets, low participation and improved investment in education. In this sense, participation in groups and cooperatives and a better access to extension and advisory services have shown a great potential and could be effectively supported by an increased implementation and harmonization efforts between the two selected policy measure, *Agricultural production market oriented (including standard and quality in agricultural marketing developed and harmonized by the Government, in collaboration with other stakeholders)* and *Availability of cooperative officers, field officers and field extension officers ensured.*

4. DISCUSSION

The current doctoral thesis has aimed to inform the design and implementation of interventions and policies questioning how and why they are targeted towards particular farmers, communities or agro-ecologies, as well as how much room or flexibility they allow for adjustment and adaptation to suit its intended beneficiaries. The thesis has investigated the impact of rural diversity in Eastern African farmers' decision-making process, analysing the drivers of technological innovation uptake among heterogeneous users, as well as their differentiated access to markets.

Main findings of the thesis are elaborated in section 4.1 with particular reference to the two case studies. Discussions of the two studies are presented following the research questions of the thesis, which are recalled to facilitating the reading. Then, section 4.2 provides policy implications of the thesis.

4.1. Responses to the research questions

4.1.1. Less endowed smallholders and development interventions

This section elaborates on the answer to the first research question of the current thesis, namely: *Which factors constrain smallholders endowed with less resources from benefitting from development interventions aimed at technological change and market access?*

The current thesis has sought to consider households heterogeneity in terms of resource endowments. As for the analysis of less endowed households, the two case studies have provided convergent results. Interventions aimed at alleviating rural poverty cannot rely on standardised frameworks designed for all farmers. Indeed, categories of smallholders that lack of minimum resources show low potential to benefit from generalized interventions aimed at promoting technological change and improved market access.

The first case study highlights that intervention aimed to trigger processes of technological change cannot disregard the existence of vulnerable households. Outcomes on the adoption of improved seeds have shown that households who do not adopt technological innovations are characterised by vulnerability conditions. These households are generally female-headed, with lower level of education, which are particularly vulnerable categories in developing countries. They are also characterized by lower size in terms of cultivated farmland and are surrounded by a weak institutional environment. In fact, they do not have access to extension and advisory services, to input subsidies and are unable to access distant market infrastructures. These characteristics imply that besides their

difficult access to agricultural inputs due to a constrained access to input subsidies, extension services and distant market, these households lack of sufficient resources and are probably more risk adverse, which results in a lower propensity to innovation adoption.

In line with these considerations, the second case study suggests correlations among famers that do not access the market and the lack of sufficient asset endowment required in each site analyzed in the study.

4.1.2. More endowed smallholders and development interventions

This section elaborates on the answer to the second research question of the current thesis, namely: *Which factors constrain smallholders endowed with more resources from benefitting from development interventions aimed at technological change and market access?*

The two case studies have provided coherent results also with regard to more endowed households. Considering the practical constraints for the uptake of technological innovations and the participation in the value chain can be crucial for designing interventions aimed at poor-endowed farmers. However, the needs, constraints and strategies of more endowed farmers may appear more complex and less obvious to interpret and thus require two further in-depth considerations.

First, the second case study challenges the concept of "more endowed smallholders" itself. Literature often refers to minimum requirements to participate in the market (Minh and Osei-Amponsah, 2021). However, understanding such minimum requirements is far from straightforward. Correlations emerged in the study findings suggest that each value chain in each specific site requires specific levels and combinations of assets. This poses two challenges. The first challenge relates to the assessment of the high level of within and across sites heterogeneity. The second – and perhaps more complex –, consists in the definition of a level of criticality to the differentiated households' conditions. Therefore, identifying households sufficiently endowed to participate in the market is not an easy task.

Second, even though defining what "more endowed households" means in a site to which an intervention is directed is of paramount importance, this may not be sufficient for understanding households' multifaceted behaviours. The first case study highlights that, albeit the existing barriers for innovation adoption undoubtedly act on more vulnerable households, innovation uptake does not necessarily increase *tout court* when such barriers are removed. Even though outcomes of the study confirm that the adoption of innovations is linked to a better resources' endowment, increasing resources endowment can lead to differentiated non-obvious behaviors among households.

Households could decide to exclusively use the technological innovation at hand, but they could also opt for maintaining and use pre-existing local varieties. Indeed, and quite surprisingly, better endowed households participating in the first study have shown to maintain traditional local seeds. More precisely, results of this study suggests that more endowed households combine improved and local varieties following a twofold strategy: participating in larger markets where quality and quantity standards are better addressed by improved varieties; and participating in local market where consumers' consumption preferences are better addressed by local varieties. From these outcomes emerges a bi-directional interconnection between technological change and market access, that challenges the traditional model that posits only a linear uni-directional pattern, in which technological change drives increased productivity and thus market participation (cfr., Devaux et al., 2018).

4.1.3. The impact of rural diversity on development initiatives

This section elaborates on the answer to the third research question of the current thesis, namely: *How does rural diversity impact the potential effectiveness for smallholders of development interventions and policies?*

Literature has consistently showed that many value chain development interventions and innovation diffusion programmes have not yield the expected impacts in terms of poverty reduction (Devaux et al., 2018). Theoretical and empirical efforts have been devoted to investigating the reasons behind the failures of many development-oriented interventions and policies. A very critical point is that interventions and policies have often overlooked the role of rural diversity in determining the ability of households to participate and benefit from development programmes. The current thesis provides a theoretical and empirical contribution to improve the state of knowledge on rural diversity. Empirical findings suggest that a poor understanding of the heterogeneity within and across the sites to which interventions and policies are directed can undermine their effectiveness. Based on our findings, we can draw a set of considerations.

First, differences within sites to which development interventions are directed exist. Failing to account for such differences may imply the design of ineffective interventions. Heterogeneity *is*, and *is not*, a problem *per se.* Heterogeneity *is* a problem *per se* when differences regards being vulnerable or not. For instance, in these cases, problems can emerge when interventions are not able to associate to different asset endowments a different level and nature of inadequacy/criticality for participating in a value chain. Our second study suggests the existence of specific critical levels of asset

combinations required for value chain participation. Findings reveal that some households reach the required levels, while some others do not. Failing to specify who is value chain ready and who is not undermines the design of differentiated interventions that effectively address the challenges that each smallholder "category" faces.

Conversely, if we consider the results of the first case study concerning innovations adoption, we see a situation in which heterogeneity *is not* a problem *per se.* This happens when differences are not associated with being vulnerable or not. Literature has traditionally assumed that vulnerability conditions (e.g., poor resources endowments) are a strong constraint to agriculture innovation adoption (e.g., Ruzzante, 2021). Even though our findings confirm such assumption, interventions based on a polarized vision of non-adopters (namely, less endowed households) and adopters (namely, more endowed households) simplify the complexity of the processes of innovation adoption and diffusion and might fail in yielding the expected results. Our outcomes suggest that over a certain threshold of resources endowment, heterogeneity may not be a problem *per se*. We have observed highly endowed households deliberately choosing not to exclusively adopt improved seed varieties. This is at odds with the deterministic assumption of most policies and interventions, according to which innovations diffusion and adoption trigger a secure pattern towards technological change and market integration (Glover, 2019) and that, once having adopted an innovation, households abandon traditional technologies. We observed, instead, that households more integrated in the market, did not follow this pattern, but combined the use of improved and local varieties, which is for them an active rational choice pursuing a more profitable livelihood strategy rather than a second-best solution for lack of alternatives. Based on this, we claim that policies and interventions often fail to understand the real nature of famers' diversity, which is based on differentiated preferences, strategies and decisions aimed at flexibly adapt to a rapid-evolving economic environment. That is to say that interventions and policies should consider households' *agency* and the promising potential arising from *bricolage*[9].

Second, differences across sites exist, as well. We have devoted consistent theoretical and empirical efforts in analysing heterogeneity across sites in the second case study. Even though identifying within site heterogeneity is crucial, it may not be enough for designing effective policies and interventions. In this sense, our findings suggest an answer to the following question: can be a specific

[9] The concept of "bricolage" has been traditionally described as making do with "whatever is at hand" (Stinchfield et al., 2013), or, in a wider interpretation, the combination and reuse of resources for different applications than those for which they were originally intended or used (Baker & Nelson, 2005)

value chain intervention replicated in other locations? (see Kidoido and Child, 2014). Even if one considers the same commodity chain in similar contexts (e.g., East Africa), the answer to this question may be negative or, in a more optimistic fashion, replicability cannot be given for granted. Our results confirm that "value chains are embedded in diverse social, cultural, economic and institutional environments" (Kidoido and Child, 2014, p. 8). We have explored these context-specificity in the process of capital building/erosion (i.e., asset interdependencies). Results suggest that policies and interventions unable to understand and act on such critical context-specific interconnections fall short of achieving the expected results.

4.2. Policy implications

The current thesis has sought to provide indications for the design of effective policies and interventions. First, research is needed to find the way to capture within and across site heterogeneity. The two studies have proposed two conceptual frameworks for assessing within and across site heterogeneity, suitable for context analyses prior to the design of policies and interventions. Indeed, we posit that an in-depth context analysis is a top priority for policies/interventions design. Existing literature and research can provide valuable keys for exploring smallholders' heterogeneous conditions prior to an intervention/policy implementation. However, our findings suggests that unexpected patterns are always "around the corner". In this sense, the choice of methods for analysis is not neutral. A strict reliance on either quantitative or qualitative analysis may narrow the understanding of complex phenomena. Our findings have greatly benefitted from the use of different data sources and analytical methods. On the one hand, the adoption of qualitative data was particularly relevant for understanding unexpected dynamics arising from quantitative analysis. For example, this helped to interpret why farmers more distant from the market tended to exclusively use improved varieties, that is generally a preferred option from households highly market-oriented and closer to the market. Qualitative data collected in-field disclosed that farmers have a certain entrepreneurial attitude, consisting in aggregating the produce, renting a truck, and selling it directly to important national market, thus overcoming distances and local intermediation. On the other hand, the use of mixed methods and data sources allowed us to overcome a strict causal, deterministic approach. Ex-ante theorization was certainly used, but iteration across data and theory was beneficial for exploring an unobservable phenomenon such as heterogeneity. This approach helped to understand patterns behind process of asset building/erosion across sites, a rought proxy of heterogeneity across sites. Based on our findings, the combination of quali-quantitative methods and a sound validation based

on data and methods triangulation can enhance the understanding of the complex phenomena in place. Lastly, an in-depth context analyses upstream to the implementation of an intervention should be prioritized for informing downstream impact evaluations (Kidoido & Child, 2014). More precisely, an in-depth context analysis should be part of each impact evaluation.

Interventions and policies should also account for within and across sites heterogeneity. Understanding rural diversity by means of a comprehensive research-based context analysis is crucial but it is just the first step towards the design of effective policies/interventions. Before the implementation of programmes for agricultural innovations and VC participation, specific interventions targeting more vulnerable households should be put in place. Our findings confirm that, in general, vulnerable households are characterised by low education level and low access to services. Even though interventions should prioritise these common critical conditions and as the definition of value chain readiness has highlighted, other conditions should be considered for interventions pursuing specific objectives. The level of criticality associated to a specific low combination of asset endowment for VC participation may vary across locations. For example, specific household's conditions may be highly critical for interventions on VCD, while this may be less true for other typologies of interventions. Nevertheless, building minimum livelihood conditions generally provides spillover effects which may enhance the effectiveness of differentiated interventions. Spillover effects across interventions are highly desirable and will be better discussed in the following points.

The current thesis suggests that "more endowed households" is a simplistic categorization. Even though this is not an original finding, it lays the ground for disclosing a more complex pattern emerged across the thesis. The second case study claimed the role of assets thresholds for benefitting from VCD interventions[10]. Nevertheless, our findings from the first case study allow to interpret and extend this statement. Over a site/intervention specific critical "basic conditions" threshold, things become more complicated and farmers' behaviour may become more difficult to interpret and less predictable. For example, over this threshold, "more endowed" improved seeds adopters displace or maintain local varieties for pursuing differentiated, valid, strategies. Traditional economic theory states that choices are based on the individual's expectation to enhance his/her utility, which is conventionally measured by profit. Farmers are therefore assumed to be rational profit maximisers (Moxey et al., 1995). If we carry this assumption to the extreme, one would expect a certain degree of homogeneity

[10] E.g., According to Devaux et al. (2018) lower and higher asset thresholds may not benefit for VCD interventions.

in farmers' choices. This is consistent with our findings, but only in relation to more vulnerable households that do not adopt improved varieties. In their case, , namely when finance is a dominant determinant of utility (Edwards-Jones, 2006), traditional economic theory works at its best. Findings suggest that the relative importance of finance may gradually reduce in comparison to other factors for less vulnerable households. Furthermore, utility's determinants are individual specific. The same determinants may generate different levels of utility across individuals, and therefore different choices (Edwards-Jones, 2006). We can cautiously assume that above a certain thresholds of resources endowment, the importance of finance decline and household stand a greater chance to assume risks, opening the way to new, differentiated combinations of determinants from which they derive their "well being". This may explain the pattern of their gradually increasing differentiated behaviours, as well as provide some indications for the design of development interventions.

Since innovation diffusion and VCD processes are intrinsically unpredictable (Devaux et al., 2018), interventions should be more sensitive to farmers' agency, particularly when they are addressed to "more endowed" households. This might mean that besides the well documented importance of adopting participatory methods for understanding real farmers' challenges, needs and aspirations (Wiggins et al., 2021), interventions should be more flexible and more inclusive in determining their objectives. Farmers should be allowed to participate in single components or aspects of an intervention, to alter or to use them differently from what they were designed for. In this sense, key words from innovation literature such as *reconfiguration* or *bricolage*, should be extended to the general lexicon of development interventions. Theoretical and empirical developments of the Livelihood Framework and the increasing inputs from psychology, sociology and ethno-anthropology to farmers' decision-making modelling have highly contributed to understand rural diversity and, partially, to reshape interventions' design. However, for development interventions disclose their potential, a contextual policy change is required. This leads us to further concurrent considerations.

First, the design of participative flexible packages of interventions tailored to real farmers' expectations may be constrained by existing national, regional or international policies. To this regard, the second study has highlighted the importance of the coexistence of formal and informal seed systems to allow farmers to source their preferred varieties. Nevertheless, the dominant international pathway for seed systems is mostly based on legal and policy frameworks favouring seed supply by the private sector, thus relying on the formal seed system (Westengen et al., 2019). This might pose effective challenges to the development of interventions aimed at incentivizing farmers to make deliberate varieties' choice.

Second, we have already stated that interventions should consist of packages, which unfold into a portfolio of flexible alternatives. Policy and measures should, and most of the times are, built using a "policy packaging" approach. A policy package has been defined as "a combination of policy measures designed to address one or more policy objectives, created in order to improve the effectiveness of the individual policy measures, and implemented while minimizing possible unintended effects, and/or facilitating interventions' legitimacy and feasibility in order to increase efficiency" (Givoni et al., 2013, p. 3). In some cases, as emerged from the second study, existing policy packages can be more realistically assimilated to "assemblages of policy measures", only coexisting in time and space (ibid.). One of the reasons can be certainly attributed to the persistent lack of funds for policy implementation. As stressed by MAP members and key informants, policies/measures exist, but there are not fund for their proper implementation and coordination, even when foreseen. In other cases, critical interconnections (such as assets interdependencies) may not have been mapped, thus lacking in strategic packages of measures.

Therefore, the problem of policy harmonization arises. Existing measures have shown two opposite sources of criticality: a certain degree of overlapping, as well as a lack of due interconnection. Policy harmonization is a key word for the development of effective national policies, and, to date, its importance extends to regional level. East African countries are strongly committed to regional harmonization of agricultural policies towards the development of a regional market with the intent to reach a level of fluidity in exchanges based on specialization (Warinda et al., 2020). This includes regional trade, food standards and multiplication and circulation of seeds (ibid.). In this sense, harmonization has a fair number of sceptics on its potential to advance rural development goals. Increasing regional cooperative efforts is now undoubtedly a priority to provide economic resilience in response to COVID-19. For instance, the African Union is promoting the development of public health through the establishment of eight regional institutions, covering all countries on the continent (Blanton et al., 2020). Also, regional and subregional cooperation might play a crucial role to guarantee food security in the area and minimizing the perturbations affecting, in different ways in each country, the economic operations along the VCs (Dupoux et al., 2020). Even though the current thesis recognizes the relevance of regional cooperation and harmonization, we stand by a careful interaction among multilateral regimes, national public governance, and national actors. According to Westengen and colleagues (2019), we posit that in relation to the governance policy for seed system development, national governments should maintain attention on the local dynamics, on the real needs of farmers and local consumers and on the potential market value arising therefrom. Indeed, local

farmers/consumers' interests are subject to the risk to be less represented in comparison to commercial actors advocating for the promotion of more profitable crop varieties. Moreover, uncertain borders closures and national restrictions are now affecting aggregation, distribution and processing along the VCs, both on the input and output sides (Nchanji et al., 2020). More than ever, the role of different local dynamics and markets should be considered and put at the center of country-specific complementary strategies maximising the benefits for food security deriving from the simultaneous development of global, regional, national and local VCs.

Lastly, from the current thesis emerges a consideration on the role of harmonization for the process of technological change and for market access. Traditionally, from an operative perspective, on one side development interventions have concentrated on research towards technological innovations development and farm-level innovation uptake, on the other side on favouring smallholders' market access. Although they may appear different topics, with the formers more related to the upstream level of the VC and the latter to the downstream level, they are not. From a theoretical perspective these two topics have been traditionally framed as deterministically interconnected. This approach rests on the assumption that availability of technological innovations would lead to productivity increase and thus to food insecurity and poverty reduction. However, this vision has been challenged by practitioners and researchers. The current thesis provides an important contribution to this extent. Findings from the two case studies depict a clear picture not merely of innovation and VC interconnection, but clearly also highlight their bi-directional linkage. In this regard, the influence of market in determining innovation adoption decisions has been consistently demonstrated by the first case study. Low market access, both for inputs and outputs, is a practical barrier to the uptake of innovations. Distance from the market might be, or might be not, a constraint to market access. When combined with a sufficient resources' endowment, it can be overcome by a specialization effort based on the exclusive use of improved varieties and on product aggregation. The access to differentiated markets may lead to a diversification strategy based on improved varieties adoption and local varieties maintenance. Conversely, the second case study well emphasizes how the low uptake of innovations affects smallholders' market access. In particular, lack of subsidies for accessing innovative inputs, unreliable providers delivering fake improved seeds, low access to extension and in some cases to cooperatives which could effectively drive innovation uptake, have been unanimously pointed out by interviewed actors and MAP members. Innovation uptake and value chains participation do have synergistic effects, and this should be considered when designing development interventions. Interventions that have tried to integrate innovations and VCD exist, and they are generally based on

scientific research and involvement of farmers through participatory approaches, in combination with VCD strategies (e.g., Stur et al., 2013). However, such approaches may be challenged by the existing heterogeneity within and across locations. In particular, as findings from the second case study have highlighted, farmers' conditions and strategies may differ greatly. They may have different land, tools and machinery, education and skills, be or not part of networks, be or not embedded in a conducive institutional environment providing access to extension and subsidies, and so on. Following the approach adopted for this research, we suggest the use of a holistic approach to combine VCD and innovations. Based on the idea that differences among "more endowed" households and "less endowed" household exist, interventions should consider differentiated strategies. On the one hand, specific interventions should aim at eliminating the existing barriers to market access and innovation uptake for more vulnerable households. A portfolio of differentiated interventions should be alternatively designed for "more endowed" households, answering two main questions. The first is "Which innovation may represent a desirable opportunity for farmers?". For instance, as pointed out by the first case study, farmers' preferences for crop varieties' attributes should be considered when setting breeding priorities. The second is "When innovation represent a desirable opportunity for farmers?". In this sense, market access pathways should be thoroughly considered. Accessing different markets imply responding to different consumers' preferences. This may play a major role in setting farmers' production priorities and, accordingly, innovation adoption decision. This study has demonstrated that besides endemic constraints, farmers are highly flexible in combining opportunities deriving from market access and innovation adoption. Therefore, partial adoption behaviors should not be surprisingly. We are hopeful that the intercepted flexibility and creativity guide future research in rural contexts in East Africa.

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