Positive tipping points for accelerating adoption of regenerative practices in African smallholder farming systems: What drives and sustains adoption?

Authors: Antony Philip Emenyu[1*], Thomas Pienkowski[2], Andrew M. Cunliffe[1], Timothy M. Lenton[1], Tom Powell[1]

[1]Global Systems Institute, Faculty of Environment, Science and Economy, University of Exeter

[2]Centre for Environmental Policy, Faculty of Natural Sciences, Imperial College London

Antony Philip Emenyu: ae474@exeter.ac.uk

Tom Powell: t.powell@exeter.ac.uk

ORCID

Antony Philip Emenyu	https://orcid.org/0009-0009-5568-7325
Thomas Pienkowski	https://orcid.org/0000-0002-3803-7533
Andrew M. Cunliffe	https://orcid.org/0000-0002-8346-4278
Timothy M. Lenton	https://orcid.org/0000-0002-6725-7498
Tom Powell	https://orcid.org/0000-0002-5240-0351

~~1~~

Abstract

Mass adoption of Rregenerative agriculture (RA) practices could improve the resilience and increase productivity of African smallholder farming systems in the face of growing climate change pressures.have been promoted as a critical climate change resilience

strategy and adaptation solution for smallholder farmers in Sub-Saharan Africa. Recent research suggests that positive tipping points in the adoption of such sustainable technologies and practices can be driven by amplifying feedback processes such as social contagion. However, most research on scaling agricultural practices has not focused on the factors and processes with the potential to drive rapid and self-propelling scaling.most RA

programmes struggle with securing and sustaining high adoption rates with many facing dis-adoption.

To address this gap, we combine Lenton et al. (2022)'s framework for operationalisation of positive tipping points with Moore et al. (2015)'s conceptualisation of scaling to understand rapid scaling in a case study in East Africa (The International Small group and Tree planting programme, TIST)We used Lenton et al.'s positive tipping points framework to assess the potential for fast and lasting

adoption of Regenerative Agriculture (RA) in Sub-Saharan Africa.-We present three key insights: (1) To achieve rapid and sustained scaling, it is essential to scale-out (reach more people) while at the same time scaling-up (impacting policy and institutions) and deep (impacting beliefs and norms); (2) these different dimensions of scaling continuously interact, often reinforcing each other and; (3) interactions between and across scaling dimensions are mediated by feedback processes. If amplifying feedbacks are strong enough, scaling could be rapid and self-sustaining. TIST scaling reveals that complementary carbon payments, learning by doing and building social capital are key for sustained, accelerated scaling.

This involved reviewing literature and combining evidence from the successful expansion of the International Small Group and Tree Planting Program (TIST) in East Africa to examine the conditions and feedback processes that drive RA adoption. We found that the key leverage points for TIST wide and rapid adoption were: (1) the cultivation of reinforcing feedback processes that strengthened the social capital around adoption and (2) elimination of barriers to carbon accreditation. Integrating carbon accreditation protocols as standard in design or review of RA interventions could provide an essential leverage to boost adoption rates. Future studies could explore what drives variations in scaling rates and patterns between the sites to inform more site specific interventions.

Keywords: amplifying feedbacks, climate change resilience, smallholder farmers, sub-Saharan Africa, Regenerative agriculture, scaling, agroforestry ~~International Small group and Tree Planting programme (TIST), agroforestry, reinforcing~~

~~feedback, climate change resilience~~

~~1.0~~ Introduction

Agriculture in sub-Saharan Africa is highly vulnerable to climate change effects. The International Fund for Agricultural Development estimates that 70% of the total food supply in the continent is from smallholder farms (IFAD, n.d.). Most of these farms are rainfed, have highly degraded soils and extremely low capital to invest in improving production systems (Nezomba et al., 2017) thus limiting their adaptive capacity. The Intergovernmental Panel on Climate Change Working Group II report states that most smallholder farmers in the global South, including Africa, have already reached their soft limits for human adaptation to climate change(IPCC, 2022). Implying that, while adaptation options still exist, they remain inaccessible to smallholder farmers due to financial, governance, institutional, and policy constraints. Nevertheless, the impacts of climate change continue to worsen across the region. Most climate models agree that, across most parts of sub-Saharan Africa, dry seasons will become longer and hotter while wet seasons will become shorter with more intense rainfall (Ayugi et al., 2021; Dosio et al., 2021; Wainwright et al., 2021), putting already vulnerable smallholder farmers at a higher risk of food and livelihood insecurity. Despite these challenges, there is compelling evidence that the adoption and effective implementation of regenerative agriculture (RA) could enhance the resilience and productivity of smallholder farming systems in the face of growing climate change pressures (Rehberger et al., 2023). For instance, it is estimated that with just 50% adoption of RA, African smallholder farmers could potentially see a 30% reduction in soil erosion, 60% increase in water infiltration rates (reducing run-off and increasing soil water storage), 24% increase in nitrogen content and 20% increase in soil carbon content, which could add approximately $70bn gross value per year to African farmers (IUCN, 2021). Despite these potential benefits, most interventions promoting RA practices struggle to attain and sustain scale. Here, scaling means expanding, adapting, and sustaining successful initiatives in different places and over time to reach a greater number of beneficiaries (Jagadish et al., 2021).

~~Smallholder farms account for close to 80% of all farms in sub-Saharan Africa (OECD-FAO, 2016) and are often characterised by rainfed farming on highly degraded soils, where farmers have limited capital resources to invest in improving their production systems. These characteristics make smallholder farmers highly vulnerable to effects of climate change, placing them at a high risk of food and livelihood insecurity. The Intergovernmental Panel on Climate Change (IPCC) (2022) Working Group II report states that most smallholder farmers in Africa and the global south have already reached their soft limits for human adaptation. Implying that, while certain adaptation options could exist, they remain inaccessible to smallholder farmers due to financial, governance, institutional and policy constraints. At the same time, the impacts of climate change are worsening across Africa. For instance, under the current emissions trajectory, Coupled Model Intercomparison Project Phase 5 estimated that temperatures across Africa would increase by 2.7°C by 2050s while rainy seasons would shorten, accompanied by more intense rain events (Girvetz et al., 2019). Such changes could~~

result in irreversible losses in productivity, and potentially the complete collapse of current agricultural production systems, leading to high food insecurity. The latter risk is amplified by the limited ability of smallholders to adapt.

There is general agreement that rapid adoption of RA practices is essential to cope with growing climate change pressures on the food system (LaSalle & Hepperly, 2008; Rehberger et al., 2023; Strauss & Chhabria, 2022). Definitions of what constitutes RA and how it differs from other good practices in conventional agriculture have been debated (Giller et al., 2021; Newton et al., 2020; Schreefel et al., 2020). However, despite this contention, almost all definitions recognise the importance of soil conservation and a systems approach to defining RA. In this paper, RA is defined as '*farming practices that improve soil, water and overall ecosystem health, increase carbon sequestration, increase biodiversity, maintain or improve farm productivity and improve social and economic wellbeing of the farming community*' (Newton et al., 2020). Examples include minimum tillage, maintaining soil cover, fostering plant biodiversity including agroforestry, and integration of livestock (Giller et al., 2021; Newton et al., 2020). However, for practical purposes, Giller et al.,(2021) suggests that for any given context RA champions need to ask five key questions: (1) What problem is RA meant to solve? (2) What is to be regenerated? (3) What agronomic mechanism will enable or facilitate regeneration? (4) Can the mechanism be integrated into economically and socially viable agronomic practices for the specific context and (5) What political, social, and/or economic forces can drive use of the new practice? Concerning scaling, these questions could relate to Why scale? What to scale? How to scale quickly? Here, we focus on the question of how to scale quickly.

In recent years, regenerative agriculture (RA) has gained traction in policymaking. Both the Sharm El-Sheikh Adaptation Agenda and the Breakthrough Agenda recognising the need for a mass transition to RA by 2030 to strengthen the resilience and adaptability of smallholder farmers to the impacts of climate change (FOLU, 2021; Marrakech Partnership for Global Climate action, 2022). RA here refers to farming practices that improve soil, water and overall ecosystem health, increase carbon sequestration, increase biodiversity, maintain or improve farm productivity and improve social and economic wellbeing (see Newton et al., 2020). Such practices could include conservation agriculture, agroforestry, and permaculture. According to the International Union for Conservation of Nature(IUCN, 2021), with just 50% adoption of RA, African smallholder farmers could potentially see a 30% reduction in soil erosion, up to a 60% increase in water infiltration rates (reducing run-off and increasing soil water storage), a 24% increase in nitrogen content and at least a 20% increase in soil carbon content. This could add approximately $70bn gross value per year to African farmers (IUCN, 2021). However, despite the evidence of the various benefits of RA, programmes promoting RA across the continent have struggled to quickly attain and sustain scale. While several studies look into factors that influence adoption of various RA practices across the continent (see Bouwman et al., 2021; Grabowski et al., 2016; Guteta & Abegaz, 2016), there is still little understanding of what could enable rapid scaling. As a result, most RA programmes, despite managing to secure some early adoption success, fail to reach adoption tipping points, instead stagnating or experiencing dis-adoption (Grabowski et al., 2016; Habanyati et al., 2020; Kehinde & Adeyemo, 2017). Without an understanding of processes driving rapid transition from initial early adoption success to continuously higher and sustained adoption rates, most RA programmes will continue to struggle to attain scale.

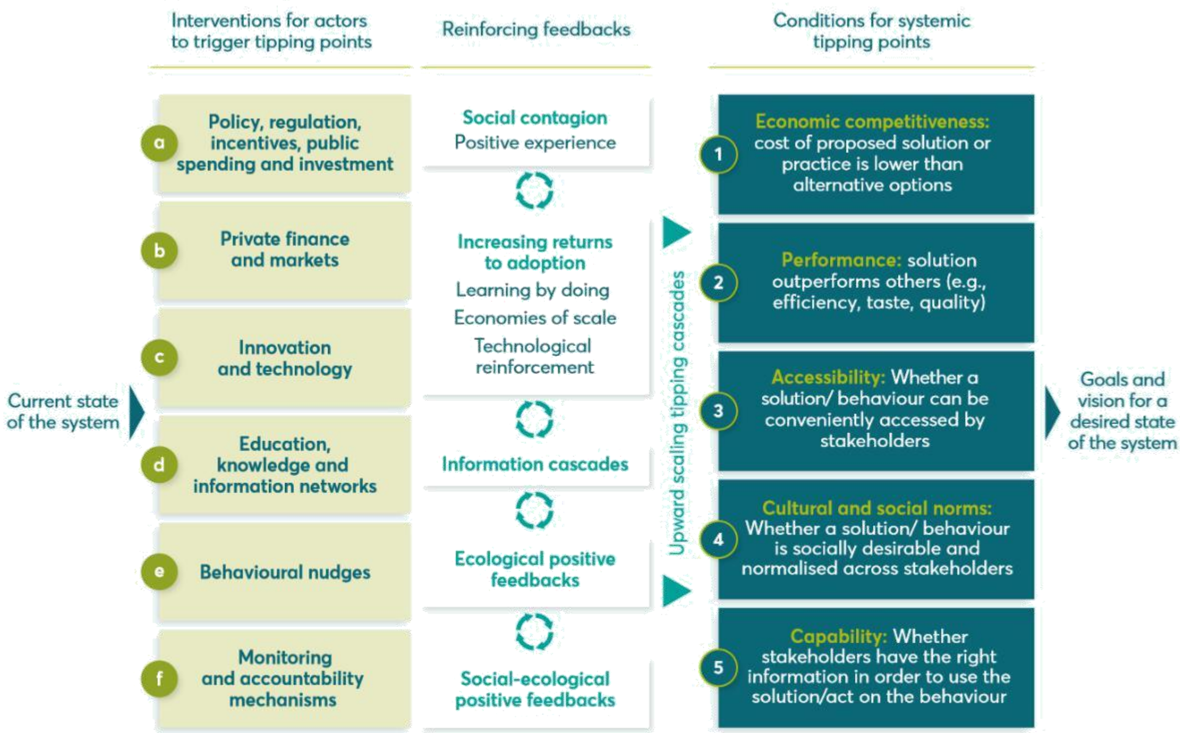
Moore et al., (2022)identify three dimensions of scaling: scaling out, scaling up, and scaling deep. Scaling out involves expanding an initiative to more people, more places or promoting organic spread(Mills et al., 2019). Scaling up entails engaging with higher institutional levels to change the rules, logics, incentives (Moore et al., 2015) or leveraging existing ones to facilitate uptake (Geels, 2002). Finally, scaling deep involves shifting attitudes, norms, knowledge, and values to accelerate adoption (Moore et al., 2015). The magnitude of the challenges facing smallholder farmers in Africa necessitates rapid and exponential scaling out of RA. While most studies on scaling within the agricultural sector identify the importance of a clear vision and suggest strategies (Gillespie et al., 2015; Millar & Connell, 2010; Nicol, 2020), many of the scaling frameworks used do not explicitly explore the factors and processes that might catalyse such desired rapid and exponential growth. A better theoretical understanding of these could help in the design of interventions that leverage positive feedback processes for rapid and non-linear scaling of RA.

Lenton *et al.* (2022) advanced the idea that some actions can trigger or strengthen reinforcing feedback processes that in turn drive rapid adoption of interventions in social-technological-ecological systems. This reasoning was brought together in a conceptual framework for operationalising Positive Tipping Points (PTPf), which identifies typologies of reinforcing feedbacks and enabling conditions that can trigger positive tipping points, and interventions that could accelerate them. A corresponding report (FOLU, 2021) proposed that these dynamics could be occurring for farmers in parts of India but this has not been rigorously assessed in African farming systems.

In this paper, we build an understanding of the enabling conditions and reinforcing feedback processes for accelerated and sustained adoption of RA to help inform efforts to rapidly scale these RA strategies as an urgent response to the climate change pressures on smallholder farming systems. We first review literature on adoption of various RA practices such as conservation agriculture, agroforestry, and climate smart agriculture to identify various enabling conditions that seem to favour or discourage adoption. We then focus on The International Small group and Tree planting programme (TIST) in East Africa as a case study to illustrate how the various enabling conditions and reinforcing feedback processes function in a practical context. Finally, we explore what lessons could be drawn from the scaling of TIST to develop an understanding of potential leverages to trigger accelerated adoption of RA in Africa. In the next section we provide a brief RA focused introduction of the PTPf. After this we introduce how TIST applies various aspects of this framework and finally discuss what lessons can be drawn from the data on TIST to inform other programmes seeking to adopt this approach.

Here, we draw on the framework for operationalisation of positive tipping points proposed by Lenton et al., (2022) to explore enablers and processes that could accelerate scaling. It proposes that under certain enabling conditions, some actions can trigger or strengthen amplifying feedback processes that drive rapid adoption of new technologies or behaviours in social-technological systems (Lenton et al., 2022). If the amplifying feedback processes are strong enough, adoption could be rapid and self-propelling as the system reaches a tipping point. In this paper we combine theories of scaling and positive tipping points to explore the adoption of RA in sub-Saharan Africa. Specifically, we examine Moore et al.'s three dimensions of scaling to identify the potential role of feedbacks between the spread of adoption between individuals, changes in governance and institutions, and changes in culture, values, and behavioural norms. We draw on literature from various regenerative farming interventions across Africa, using The International Small group and Tree planting programme (TIST) in East Africa as a case study.

~~The PTPf identifies various enabling conditions, reinforcing feedback processes and possible interventions that could ignite system level transitions towards a positive tipping point (see Figure 1). See Ong et al.(2023) for an illustration of how some of these tipping points dynamics could operate in real world systems such as a packaging system.~~



~~*Figure 1: Framework for operationalising positive tipping points adopted from the Food and Land Use Coalition (FOLU) report on accelerating the 10 critical transitions (FOLU, 2021, p. 7).*~~

Conceptual Framing

A social tipping point is reached when a critical mass of adopters triggers the mass adoption of a new idea, technology or innovation leading to social system transformation(Lenton et al., 2022). In the case of adoption of RA practices, expansion to new sites, recruiting more program participants, and promoting organic spread (scaling out) accompanied with complementary changes in policies, institutions (scaling up), and cultural norms and beliefs (scaling deep) could provide the necessary leverage for achieving such a tipping point. The different dimensions of scaling interact through feedback processes, often complementing each other and amplifying the resultant changes in scale (Figure 1). For instance, policies that create synergies between behavioural and technological changes could lead to virtuous political feedback loops (Fesenfeld et al., 2022), which in turn influence social norms and potentially adoption of certain ideas and interventions.

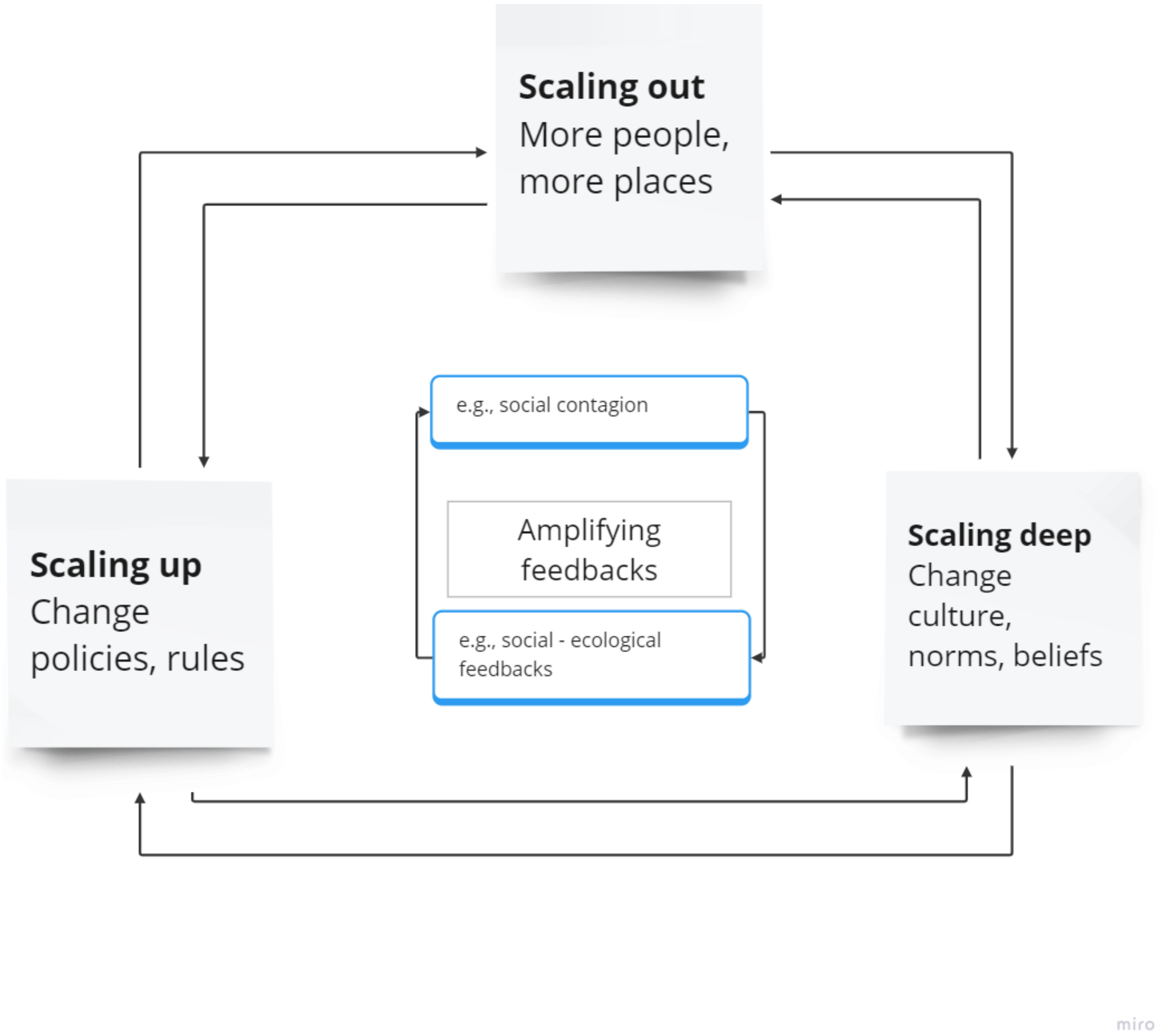


Figure 1: The interaction between the different dimensions of scaling driven by amplifying feedback processes. The amplifying feedback processes act within and across multiple spatial scales (from local, national to international) and influencing changes to the scaling within and across those levels in the process.

Several feedback processes could be involved at any time and identifying these processes is key in positively influencing scaling. These feedback processes could include social contagion; information cascades; increasing returns to adoption; learning by doing; social-ecological effects; and network effects(Lenton et al., 2022). Insights into these interactions could help to identify the most effective actions to accelerate adoption in a particular context. Just like the dimensions of scaling, these feedback processes are not mutually exclusive and act across multiple spatial scales. For instance, the adoption of agroforestry at the community level causes landscape-level social-ecological impacts (Buxton et al., 2021) driven by social-ecological amplifying feedback processes. The scaling dimensions and feedback processes often compliment, antagonise, or even balance one another and affect the impact of any given intervention. The same scaling interventions could have varying effects across scaling levels. For instance, while agricultural subsidies could increase real household incomes at small scale, once scaled up for the same group, the average welfare effects could drop (Bergguist et al., 2023). At small scales, the land-rich experience larger income gains from subsidies at the expense of the land-poor. However, at scale, input prices might decrease for input-intensive crops while the cost of labour increases, hence, increasing income benefits to the land poor over the land rich.

Activation of these feedback processes requires certain enabling conditions to be in place. Some of these conditions relate to the innovation itself and can be partly addressed at the design stage, such as price and quality. Others such as complementarity and performance, desirability and symbolism, accessibility and convenience, information and social networks depend on how the innovation fits within the environment it is to be implemented (Lenton et al., 2022). These conditions are highly dynamic, continuously adjusting in response to the actions taken and the feedback processes triggered, modifying the intervention environment. To keep up with these dynamics, implementors have to be highly proactive and adaptive in their response.

Enabling conditions and feedback processes for successful adoption of RA in Africa

~~2.0 Enabling conditions for successful adoption of RA in Africa~~

Innovation adoption is a complex process with multiple possible outcomes; adoption (continued use of an innovation) (Ainembabazi & Mugisha, 2014; Amadu et al., 2020), partial adoption (using part of the innovation) (Zulu-Mbata et al., 2016), adoption intensity (using more or less of the innovation)(Kunzekweguta et al., 2017; Mujeyi et al., 2022), non-adoption (not using the innovation) (Khoza et al., 2019), dis-adoption (stopping use of the innovation) (Alpizar et al., 2022; Grabowski et al., 2016), and adaptation (editing the innovation) (Bouwman et al., 2021). Here, an innovation is any intervention new to a given location or context. It could be a product (e.g., a new plant variety), a practice (e.g., cover cropping, governance approach) or knowledge (e.g., a planting technique). The individual attributes of an innovation (e.g., price, quality) as well as how well it integrates with existing systems (e.g., complementarity, accessibility, symbolism, performance) would affect its scalability and readiness to scale. Here adoption is used to mean the same as scaling out.

~~Adoption is a complex process with multiple possible outcomes; adoption (continued application of the practice) (Ainembabazi & Mugisha, 2014; Amadu et al., 2020), partial adoption (applying part of the practice) (Zulu-Mbata et al., 2016), changes in adoption intensity (applying more or less of the practice) (Kunzekweguta et al., 2017; Mujeyi et al., 2022), non-adoption (not applying the practice) (Khoza et al., 2019), dis-adoption (stopping application of the practice) (Alpizar et al., 2022; Grabowski et al., 2016), and adaptation (editing the practice) (Bouwman et al., 2021). Several key factors increase the likelihood of successful adoption: the intervention has to be economically competitive, culturally and socially appropriate, easily accessible and outperform other alternatives on the criteria most relevant to the potential adopter, among other factors(Rogers, 2003). RA practices with these features are more likely to be adopted by farmers, and thus benefit them. Conversely, RA features are less likely to be adopted or may be dis-adopted later on.~~

Cost, performance, and capability: The cost of an innovation is often evaluated in terms of a farmer's available resources (can I afford it?) either in terms of capital or labour, how it fits with existing systems (does it complement what I have?), or perceptions of performance (can it make things better?). For instance, for a farmer who already has oxen, buying an ox plough could be cheaper than hiring a tractor. However, the converse may be true for a farmer without oxen. Perceptions of performance may motivate initial investment, however actual performance drives future investments. To fully experience the benefits of an innovation, farmers need to have the capability to effectively use the innovation. In most cases farmers must meet the innovation's effective implementation requirements (i.e., the requirements to maximize the benefits of an innovation), such as labour (Habanyati et al., 2020), time (Bouwman et al., 2021), and land requirements (Kurgat et al., 2020) to fully experience the benefits. Therefore, interventions that increase the affordability of an innovation, the capability of farmers and optimize performance would most likely increase the scalability of the innovation.

The interaction between cost and performance could trigger certain amplifying feedbacks and lead to virtuous rapid scaling cycles. For instance, if the cost of implementation decreases while the performance increases, increasing returns could be achieved (Takeshima, 2017). Increasing returns could also result from farmers changing their enterprise mix (Li et al., 2023), specialisation (Takeshima, 2017) or mechanisation (Takeshima, 2017). As farmers learn through practice, they get more efficient and potentially obtain higher benefits from the intervention. These benefits from increasing returns or learning by doing could trigger mass sequential adoption through social contagion as farmers learn from, listen to, observe and mimic successful peers in their social networks (Centola, 2021). At programme level, learning by doing could lead to reduced barriers to entry and better intervention benefits, thus, increasing the likelihood of successful scaling.

Economic competitiveness and performance: In smallholder systems where households depend entirely on their farms for their livelihood, purchasing input to the farm could come at the expense of household subsistence. Thus, the economic competitiveness of an intervention is highly intertwined with its likelihood of being adopted. Economic competitiveness here could relate to the cost of applying the practice relative to the farmers capability to meet those costs (Grabowski et al., 2016; Razafimahatratra et al., 2021) or the opportunity cost of transition. The capacity to meet these costs is linked to performance in terms of yield, ability of the RA practice to reduce crop losses from erratic rain (Grabowski et al., 2016) or pest and diseases (Simtowe & Mausch, 2019) or any parameter most useful to the targeted farmer. It is worth noting that the ability to convert farm outputs (yield) into cash to meet the costs is affected by external forces like access to markets, the various market forces and supporting infrastructure and systems. By addressing the cost factors, optimization of performance of the intervention and diversifying the range of marketable products for instance inclusion of the sale of captured carbon alongside other products (Benjamin et al., 2018), it is possible

~~to improve the financial outcome of farmers. To obtain the saleable farm products described above hence experience the performance of the RA intervention, the farmer has to be able to meet the RA practice requirements such as labour demands (Habanyati et al., 2020), time (Bouwman et al., 2021), and land (Kurgat et al., 2020). Therefore, a farmers' own resource limitations (Grabowski et al., 2016) and/or their ability to work around these limitations could be a major limiting factor. Therefore, interventions that could help bridge such resource gaps for instance improving access to credit could improve performance.~~

~~While mechanisms like persuasion, regulation and incentives have often been used to bridge the adoption gap for most interventions (Ajayi et al., 2008), positive perception of a RA practice plays a big role in driving continued adoption. Rogers famously argues in his book 'Diffusion of innovations' that perceptions come from observing and talking to neighbours who have adopted the intervention(Rogers, 2003). It is thus important to increasing duration of exposure particularly for interventions whose benefits could take a long time to get fully realised (Alpizar et al., 2022) while providing technical support (Habanyati et al., 2020) to address any issues that may emerge during the exposure period. However, it is important to manage expectations or otherwise risk potential dis-adoption if the practice does not deliver what it promised (Chinseu et al., 2019). Multi-disciplinary participatory research and project development processes that integrate farmer knowledge and experiences could play a big role in matching expectations to the local context and equipping farmers with the tools and information to effectively apply the RA practice in-order to derive the promised benefits (Entz et al., 2022; Noordin et al., 2001).~~

Desirability and symbolism: Cultural beliefs, norms and traditions shape what is acceptable within a given society. Changing social norms and beliefs (scaling deep) often precede and could drive political (scaling up) and technological changes and if the amplifying feedbacks are strong, this cycle of changes could potentially tip social behaviour. In the RA adoption space, such norms could relate to: livelihood strategies for a given group (Agundez et al., 2022); gender roles and associated resource access rights (Kehinde & Adeyemo, 2017; Khoza et al., 2019); and social-cultural beliefs (myths about certain practices) (Agundez et al., 2022; Assogbadjo et al., 2012). For instance, in northern Malawi, Bambara groundnuts (*Vigna subterranean*) had been promoted for its high nutritious value, drought tolerance and soil-enhancing qualities. However, certain groups culturally associated this plant with death thus limiting its cultivation, distribution, and marketing (Forsythe et al., 2015). Resistance to the adoption of potentially beneficial interventions could, in principle, be mitigated through educational campaigns through communities of practice (Page & Dilling, 2019). However, there can be important ethical considerations around changing beliefs and practices in ways that could change the identity of a people.

Social norms and behaviour can be moulded and shaped through actions of third-party entities such as the government, intergovernmental and non-government organisations, academics, and faith-based organisations, who may have competing motivations (Fehr & Fischbacher, 2004; Halevy & Halali, 2015). It is therefore crucial that communities, whose cultural beliefs, norms, and traditions are impacted, are provided with adequate information about interventions, enabling them to independently assess their options and make informed choices. In the smallholder setting, this often involves intensive and consistent agricultural extension, characterised by active farmer participation, practical demonstrations of RA practices benefits, and working with common interest groups (Reed, 2007). Groups particularly provide a space for consultation between peers and leverage the power of social influence towards adoption of group norms (Alexander et al., 2022). In practice, agricultural extension services and community groups are often affiliated to certain entities whose viewpoints and norms they champion. Utilising existing extension and community structure therefore risks playing into preexisting power dynamics and potentially contributing to processes with unintended and often undesirable outcomes.

~~**Cultural and social appropriateness:** Cultural beliefs, norms and traditions shape what is acceptable and what is not within a given society. In relation to RA adoption, this could relate to; livelihood strategies for a given group (Agundez et al., 2022)(Agundez et al., 2022), gender roles and associated resource access rights (Kehinde & Adeyemo, 2017; Khoza et al., 2019; Kunzekweguta et al., 2017; Ngaiwi et al., 2023)(Kehinde & Adeyemo, 2017; Khoza et al., 2019; Kunzekweguta et al., 2017; Ngaiwi et al., 2023) and the social-cultural beliefs (myths about certain practices) (Agundez et al., 2022; Assogbadjo et al., 2012).(Agundez et al., 2022; Assogbadjo et al., 2012). For instance, in areas of Zimbabwe, pearl millet (*Pennisetum glaucum*) has been promoted as a drought-tolerant alternative to maize following maize crop failure due to droughts; however, some cultures believe that growing pearl millet would anger ancestral spirits (Mambondiyani, 2020).(Mambondiyani, 2020). In Northern Malawi, Bambara groundnuts (*Vigna subterranean*) has been promoted for its high nutritious value, drought tolerance and soil-enhancing qualities; however, certain groups associate it with death, which has greatly limited its adoption, distribution and marketing (Forsythe et al., 2015)(Forsythe et al., 2015). Many of these beliefs associated with particular crops and their uses have a gender element as well. For instance, while men and youth could support with some agronomic activities in Bambara groundnut production, it is taboo for them to touch the seed. To improve the tolerance and acceptability of useful interventions like Bambara groundnuts that could be considered alien in certain cultural contexts, Moore et al. (2015) suggests intensive education campaigns and extensive sharing knowledge and new practices through communities of practice, a process they describe as scaling deep.~~

~~As Moore et al. (2022?) suggests, society norms can be moulded and shaped through actions of third-party entities such as government, intergovernmental and non-government organisations, academia, faith-based organisations often with competing goals. In the smallholder farming space, one dimension of competition relevant here is between an approach focused on extending the 'green revolution in Africa' versus 'scaling RA'. While proponents for each of the possible pathways could justify their individual investment choices, it is important for the communities whose cultural beliefs, norms and traditions are at stake to be provided with sufficient information and supported in making an independent evaluation of their alternatives. In the smallholder setting, this often involves intensive and consistent agricultural extension, characterised by active farmer participation, practical~~

~~demonstration of the RA practice benefits and working with common interest groups. Groups particularly provide a space for consultation between peers and leverage the power of social influence towards adoption of group norms (Alexander et al., 2022). In practice, agricultural extension services and community groups are often affiliated to certain entities whose viewpoints and norms they champion. Therefore, if one seeks to use existing extension and community structures, it is worth doing some due diligence on the norms, beliefs and traditions of the organisations overseeing these structures as well as the individuals implementing them.~~

Accessibility/Convenience: ~~**Accessibility**~~ For a product or process to be considered accessible, it must be available, farmers must be able to reach the point of supply with ease, and they need to have the rights to use it. Availability refers to the physical presence, for instance, of land (Kehinde & Adeyemo, 2017; Razafimahatratra et al., 2021), water for irrigation (Maindi et al., 2020) and essential inputs (Murindangabo et al., 2021) in case of most RA interventions. However, just because a resource is available does not guarantee accessibility due to infrastructural barriers or issues associated with resource use rights. For example, distance from markets/point of supply (Abdulai et al., 2021; Kifle et al., 2022; Kunzekweguta et al., 2017; Mujeyi et al., 2022), inadequate road infrastructure (Maindi et al., 2020; Wafula et al., 2016), and ownership of transport assets to reduce the relative distance (Mujeyi et al., 2022), land tenure (Murindangabo et al., 2021; Owombo & Idumah, 2017; Teklu et al., 2023) and rights to protect and own trees in agroforestry schemes (Kouassi et al., 2021) could limit access, and capability of potential user and thus adoption.

Addressing the various dimensions of accessibility could improve farmer interaction, increase their likelihood of experiencing innovation benefits and potentially adoption. On the other hand, by taking steps to address these challenges, it is likely that certain amplifying feedback processes could be triggered resulting to virtuous scaling cycles. For instance, addressing the issues of rights could involve both addressing certain social norms linked to gender roles (scaling deep) and reviewing policies around land rights (scaling-up). On the other hand, infrastructural investments such as road networks and markets often come after policy changes (scaling up). The latter could lower the cost of investment creating opportunities for increasing returns and potentially network effects. Network effects occur when the benefits offered by a product or service increases with the number of users (Tucker, 2018).

~~could relate to the intervention itself in case of a product (for example improved seed, seedlings) or essential inputs in case of a process (for instance, agroforestry, conservation agriculture). For a product, or process to be considered accessible, it must be available, farmers have to be able to physically reach the point of supply with ease, and they need to have the rights to use it. Availability refers to the physical presence of the intended product. In relation to adoption of RA, availability of land (Kehinde & Adeyemo, 2017; Razafimahatratra et al., 2021), water for irrigation (Maindi et al., 2020) and essential inputs (Murindangabo et al., 2021) stand out as key determinants. Physical access on the other hand relates to infrastructural barriers to reaching the point of supply for example poor road infrastructure (Maindi et al., 2020; Wafula et al., 2016), an isolated geographic location (Abebaw~~

& Haile, 2013), physical proximity to markets (Abdulai et al., 2021; Kifle et al., 2022; Kunzekweguta et al., 2017; Mujeyi et al., 2022), and ownership of transport assets (Mujeyi et al., 2022). Rights to use relate to exclusion of certain groups. The most common example in smallholder context relates to land tenure (Murindangabo et al., 2021; Owombo & Idumah, 2017; Teklu et al., 2023) and rights to protect and own trees in agroforestry schemes (Kouassi et al., 2021).

A key aspect in moderating accessibility is information of what is needed, why, where to get it, how to get it, and so on. It is thus important to ensure that the farmer has access to or know where and how to access all the essential information associated with the intervention. Awazi et al. (2022) found access to information, along with access to land and household income as key determinants for choice of agroforestry system (between no agroforestry, agrosilvipastoral system, silvipastoral system and agrosilvicultural system) as a climate change adaptation mechanism. The level of access, perception and trust of any particular information source could vary from group to group thus to effectively communicate, one has to understand the most favoured sources of information for any particular group (Djido et al., 2021; Muriith et al., 2021).

Addressing the different dimensions of accessibility calls for often higher-level interventions spanning from infrastructural projects to policy and market-based interventions. Physical access challenges call for investments on infrastructure such as roads to improve connectivity and link rural areas to markets. It also calls for establishment of markets and associated infrastructure closer to the rural sites. On the other hand, market-based incentives designed to boost supply of these essential inputs could play an important role in improving and sustaining supply of such essential inputs. Though not a panacea, enacting appropriate policies to address issues of rights, extensive education, and enforcement of contracts and agreements could be a possible pathway to addressing issues of rights to access. While the appropriate solution could vary with the context and nature of the problem, it is likely that any solution will involve reaching out to different actors at multiple levels of the social-technological-ecological system. For instance, through enhancement of smallholder groundnut seed, the Southern Groundnut Platform contributed to 11% increase in area under groundnut cultivation in Southern Tanzania and resulted in 15% increase in groundnut production between 2012 and 2018 (Akpo et al., 2021). Akpo *et al.* (2021) reports various other cases of multi-stakeholder platforms

~~247 improving smallholder seed access in Ghana, Mali, Nigeria, Burkina Faso, Ethiopia, and India.~~

Information/social networks: While mechanisms like persuasion, regulation and incentives have often been used to bridge the adoption gap for most interventions (Ajayi et al., 2008), positive perception of performance of a RA practice plays a key role in driving both the initial engagement with and continued use of an innovation. Exposure to the innovation forms an essential part in enabling the potential adopters to understand the innovation, its performance and their own capability to effectively use it. For interventions whose benefits could take long to be realised, increasing duration of exposure (Alpizar et al., 2022) while providing technical support (Habanyati et al., 2020) is an essential step. However, it is important to manage expectations or else risk potential dis-adoption if the innovation does not deliver as expected (Chinseu et al., 2019). Access to complete information is crucial in shaping potential adopters' experiences with an innovation, thereby influencing its likelihood of adoption or non-adoption.

The impact of all the enabling conditions discussed above is information dependent. Therefore, the type of information, how to present it, to whom, when, how often, and where are all key questions when creating conditions for successful adoption. The level of access, perception and trust of any particular information source could vary from group to group. Thus, to effectively communicate, one must understand the most favoured sources of information for any particular group (Djido et al., 2021; Muriith et al., 2021). In the smallholder context, while multi-media sources such as radios, short-term message services on mobile phones and newsletters could be useful (Oladele et al., 2019), extension service and informal farmer networks particularly play key roles in information flow (Brown et al., 2017; Djokoto et al., 2016; Habanyati et al., 2020). Extension here does not limit itself to public extension services (for examples agricultural officers, forestry officers) but also includes private and NGO farmer support services. Beyond facilitating information flow, extension approaches that prioritise farmer participation and practical demonstration of the RA practice benefits are likely to be more effective in improving farmer perception and adoption (Reed, 2007).

When it comes to farmer networks, farmers are more likely to choose who to consult based on homophily (people similar to themselves, e.g., religion, tribe), kinship and/or physical proximity (Giroux et al., 2023). Therefore, to strengthen and leverage the social capital in farmer networks, it makes sense to work with groups of people near each other. For highly complex behaviours like adoption of a new innovation, the strong social networks cultivated in a group environment can play a powerful role in propelling behavioural contagion(Centola, 2021). Groups also provide secondary services that could improve the ability of individual group members to address resource limitations that could affect adoption such as providing access to affordable credit.

Most of the amplifying feedback processes linked to scaling leverage the power of information and social networks. For instance, network effects rely on the benefits of being part of a large network (Tucker, 2018), social contagions is driven by farmers getting information from, observing and imitating influential members of their social networks (Herrando & Constantinides, 2021; Randall et al., 2015). For information cascades, agents are most likely to act on information from trusted contacts and then only evaluate these reactions later (Tokita et al., 2021). Some of these feedback processes could result in the reconfiguration of social network structure, impacting the scaling processes that are reliant on these social network structures. For instance, in the event of undesirable outcomes, agents would likely change their trusted contacts to avoid going through a similar experience in the future (Tokita et al., 2021). Therefore, it is worth ensuring that expectations are managed, the information shared is authentic and multiple points of the network are targeted to minimise chances of information loss in case of a network reconfigurations.

Learning is an essential step in the adoption process and in its absence, the capability of the user could be greatly diminished and along with it the benefits drawn from an innovation. While information cascades can be highly effective in recruiting large numbers of participants in a short time, there is a risk that social learning could be blocked as agents conform too quickly not allowing time to aggregate information and update personal beliefs (Bikhchandani et al., 2021). It is therefore essential to create a balance between having rapid scaling and ensuring that individuals learn enough to explore and experience the benefit of an innovation.

Capability: Capability could be applied to the farmers themselves or to the RA practice being promoted. When applied to the farmer, capability implies one's ability to effectively apply the RA practice. Andersson and D'Souza (2014) observed that one of the key limitations to farmers trying out and adopting conservation farming is the added cost in equipment like the ripper, cost of labour to gather and apply mulch or control weeds in absence of herbicide. Under these circumstances, access to affordable credit could provide a viable pathway to improving the capability of smallholders to apply conservation agriculture practices hence increasing their chances to experience its benefits and adoption (Kehinde & Adeyemo, 2017; Mujeyi et al., 2022). When it comes the accessing credit from formal financial institutions, one of the main challenges for smallholders is the limited access to resources that could serve as security for the credit (Nkonki-Mandleni et al., 2022). Other than influencing access to credit, access to resources such as land and security of tenure could directly improve or reduce the capability of the farmer to engage in certain practices. Capability could also relate to perceived usefulness of the RA intervention, which as Mugandani & Mafongoya (2019) and Oduniyi & Tekana (2019) observed had a greater influence on adoption than awareness.

When it comes to capability and all the other enabling conditions discussed above, information is key. In the smallholder context, while multi-media sources such as radios, short term message services on mobile phones and newsletters could be useful (Oladele et al., 2019), extension service and informal farmer networks particularly play key roles in information flow (Brown et al., 2017; Djokoto et al., 2016; Habanyati et al., 2020). Extension here does not limit itself to public extension services (for examples agricultural officers, forestry officers) but also includes private, and NGO farmer support services. Beyond facilitating information flow, improvement of perception is favoured by adopting extension approaches that prioritise farmer participation (Entz et al., 2022) and practical demonstration of the RA practice benefits (Habanyati et al., 2020). When it comes to farmer networks, farmers are more likely to choose who to consult based on homophily (people similar to themselves, e.g., religion, tribe), kinship and/or physical proximity (Giroux et al., 2023). Therefore, strengthen the social capital in farmer networks, it makes sense to work with groups. Apart from creating rich information networks and generating peer pressure towards adoption of what the group considers preferable, groups also provide secondary services that could improve the capability of individual group members. For instance, cooperatives are formed primarily to support members with among other services, provision of improved inputs and loans. In-fact, Abebaw & Haile (2013) found that cooperative members were more likely to possess oxen, have leadership experience and have off-farm work compared to non-members.

3.0 Reinforcing feedback processes in adoption of RA

Throughout the various phases during which potential adopters interact with a particular RA practice, the various aspects of economic competitiveness, accessibility, cultural appropriateness, performance, and capability interact, influencing the system transition (see Figure 2 below).

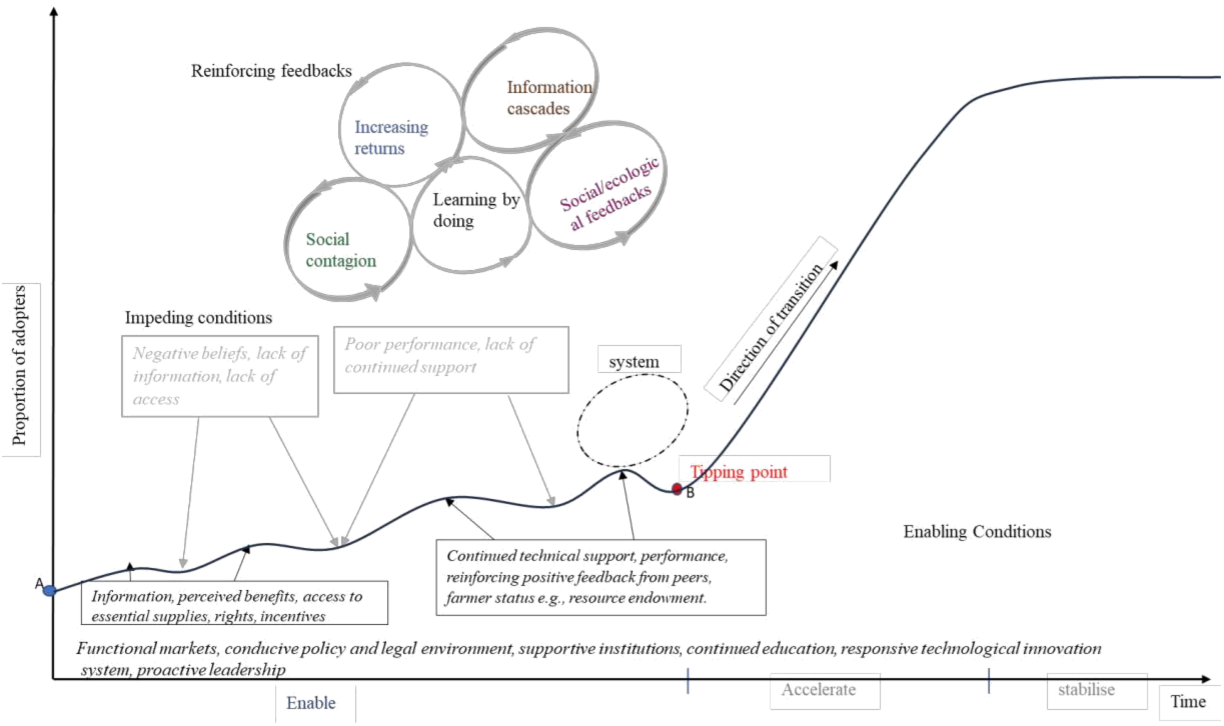


Figure 2: System transition diagram adapted from Fesenfeld et al. (2022) to show the enabling conditions that are influential at various stages of a farming system transition towards a tipping point. Across the entire transition process, functional markets, conducive policy, and legal environment (e.g., tenure security) coupled with supportive institutions, complementary infrastructure (e.g., roads), continued education to address cultural biases, a responsive technological innovation system (e.g., in terms of capability, functionality and cultural appropriateness) and proactive leadership play a major role.

In the Enable Phase from when the RA practice is first introduced (point A, Figure 2) to when there is a tipping point of accelerating mass adoption (point B, Figure 2), different factors (enabling conditions) gain importance for different people at different points in time. At the initial stages of introduction, access to information about the practice, perceived benefits of the practice, access to essential supplies and key resources play a key role driving potential adopters to try-out the practice. At the later stages, as people continue interacting with the practice, the performance of the practice, access to continued technical support and feedback from peers gain greater importance in sustaining continued use. As more people use the practice, and demonstrate evidence for its performance, they either attract or discourage others from engaging with the practice, new markets emerge for the products and/or inputs for the practice. At the tipping point (point B, Figure 2), a large enough proportion of the population has adopted the practice such that the rate of adoption becomes self-sustaining and creates further exponential growth in the target population (Lenton et al., 2022; Rogers, 2003). While the factors discussed above independently and in combination enhance the chances of successful adoption at individual and household levels, certain factors independently or in combination could trigger self-propelling, reinforcing feedback processes that could either accelerate or dampen the rate at which the whole community embraces the practice as the norm (scaling out).

Moore *et al.* (2015) describe three possible pathways to scaling of any development intervention; scaling out, scaling deep and scaling up. Scaling out involves impacting greater numbers of people, scaling deep impacting the cultural roots, while scaling up deals with impacting policies and laws. Scaling can occur at an institutional level but is not confined there. Beyond institutional boundaries, processes like scaling deep could influence the culture of an entire community while the influence of

~~policy and laws in scaling up could extend to other institutional levels including national and International.~~

A case study of The International Small group and Tree planting programme (TIST) in East Africa.

~~**4.0 A case study of The International Small group and Tree planting programme (TIST) in East Africa.**~~

TIST is an agroforestry payment for ecosystem service (PES) programme that is currently running in Kenya, Uganda, Tanzania, and India (Benjamin et al., 2018). The programme also promotes reforestation, conservation farming, entrepreneurship and operates in small groups of 6-12 farmers within walking distance of each other(Reid & Swiderska, 2008). Since its launch in 1999, TIST has reached over 216,812 farming households in 33,911 small groups, maintained over 25 million trees, and offset over 7 million tonnes of carbon (https://programme.tist.org, *accessed on 20/07/2024*). In East Africa, Kenya (15,529 groups) has the highest number of groups enrolled followed by Uganda (5,976 groups) (Figure 2).

~~TIST is an agroforestry payment for ecosystem service (PES) programme that also promotes conservation farming (Benjamin et al., 2018). The programme is running in Kenya, Uganda, Tanzania, and India and over the years, it has reached over 176,000 farming households in 26,996 small groups, maintained over 22 million trees, and offset over 7 million tonnes of carbon (https://programme.tist.org). In East Africa, Kenya (15,529 Groups) has the highest number of groups enrolled followed by Uganda (5,976 groups) (see Figure 3).~~

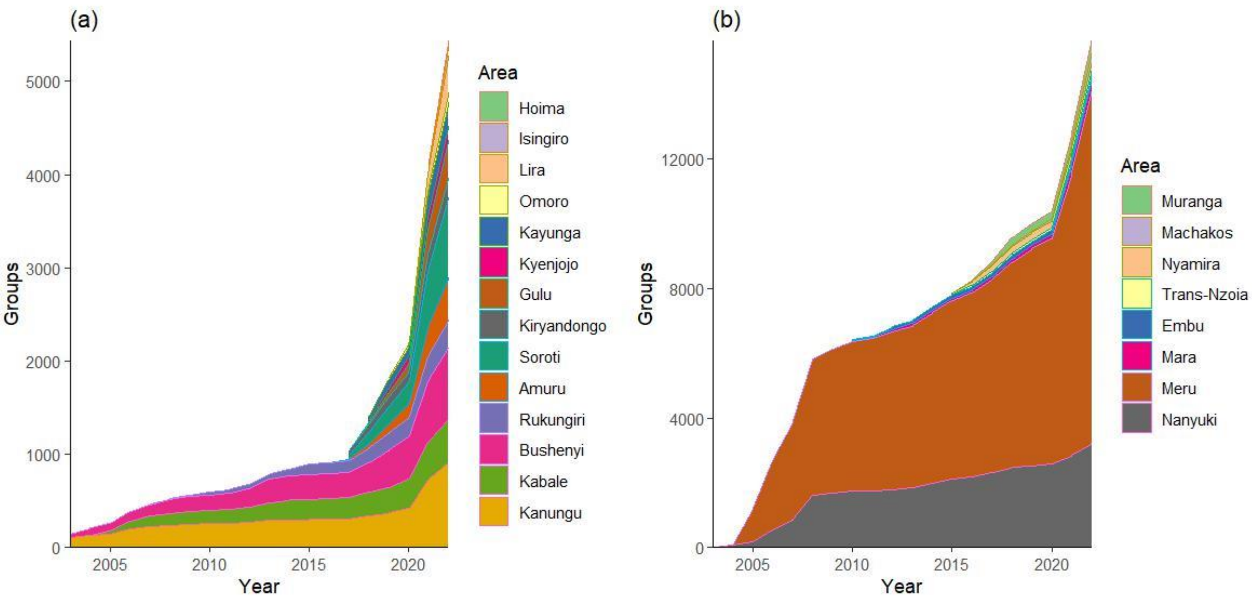


Figure 2: Enrolment of TIST participants in Uganda (a) and Kenya (b) between 2003 and 2022. Enrolment varies between countries and sites within each country thus highlighting the context specificity of scaling processes.

~~*Figure 3: Enrolment of TIST participant in Uganda (a) and Kenya (b) between 2003 and 2022. The expansion of the programme takes on a different pattern in each of the countries implying that different factors are perhaps involved.*~~

Figure 2 above shows variation in enrolment across different sites thus highlighting the contextual nature of scaling and hinting on the need to address each scaling challenge on a case-by-case basis. In Kenya, participant enrolment rates in the Meru and Nanyuki project areas overshadow all the other sites in the country and shape the national enrolment picture while in Uganda, the programme expanded to several new project areas after 2015, with some (Soroti, Gulu, Amuru, and Lira) achieving high rates of enrolment comparable to the older sites. For instance, of the five sites with the highest number of groups in Uganda, three sites are less than seven years old as of 2024, and among these Soroti has the second-highest enrolment rate of all the sites in the country.

~~In Kenya, participant enrolment rates in Meru and Nanyuki overshadow all the other sites in the country and shape the national enrolment picture while in Uganda, the programme expanded to several new areas after 2015, with afew (Soroti, Gulu, Amuru and Lira) achieving relatively high rates of enrolment since introduction of the programme. For instance, of the five sites with the highest number of groups in Uganda, three sites are less than six years old and among these Soroti has the second highest enrolment rate of all the sites in the country.~~

Scaling of TIST

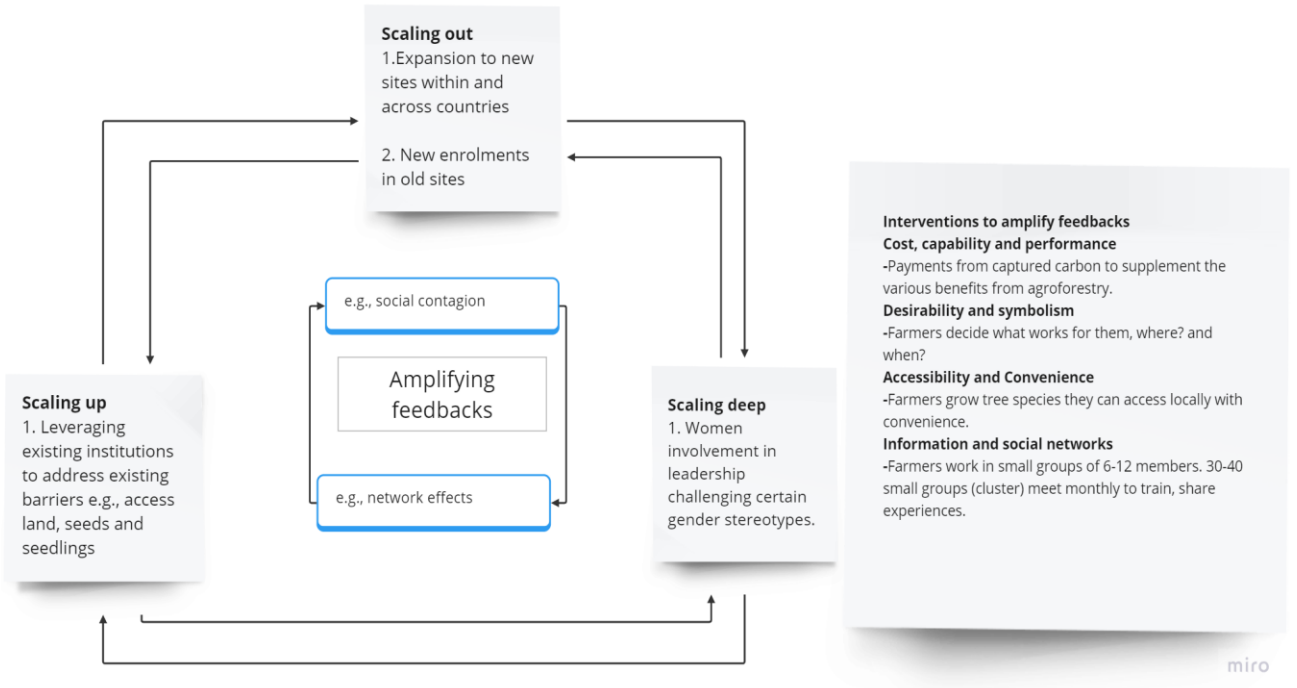


Figure 3: The different forms in which TIST scales up, deep and out. The various interventions activate and contribute to the amplification of certain feedback processes that drive the various forms of scaling and the interaction between them.

~~**5.0 Scaling of TIST**~~

~~TIST demonstrates all three forms of scaling, scaling out, up and deep (see Table 1).~~

~~**6.0 Table 1: Evidence for the different forms of scaling by TIST**~~

~~**Scaling type**~~	~~**Evidence for scaling and possible triggers in TIST**~~

Scaling out (mass adoption of TIST practices)	• The number of participants enrolling into TIST in both Uganda and Kenya have continuously increased since initial introduction with 10 out of 18 sites in Uganda enrolling after 2015 (See Figure 3).
Scaling up (TIST adopting good lessons as organisation policy)	• Good practices at group level are shared with other groups in cluster meetings and published in monthly newsletter across all the groups in the country. Through this process, good practices in different locations get integrated across the different project levels and informing programme policy revisions. Through these processes, TIST continuously adapts and changes its policy to deepen and extend its impact. • TIST rigorously documents and communicates its impact. Through by doing this, it is influencing changes in design and governance of agroforestry interventions in the region with a number of programmes Kilimanjaro project, itereka and others opting to adapt the TIST model in their implementation as part of the TIST DIY group.
Scaling deep (Impacting norms)	• TIST takes deliberate action to ensure that women farmers are represented in groups, constituting at least 40% of group membership composition (Masiga et al., 2012). With group leadership appointed on rotational basis and alternating by gender, women are assured an opportunity to lead the group and access the same trainings and information. The same pattern of alternating leadership occurs at all levels of the programme structure. Through these mechanisms, TIST facilitates gender balance in contexts where such privileges were lacking (Benjamin et al., 2018). • TIST conducts routine group trainings on various aspects ranging from financial services, appropriate farming practices and other group relevant aspects to complement the routine extension services provided by the cluster servants. Some of these trainings trigger responses that drive further adoption of the desired practices. For instance, TIST farmers that kept proper records were observed to have more favourable credit compared to those that did not. Proper record keeping was associated to the routine training's farmers received (Benjamin et al., 2018) . • Outreach to children of TIST group members who will likely inherit the farms and trees as an opportunity to improve programme stability and sustainability (Masiga et al., 2012).

Enabling conditions and amplifying feedback processes in the scaling of TIST.

299 7.0 How is TIST meeting the enabling conditions for enrolment in its sites.

Cost, capability and performance: While the promise of supplemental income from captured carbon is a key incentive for initial enrolment in the program, the additional diverse benefits and the low cost of participation gives participants multiple reasons to join and stay involved with the program. By design, TIST prioritises maximisation of the benefits from participation in the programme while increasing the capability of the farmers to engage with the program through minimisation of involvement costs. On the benefits side, the programme supports its participants to access payments for the carbon captured by their trees to supplement the other benefits the trees already provide or may provide in the future. Such benefits include soil improvement, erosion control, wind breaks, firewood, fruits from fruit trees, fencing material, timber, medicine, bee habitats, natural insecticides, and fodder (Reid & Swiderska, 2008). The programme also offers secondary benefits to participants such as better access to credit (Benjamin et al., 2016), improved social capital, gender equity (Benjamin et al., 2018) and various livelihood diversification opportunities. On the cost side, farmers in the program are encouraged to establish their own tree nurseries at group levels and grow locally available tree species. This localisation of supply and flexibility of choice aims to improve affordability and the contextual appropriateness of seedlings. Secondly, TIST does not restrict participation based on land size or location. Therefore, interested farmers do not have to incur any extra costs to access land in order to participate. This cost reduction, while increasing the benefits, also increases the returns to participation potentially igniting social contagion as farmers observe and imitate successful peers, network effects as the increase in the number of adopters results into stronger social support systems and a build-up of social-ecological feedbacks leading to greater social-ecological impacts (See Figure 4).

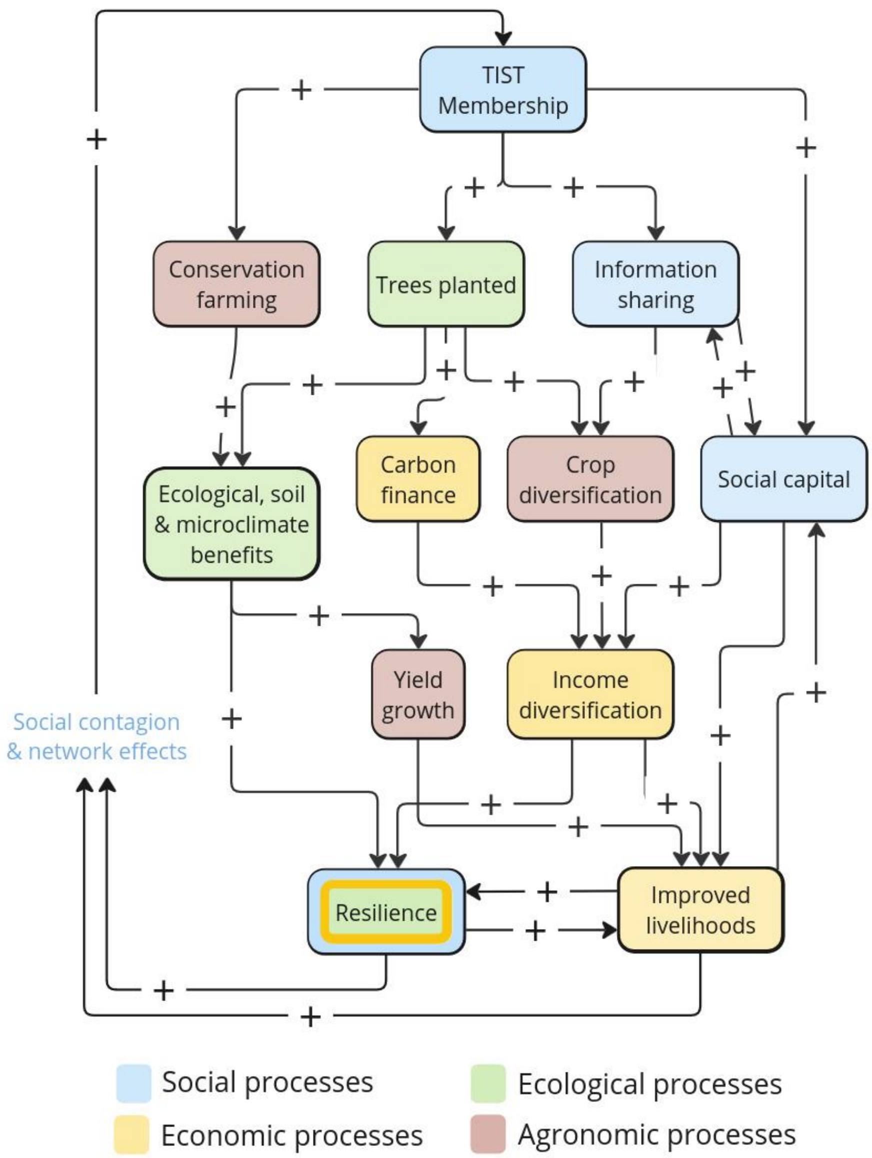


Figure 4: Amplifying feedback processes driving adoption of TIST at community level. Conservation agriculture and agroforestry improve the soil ecological functioning hence contributing to improved and more stable yields, while the various tree products along with carbon finance contribute to income diversification. Through working in groups, there is better information sharing which in-turn builds and reinforces the social capital. All the various contribute to improved resilience as well as drive social contagion in TIST.

Economic competitiveness and performance: By design, TIST prioritises the minimisation of input costs while at the same time maximising the benefits from participation in the programme. Being an agroforestry programme, tree seedlings are an essential input. In the programme, farmers choose which tree to plant and are encouraged to establish tree nurseries at group level. The localisation of supply and flexibility of choice potentially improves affordability of seedlings.

TIST further supports its members to access payments for the carbon captured by their trees. These payments are a supplement to the other benefits farmers already get from planting the same tree species if they were not in the programme such as soil improvement, erosion prevention, wind breaks, firewood, fruits from fruit trees, fencing material, timber, medicine, bee habitats, natural insecticides (Reid & Swiderska, 2008). Benjamin *et al.* (2018) found that women who participated in the TIST programme were more likely to get a higher profit margin from their agroforestry activities than those who did not.

Beyond the benefits from agroforestry, participants in TIST also have access to other benefits from participations like better access to credit(Benjamin et al., 2016), improved social capital, improved gender equality(Benjamin et al., 2018), livelihood diversification as groups engage in alternative activities like art and crafts. These various benefits improve the overall performance of the program and its impact to the lives of those involved.

Desirability and symbolism: Since TIST is farmer-centred and farmer-led, the farmers' own beliefs, norms and value system are integrated within program participation decisions like what tree species to plant, where, and how to plant. With farmers driving decisions, they are also able to drive appropriate local policy changes from the grassroots. To aid this, TIST employs 'cluster servants' to provide extension services, supporting farmers in making such context-relevant changes without compromising program operational principles. The cluster servants are appointed from the community of farmers and so are familiar with both the local context and the programme's operational dynamics. In the absence of external support, farmers often promote their innovations among peers (Reed, 2007). Under TIST, various groups in the same cluster (30-40 small groups) meet monthly, thus creating a platform for peer-to-peer innovation promotion. These monthly cluster meetings also strengthen the social support networks that play a key part in dealing with the more nuanced and personal adoption challenges.

Accessibility and convenience: Enrolment in the TIST programme is open to all interested smallholders within the different project areas. Participation is not restricted by farm size (Benjamin & Blum, 2015) implying that even farmers with access to very small pieces of land are capable of participating. Groups source their seed and seedlings. For instance, groups are encouraged to establish and manage the nurseries but could also obtain seeds through other preferred local sources. This ensures that farmers only grow species they can obtain locally and with convenience. TIST cluster servants are recruited from the local community where they remain and work. Most are group members within the same communities where they operate. This ensures that the much-needed extension support is easily and conveniently accessible by the beneficiary community. TIST offers farmers contracts of 10-30 years along with regular training and extension support in financial management, tree management, and other relevant skills (Masiga et al., 2012). For these reasons, smallholders in TIST were less likely to be credit-constrained and those that kept records enjoyed more favourable formal credit conditions (Benjamin et al., 2016). These various factors minimise the barriers to entry into the program, increasing the potential value in the benefits from participation and making the program highly scalable.

Accessibility: Enrolment into the TIST programme is open to all interested smallholders. Participation was not restricted by farm size (Benjamin & Blum, 2015) implying that even those with very small farms could enrol hence increasing accessibility to the programme. Groups establish and manage their own nurseries which makes seedlings easily accessible by the farmers.

TIST offers farmers contracts of 10-30 years along with regular trainings and extension support in financial management, tree management and other relevant skills (Masiga et al., 2012). For these reasons, smallholders in TIST were less likely to be credit constrained and those that kept records enjoyed more favourable formal credit conditions (Benjamin et al., 2016).

Cultural appropriateness: TIST empowers the farmers to make decisions on what is most appropriate to their contexts for instance. By leaving decisions like what trees to plant, where to plant them and what group to join to the farmers, the programme ensures that the programme interventions are appropriate to the farmers context.

TIST farmers are organised in small groups of 6-12 members and 40-50 groups within walking distance of each other aggregate into a cluster supported by a cluster servant (Masiga et al., 2012). Farmers in a cluster meet at regular intervals to share good practices, trade experience and share profits from carbon trade. This localised coordination and knowledge sharing structures creates space for cultivation of context specific but organisation relevant knowledge, customs, and experience.

Information and social networks: Perception of performance is dependent on what is known about the impact of the program. To introduce new entrants to the program impacts, TIST adopts a ‘come and see’ approach where representatives from a potential project area are invited to visit and directly engage with actual beneficiaries from older sites. For example, TIST started in western Uganda with representatives of the south Rwenzori Diocese visiting active farmers in Tanzania and experiencing the impact of the project there, then returning and initiating it in their region. This approach creates an opportunity for potential participants to witness the benefits, learn, gauge their capability to participate, and build networks for support during implementation.

TIST also adopts a highly participatory approach in its activities with farmers. For instance, farmers are involved in the monitoring, verification, and reporting of the trees' carbon content along with quantifiers (Benjamin et al., 2018). Individual farmer experiences are often shared during the cluster meetings, which are always open to other community members who might be interested in the program. Since the members of the cluster are often from the same geographical area and the same or closely related communities, the experiences shared are relatable and shared by people already known to the community. Through the group structure and these regular meetings, newly enrolled participants get to engage with participants who have been in the programme longer. This creates more opportunities for validation of knowledge and farmer-to-farmer support during the adoption process.

The interesting experiences from the different cluster meetings held across the country are captured and compiled into monthly newsletters, which are freely distributed by cluster servants to the different stakeholders in their areas of operation. The newsletters are also accessible to the public on the TIST website (www.tist.org), creating an opportunity for other non-program participants in the reported areas to learns about the program activities, successes and opportunities to get involved. The program also maintains an open policy to research, actively seeking collaborations with researchers and providing access to essential program datasets, which has enabled higher-level impact evaluations.

Through the various processes described above, TIST creates diverse opportunities for learning by doing, laying the foundation for social contagion as participants have access to numerous opportunities to observe impacts and peers to learn from and imitate. The social-ecological amplifying feedback processes potentially lead to landscape impacts such as increased greening of the landscape in Kenya (Buxton et al., 2021) along with the demonstrated social impacts such as economic empowerment (Benjamin et al., 2018) have increased the value of carbon credits sold by TIST thus commanding some of the highest prices for forest-based initiatives in the market, currently USD $46 per tonne (https://program.tist.org/buy-carbon-credits, *accessed on 26/7/2024*). TIST has also received various recognitions and awards attesting to its contribution, drawing in more collaborators and partners consequently increasing the value of being a member of its network and potentially leading to network effects.

Capability: TIST does not offer restrictions to various aspects of participation like where to plant trees hence- increasing the likelihood that many farmers would be capable of participating in the programme.

TIST trains cluster servants in tree quantification and involves smallholder farmers in the quantification process hence building their capacity not only understand the processes but also explain it to others. Hence, empowering them (farmers) not only to access the voluntary carbon markets(Lenton et al., 2022) but also to support other farmers in the process.

Through the group structure and regular meetings at both the group and cluster level, newly enrolled participants get to engage with participants who have been in the programme longer. This creates more opportunities for the farmers to support each other through the adoption process.

8.0 Reinforcing feedback processes driving adoption of TIST

Different reinforcing feedback processes are often involved in driving adoption of any given RA practice. For the case of TIST the processes driving adoption at household and community level could be summarised into social processes, economic processes, ecological processes, and agronomic processes as illustrated in the Figure 4 below. The processes often interact at multiple levels, contributing to yield, income and eventually improved resilience and livelihoods.

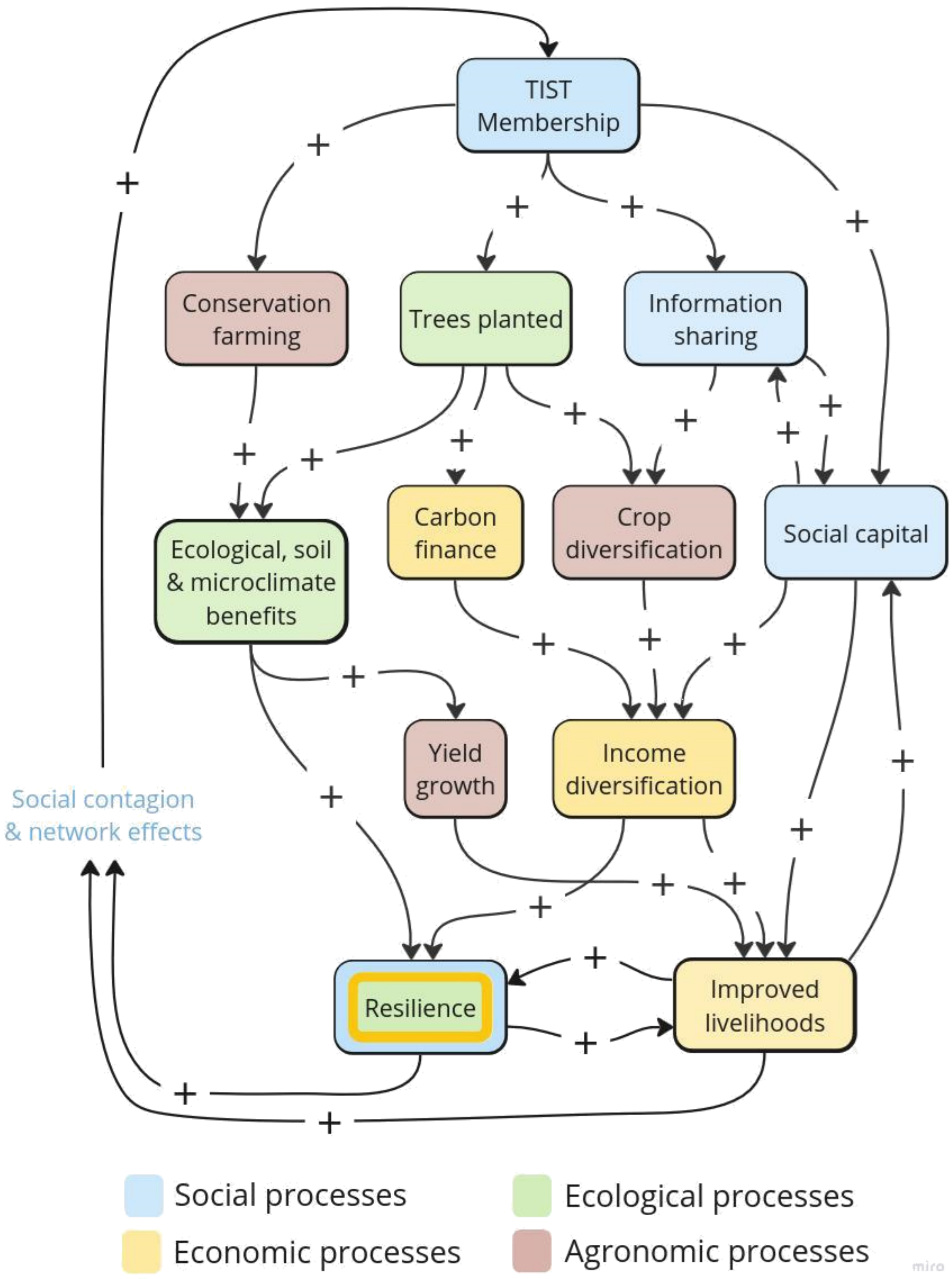


Figure 4:Reinforcing feedback processes driving adoption of TIST at community level. Conservation agriculture and agroforestry improve the soil ecological functioning hence contributing to improved and more stable yields, while the various tree products along with carbon finance contribute to income diversification. Through working in groups, there is better information sharing which in turn builds and reinforces the social capital. All the various contribute to improved resilience as well as drive social contagion in TIST.

In some cases, the results of adoption are not always positive, requiring careful analysis of the trade-offs involved. For instance, Masiga et al. (2012) describes the complex trade-off TIST farmers in Meru, Kenya have to make in deciding whether to plant eucalyptus (Figure 5). In this case, while the Green Belt Movement in Kenya discouraged planting of eucalyptus because it could damage the soils on which they were planted, the Kenya Forest Service promoted eucalyptus for its fast growth to meet demand for timber and utility poles. Furthermore, Kenyan Power had been vocal about their need for poles. While the demand for timber and poles could drive more people to plant eucalyptus, its negative effect on the soil could discourage its adoption.

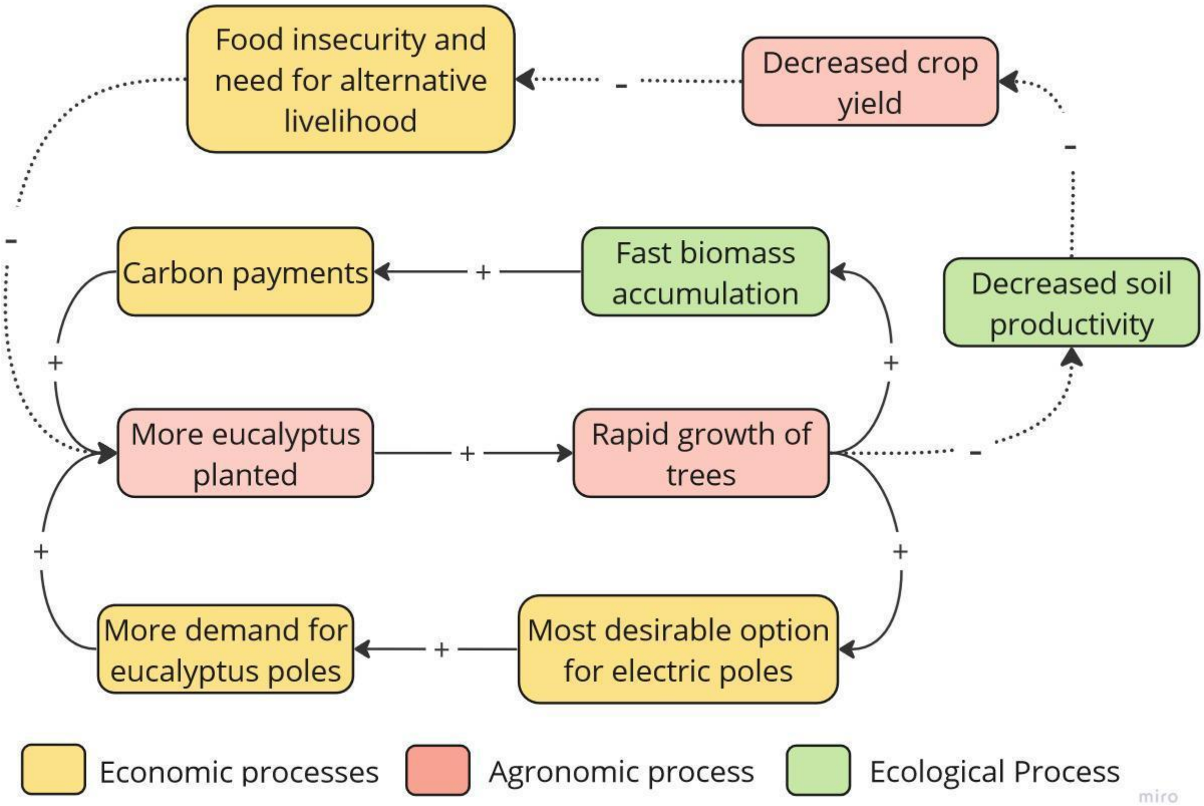


Figure 5: Reinforcing feedback loops influencing adoption of eucalyptus in Meru, Kenya.

Apart from reinforcing feedback process that could lead to opposite outcomes like the example above, some effects are more subtle but equally impactful on adoption. For instance, it has long been established that gaining information about an initiative precedes adoption (Rogers, 1963). However, if everyone knew about a practice yet no one has adopted, "*it appears that* the practice has been deliberately and publicly rejected by everyone" (Centola, 2021, p. 19) hence discouraging other potential adopters. Various other combinations of factors and actions could lead to different reinforcing feedback processes with effects that might not be fully predictable. As promoters of certain interventions, it is worth reflecting on the possible unintended reinforcing feedback processes triggered by one's actions and taking deliberate steps to strike balance between the factors involved to increase the chances of achieving the intended system level transition. For instance, to manage the effect of eucalyptus and its popularity, alongside education about the potential negative effects of planting eucalyptus, water conserving species such as *Bridelia* and *Sysygium spp* were promoted in riparian areas through training and additional payments for ecosystem services per indigenous tree planted within 100 metres of the waterway (Masiga et al., 2012).

While most of our discussion and examples have focused on RA adoption among members of the same population, well managed reinforcing feedback processes could lead to chain reactions that drive adoption in populations that are geographically dispersed and also across different levels (see figure 6). For instance, the positive testimonies from TIST beneficiaries, studies illustrating its positive impact (see Benjamin et al., 2018; Buxton et al., 2021) and commentaries about its unique approach to sustainable agro-forestry has made TIST a unique and interesting case both for research and among development practitioners with various projects like iTeraka in Madagascar, the Kilimanjaro Project in Tanzania and MyTreesTrust in Zimbabwe adapting different aspects of the TIST mechanism in their individually unique operations.

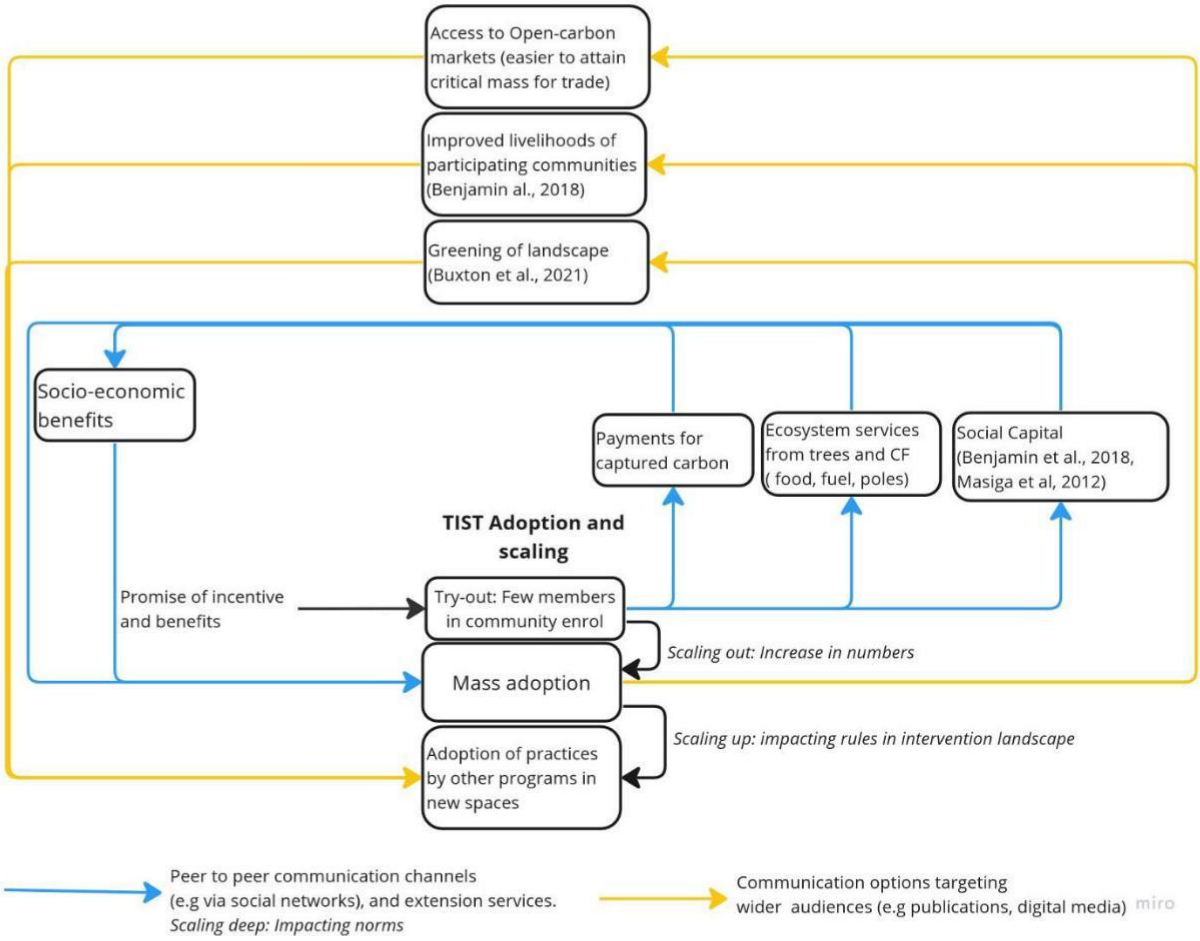


Figure 6: Reinforcing feedback processes driving multi-level adoption of TIST. Adoption progresses through levels with communication the transition from one level to another.

Moving from a few individuals trying out the RA practice to a tipping point for mass adoption relies on a series of multiple peer-to-peer interactions and action and the change occurs at the same level (community of peers). Success at this level draws attention of stakeholders at different levels or in different thematic spaces to which the programme lessons could apply, but only if they are communicated through channels familiar to the independent stakeholder groups. If an interested stakeholder decides to implement the programme in a new site, then the cycle repeats itself, with new participants potentially trying out the practice. However, the success in the previous site does not automatically predict success in a new site, but rather demonstrates the potential if the necessary enabling conditions can be met or created in the new site.

Conclusion

RA practices have been lauded as a potential solution to the growing food insecurity and declining smallholder farmer resilience to the growing climate change pressure, and their rapid and mass adoption an essential step to addressing some of the key climate change targets (IUCN, 2021; Marrakech Partnership, 2022). However, except for a few programs like TIST, most interventions promoting these practices struggle to attain the desired levels and rates of adoption. In this paper, by combining ‘the positive tipping points and Moore et al.’s scaling dimensions’ we propose a conceptual framework for rapid and mass scaling, apply it in the evaluation of TIST scaling success, and draw three key lessons;

(1) To achieve rapid and sustained scaling and potentially a positive tipping point in the adoption of RA, it is essential to scale out (reach more people) while at the same time scaling up (impacting policy and institutions) and deep (impacting beliefs and norms). One of the ways TIST achieves this is by empowering smallholder farmers to lead not only in the mobilisation and recruitment of peers through group formation but also in the decisions around what tree species to plant, where? and how? Through this process, the choices made are not only contextually relevant, but the smallholders can also influence local policies and norms to complement their adoption choices.

(2) These different dimensions of scaling (scaling out, up, and deep) continuously interact, often reinforcing each other. For instance, as more farmers in a particular location enrol into the program, they attain a critical mass to trigger changes in local policy, beliefs, and norms. Such changes could in turn trigger further adoption.

(3) Feedback processes mediate interactions between and across scaling dimensions. For instance, when a TIST group receives carbon payments, other groups, and community members are encouraged to enrol, triggering greater complementary changes in policy, norms, and beliefs. As members learn and gain experience in implementing the various program practices, they can reap even greater benefits from participation. By leveraging the social network and social capital cultivated through working in groups, new members are supported to achieve similar benefits including carbon payments. All these events amplify feedback processes for further scaling. If such feedbacks are strong, scaling can be rapid and self-perpetuating.

Although the reasoning behind the proposed conceptual framework provides a compelling structure for systematically thinking about and addressing the rapid scaling challenge for RA in sub-Saharan Africa, in its present form it lacks strong empirical backing and its practical utilisation will depend on the availability of highly context-specific data associated with the relevant variables and parameters (enabling conditions, amplifying feedbacks, and scaling goals). While monitoring and evaluation processes in existing programs could be an important resource in bridging the essential data gaps, it would be worth re-orienting the monitoring targets to meet the data needs for accelerating scaling. Secondly, most resource-limited grassroot organisation may not have the capacity to invest in robust data collection yet they are best placed to initiate certain grass root actions. For such organisation, relevant regional-level or country data sets could provide a starting point for narrowing down relevant actions and processes. Hence, as a next step, future research could investigate creating such data sets.

403 **9.0 What does the TIST scaling pattern tell us about accelerating RA adoption?**

Most RA practices by their nature offer opportunity to benefit from payments for various environmental services with such payments potentially reducing the opportunity cost for their adoption. The successful adoption of TIST is largely attributed to the programme's ability to break the institutional barriers for farmers to access such payments, allowing them to supplement the numerous livelihood diversification options and co-benefits offered by agroforestry and CA. In TIST, Farmers are involved in the monitoring, verification and reporting of the trees carbon content along with quantifiers in collaboration with international TIST staff (Benjamin et al., 2018). Small groups receive 70% of all the profits from the carbon captured and sold. These profits are shared among group members in proportion to number of trees each member planted (Masiga et al., 2012).

The growth of TIST largely leverages social capital cultivated and nurtured through participant active involvement in the programme processes, continued capacity building and working in small groups with members within walking distance of each other. TIST operates in groups of 6-12 members with each group required to plant at least 5000 trees over five years depending on availability of land in order to qualify for payments (Masiga et al., 2012). The social network created by the group structure facilitates information sharing and support systems that drive adoption (Benjamin et al., 2018) while the fact that the whole group has a shared tree planting quota, enables distribution of risks and permits even for farmers with limited access to land to join the programme (Benjamin & Blum, 2015) .

10.0Conclusion

Several studies look into factors that could affect the adoption of various RA farming practices across sub-Saharan Africa, however, little is still known about what could enable rapid scaling. In this Paper, we draw on the lessons from the rapid scaling of TIST in East Africa to understand what processes could be leveraged to rapidly scale other RA interventions in the Global South. We observe that the successful scaling of TIST could be attributed to: (1) cultivation of social capital through group structure which enables sharing of risk, facilitates information flow and grows a community of practice; (2) minimising barriers to farmers directly accessing payments for the carbon captured by their trees alongside the multiple benefits of agroforestry that they already access. While the subject of social capital has been relatively well explored in literature, carbon trading is relatively new with many potential opportunities; such as a catalyst to accelerate adoption of RA practices. A key lesson other NGOs and programmes can draw from TIST, it is worth thinking about carbon accreditation processes during RA programme design, the review of ongoing projects and that smallholder farmers can be an integral part with agency in these processes.

While the data on enrolment of TIST clearly reveals evidence of scaling, it also provokes important questions on factors and processes responsible for (a) the difference in rates of scaling and (b) variations in scaling patterns between seemingly similar sites? Finding answers to these questions could provide insights strategies to address site specific barriers to accelerated adoption. This could be a potential next step for future research.

Open Access Statement

 Data and code used for figure 2 can be accessed in the following link https://zenodo.org/doi/10.5281/zenodo.13128843

Competing Interests

The contact author has declared that none of the authors has any competing interests.

~~Acknowledgement~~Acknowledgment

This paper is part of the Oppenheimer Programme in African Landscape Systems (OPALS) jointly funded by Oppenheimer Generations Research and Conservation, Sarah Turvill and University of Exeter. The authors thank TIST for providing access to their participant enrolment data that was used in this paper.

References

Abdulai, A. N., Abdul-Rahaman, A., & Issahaku, G. (2021). Adoption and diffusion of conservation agriculture technology in Zambia: The role of social and institutional networks. *Environmental Economics and Policy Studies*, *23*, 761–780.

Agundez, D., Lawali, S., Mahamane, A., Alia, R., & Solino, M. (2022). Development of agroforestry food resources in Niger: Are farmers preferences context specific? *World Development*, *157*(105951), 1–12.

Ainembabazi, J. H., & Mugisha, J. (2014). The Role of Farming Experience on the Adoption of Agricultural Technologies: Evidence from smallholder Farmers in Uganda. *Journal of Development Studies*, *50*(5), 666–679. https://doi.org/10.1080/00220388.2013.874556

Ajayi, O. C., Akinnifesi, F. K., Sileshi, G., Chekeredza, S., & Mgomba, S. (2008). Payment for Environmental Services (PES): A Mechanism for Promoting Sustainable Agroforestry Land Use Practices among Smallholder Farmers in Southern Africa. *Conference on International Research on Food Security, Natural Resource Management and Rural Development*, 1–8.

Alexander, M., Forastiere, L., Gupta, S., & Christakis, N. A. (2022). Algorithms for seeding social networks can enhance the adoption of a public health intervention in urban India. *PNAS*, *119*(30), 1–7.

Alpizar, F., Del Carpio, M. B., Ferraro, P. J., & Meiselman, B. S. (2022). *Exposure-enhanced goods and technology disadoption*. 36–37.

Amadu, F. O., McNamara, P. E., & Miller, D. C. (2020). Understanding the adoption of Climate-Smart agriculture: A farm-level typology with empirical evidence from southern Malawi. *World Development*, *125*(104692), 1–22.

Assogbadjo, A. E., Glele Kakai, R., Djagoun, C. A. M. S., Codjia, J. T. C., & Sinsin, B. (2012). Biodiversity and socioeconomic factors supporting farmers choice of wild edible trees in the agroforestry systems of Benin (West Africa). *Forest Policy and Economics*, *14*, 41–49. https://doi.org/doi:10.1016/j.forpol.2011.07.013

Ayugi, B., Dike, V., Ngoma, H., Babaousmail, H., Mumo, R., & Ongoma, V. (2021). Future Changes in Precipitation Extremes over East Africa Based on CMIP6 Models. *Water*, *13*(2358), 1–19.

Benjamin, E. O., & Blum, M. (2015). Participation of Smallholders in agroforestry Agri-environmental scheme: A lesson from the rural mount Kenyan Region. *The Journal of Developing Areas*, *49*(4), 127–143.

Benjamin, E. O., Blum, M., & Punt, M. (2016). The impact of extension and ecosystem services on smallholder's credit constraint. *The Journal of Developing Areas*, *50*(1), 333–350. https://doi.org/10.1353/jda.2016.0020

Benjamin, E. O., Ola, O., & Buchenrieder, G. (2018). Does an agroforestry scheme with payment for ecosystem services (PES) economically empower women in sub-saharan Africa? *Ecosystem Services*, *31*, 1–11.

Bergguist, L. F., Faber, B., Fally, T., Hoelzlein, M., Miguel, E., & Rodriguez-Clare, A. (2023, January 18). *Scaling up agricultural policy interventions: Evidence from Uganda*. CEPR. https://cepr.org/voxeu/columns/scaling-agricultural-policy-interventions-evidence-uganda

Bikhchandani, S., Hirshleifer, D., Tamuz, O., & Welch, I. (2021). Information cascades and social learning. *NATIONAL BUREAU OF ECONOMIC RESEARCH*, 1–109.

Bouwman, T. I., Andersson, J. A., & Giller, K. E. (2021). Adapting yet not adopting? Conservation agriculture in Central Malawi. *Agriculture, Ecosystems & Environment*, *307*(107224), 1–14.

Brown, B., Nuberg, I., & Llewellyn, R. (2017). Negative evaluation of conservation agriculture: Perspectives from African smallholder farmers. *International Journal of Agricultural Sustainability*, *15*(4), 467–481. https://doi.org/10.1080/14735903.2017.1336051

Buxton, J., Powell, T., Ambler, J., Boulton, C., Nicholson, A., Arthur, R., Lees, K., Williams, H., & Lenton, M. T. (2021). Community-driven tree planting greens the neighboring landscape. *Scientific Reports*, *11*(18239), 1–9.

Centola, D. (2021). Influencers, Backfire Effects and the Power of the Periphery. In *Personal Networks* (pp. 1–28). Cambridge University Press.

Chinseu, E., Dougill, A., & Stringer, L. (2019). Why do smallholder farmers dis-adopt conservation agriculture? Insights from Malawi. *Land Degradation & Development*, *30*(Special Issue article), 533–543. https://doi.org/10.1002/ldr.3190

Djido, A., Zougmore, R. B., Houessionon, P., Ouedraogo, M., Ouedraogo, I., & Diouf, N. S. (2021). To what extent do weather and climate information services drive the adoption of climate smart agriculture practices in Ghana. *Climate Risk Management*, *32*(100309), 1–14.

Djokoto, J. G., Owusu, V., & Awunyo-Vitor, D. (2016). Adoption of organic agriculture: Evidence from coca farming in Ghana. *Cogent Food and Agriculture*, *2*(1, 1242181), 1–16. https://doi.org/10.1080/23311932.2016.1242181

Dosio, A., Jury, M. W., Almazroui, M., Ashfaq, M., Diallo, I., Engelbrecht, F. A., Klutse, N. A. B., Lennard, C., Pinto, I., Sylla, M. B., & Tamoffo, A. T. (2021). Projected future daily characteristics of African precipitation based on global (CMIP5, CMIP6) and regional (CORDEX, CORDEX-CORE) climate models. *Climate Dynamics*, 1–24.

Fehr, E., & Fischbacher, U. (2004). Third-party punishment and social norms. *Evolution and Human Behaviour*, *25*(2), 63–87.

Fesenfeld, L. P., Schmid, N., Finger, R., Mathys, A., & Schmidt, T. S. (2022). The politics of enabling tipping points for sustainable development. *One Earth*, *5*, 1100–1108.

Forsythe, L., Nyamanda, M., Mbachi Mwangwela, A., & Bennet, B. (2015). Belief, Taboos and Minor Crop Value Chains. *Food, Culture & Society*, *18*(3), 501–517. https://doi.org/10.1080/15528014.2015.1043112

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy*, *31*(8–9), 1257–1274.

Giller, K. E., Hijbeek, R., Andersson, J. A., & Sumberg, J. (2021). Regenerative Agriculture: An agronomic perspective. *Outlook on Agriculture*, *50*(1), 13–25.

Gillespie, S., Menon, P., & Kennedy, A. L. (2015). Scaling Up Impact on Nutrition: What Will It Take? *Advances in Nutrition*, *6*(4), 440–451.

Giroux, S., Kaminski, P., Waldman, K., Blekking, J., Evans, T., & Gaylor, K. K. (2023). Smallholder social networks: Advice seeking and adaptation in rural Kenya. *Agricultural Systems*, *205*(103574), 1–13.

Grabowski, P. P., Kerr, J. M., Haggblade, S., & Kabwe, S. (2016). Determinants of adoption and disadoption of minimum tillage by cotton farmers in eastern Tanzania. *Agriculture, Ecosystems & Environment*, *231*, 54–67.

Habanyati, E. J., Nyanga, P. H., & Umar, B. B. (2020). Factors contributing to disadoption of conservation agriculture among smallholder farmers in Petauke, Zambia. *Kasetsart Journal of Social Sciences*, *41*, 91–96.

Halevy, N., & Halali, E. (2015). Selfish third parties act as peacemakers by transforming conbflicts and promoting cooperation. *Psychological and Cognitive Sciences*, *112*(22), 6937–6942.

Herrando, C., & Constantinides, E. (2021). Emotional Contagion: A Brief Overview and Future Directions. *Frontiers in Psychology*, *12*(712606). https://doi.org/10.3389/fpsyg.2021.712606

IFAD. (n.d.). *Agriculture holds great promise for Africa. More than half of the Earth's arable land-roughly 600 million hectares-is located in Africa.* [Field report]. Change Starts Here. Retrieved 17 June 2024, from http://www.ifad.org/thefieldreport

IPCC. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability Working Group 11 Contribution to the sixth assessment Report of the Intergovenmental Panel on Climate Change. *Cambridge University Press, Cambridge, UK and New York, USA*, 84. https://doi.org/10.1017/9781009325844.

IUCN. (2021, October 25). *Regenerative agriculture works: New research and African businesses show how | IUCN*. https://www.iucn.org/news/nature-based-solutions/202110/regenerative-agriculture-works-new-research-and-african-businesses-show-how

Jagadish, A., Mills, M., & Mascia, M. B. (2021). *Catalyzing Conservation at Scale: A Practitioner's handbook (Version 0.1)*. https://doi.org/10.5281/zenodo.4894933

Kehinde, A. D., & Adeyemo, R. (2017). A probit Analysis of Factors Affecting Improved Technologies Dis-adoption in Cocoa-Based Farming Systems of Southwestern Nigeria. *International Journal of Agricultural Economics*, *2*(2), 35–41. https://doi.org/10.11648/j.ijae.20170202.12

Khoza, S., Van Niekerk, D., & Nemakonde, L. D. (2019). Understanding gender dimensions of climate-smart agriculture adoption in disaster-prone smallholder farming communities in Malawi and Zambia. *Disaster Prevention and Management*, *28*(5), 530–547. https://doi.org/10.1108/DPM-10-2018-0347

Kifle, T., Ayal, D. Y., & Mulugeta, M. (2022). Factors influencing farmers adoption of climate smart agriculture to respond climate variability in siyandebrina Wayu District, Central highlands of Ethiopia. *Climate Services*, *26*(100290), 1–10.

Kouassi, J.-L., Kouassi, A., Bene, Y., Konan, D., Tondoh, E. J., & Kouame, C. (2021). Exploring Barriers to Agroforestry Adoption by Cocoa Farmers in South-Western Cote d'lvoire. *Sustainability*, *13*(13075), 1–16.

Kunzekweguta, M., Rich, M. K., & Lyne, C. M. (2017). Factors affecting adoption and intensity of conservation agriculture techniques applied bu smallholders in Masvingo district, Zimbabwe.

Agricultural Economics Research, Policy and Practice in Southern Africa, *56*(4), 330–346. https://doi.org/10.1080/03031853.2017.1371616

Kurgat, B. K., Lamanna, C., Kimaro, A., Namoi, N., Manda, L., & Rosenstock, T. S. (2020). Adoption of Climate smart Agriculture Technologies in Tanzania. *Frontiers in Sustainable Food Systems*, *4*(55), 1–9. https://doi.org/10.3389/fsufs.2020.00055

LaSalle, T. J., & Hepperly, P. (2008). Regenerative Organic Farming: Asolution to Global Warming. *Rodale Institute*. https://www.researchgate.net/publication/237136333_Regenerative_Organic_Farming_A_Solution_to_Global_Warming

Lenton, T. M., Benson, S., Smith, T., Ewar, T., Lanel, V., Petykowski, E., Powell, T. W. R., Abrams, J. F., Blomsma, F., & Sharpe, S. (2022). Operationalising positive tipping points towards global sustainability. *Global Sustainability*, *5*(el), 1–6.

Li, C., Stomph, T.-J., Makowski, D., Li, H., Zhang, C., Zhang, F., & Van der Werf, W. (2023). The productive performance of intercropping. *PNAS*, *120*(2), 1–10.

Maindi, N. C., Osuga, I. M., & Gicheha, M. G. (2020). Advancing climate smart agriculture: Adoption potential of multiple on-farm dairy production strategies among farmers in Muranga County, Kenya. *Livestock Research for Rural Development*, *32*(4). http://www.lrrd.org/lrrd32/4/izzac32063.html

Marrakech Partnership. (2022). *Sharm-El-Sheilh Adaptation Agenda. The global transformation towards adaptive and resilient development* [Graphic]. https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=0CDcQw7AJahcKEwjQ7JHSoISBAxUAAAAAHQAAAAAQAw&url=https%3A%2F%2Fclimatechampions.unfccc.int%2Fwp-content%2Fuploads%2F2022%2F11%2FSeS-Adaptation-Agenda_Complete-Report-COP27_FINAL-1.pdf&psig=AOvVaw1XKs-wVXCQOlmnGB-3ZmMN&ust=1693480506826579&opi=89978449

Masiga, M., Yankel, C., & Iberre, C. (2012). *The International Small Group Tree Planting Program (TIST) Kenya* (Institutional Innovations in African Smallholder Carbon Projects Case Study, pp. 1–16). CGIAR Research Program on Climate Change Agriculture and Food Security (CCAFS). https://cgspace.cgiar.org/handle/10568/21216

Millar, J., & Connell, J. (2010). Strategies for scaling out impacts from agricultural systems change: The case of forages and livestock production in Laos. *Agric Hum Values*, *27*, 213–225.

Mills, M., Bode, M., Mascia, M. B., Weeks, R., & et al. (2019). How conservation initiatives go to scale. *Nature Sustainability*, *2*, 935–940.

Moore, M. L., Riddell, D., & Vocisano, D. (2015). Scaling Out, Scaling up, Scaling Deep: Strategies of Non-profits in Advancing Systemic Social Innovation. *The Journal of Corporate Citizenship*, *58*, 67–84.

Mujeyi, A., Mudhara, M., & Mutenje, M. J. (2022). Adoption patterns of climate-smart Agriculture in Integrated crop-livestock smallholder systems of Zimbabwe. *Climate and Development*, *14*(5), 399–408. https://doi.org/10.1080/17565529.2021.1930507

Muriith, L. N., Onyari, C. N., Mogaka, K. R., Gichimu, B. M., Gatumo, G. N., & Kwena, K. (2021). Adoption Determinants of Adapted Climate Smart Agricultural Technologies Among Smallholder Farmers in Machakos, Makueni and Kitui Counties of Kenya. *Journal of Agricultural Extension*, *25*(2), 75–85.

Murindangabo, Y. T., Kopecky, M., & Konvalina, P. (2021). Adoption of conservation Agriculture in Rwanda; A case study of Gicumbi District Region. *Agronomy*, *11*(1732), 1–13.

Newton, P., Civita, N., Frankel-goldwater, L., Bartel, K., & Johns, C. (2020). What Is Regenerative Agriculture? A Review of Scholar and Practitioner Definitions Based on Processes and Outcomes. *Frontiers in Sustainable Food Systems*, *4*(October), 1–11. https://doi.org/10.3389/fsufs.2020.577723

Nezomba, H., Mtambanengwe, F., Tittonell, P., & Mapfumo, P. (2017). Practical assessment of soil degradation on smallholder farmers’ fields in Zimbabwe: Integrating local knowledge and scientific diagnostic indicators. *CATENA*, *156*, 216–227.

Nicol, P. (2020). Pathways to Scaling Agroecology in the City Region: Scaling out, Scaling up and Scaling deep through Community-Led Trade. *Sustainability*, *12*(19), 1–20.

Oladele, O. I., Gitika, M. P., Ngari, F., Shimeles, A., Mamo, G., Aregawi, F., Braimoh, A. K., & Olorunfemi, O. D. (2019). Adoption of agro-weather information sources for climate smart agriculture among farmers in Embu and Ada districts of Kenya and Ethiopia. *Information Development*, *35*(4), 639–654. https://doi.org/10.1177/0266666918779639

Owombo, P. T., & Idumah, F. O. (2017). Determinants of agroforestry technology adoption among arable crop farmers in Ondo state, Nigeria: An imperical investigation. *Agroforest Syst*, *91*, 919–926. https://doi.org/10.1007/s10457-016-9967-2

Page, R., & Dilling, L. (2019). The Critical Role of Communities of Practice and Peer Learning in Scaling Hydroclimatic Information Adoption. *American Mateorological Society*, 851–862. https://doi.org/10.1175/WCAS-D-18-0130.1

Randall, J. R., Nickel, N. C., & Colman, I. (2015). Contagion from peer suicidal behaviour in a representative sample of American adolescents. *Journal of Affective Disorders*, *Research report*, 219–225.

Razafimahatratra, H. M., Bignebat, C., David-Benz, H., Belieres, J.-F., & Penot, E. (2021). Tryout and (Dis)adoption of conservation agriculture. Evidence from Western Madagascar. *Land Use Policy*, *100*(104929), 1–13.

Reed, M. S. (2007). Participatory technology development for agroforestry extension: An innovation-decision approach. *African Journal of Agricultural Research*, *2*(8), 334–341.

Rehberger, E., West, P. C., Spillane, C., & McKeown, P. C. (2023). What Climate and environmental benefits of regenerative agriculture practices? An evidence review. *Environmental Research Communications*, *5*(Topical Review). https://doi.org/10.1088/2515-7620/acd6dc

Reid, H., & Swiderska, K. (2008). Biodiversity, climate change and poverty: Exploring the links. *International Institute for Environment and Development*, 1–6.

Schreefel, L., Schulte, R. P. O., De Boer, I. J. M., Pas Schrijver, A., & van Zanten, H. H. E. (2020). Regenerative agriculture—The soil is the base. *Global Food Security*, *26*. https://doi.org/10.1016/j.gfs.2020.100404

Strauss, T., & Chhabria, P. (2022). *What is regenerative agriulture and how can it help us ge to net zero food systems? 3 insudtry leaders explain Climate Champions*. https://www.weforum.org/agenda/2022/12/3-industry-leaders-on-achieving-net-zero-goals-with-regenerative-agriculture-practices/

Takeshima, H. (2017). Custom-hired tractor services and returns to scale in smallholder agriculture: A production function approach. *Agricultural Economics*, *48*, 363–372. https://doi.org/10.1111/agec.12339

Teklu, A., Simane, B., & Bezabith, M. (2023). Multiple adoption of climate smart agricultural innovation for agricultural sustainability: Empirical evidence from the upper Blue Nile Highlands of Ethiopia. *Climate Risk Management*, *39*(100477), 1–15.

Tokita, C. K., Guess, A. M., & Tarnita, C. E. (2021). Polarized information ecosystems can reorganize social networks via information cascades. *PNAS*, *118*(50), 1–9.

Tucker, C. (2018). Network Effects and Market Power: What have we learned in the last decade? *Antitrust*, *Spring*, 72–79.

Wafula, L., Oduol, J., Oluoch-Kosura, W., Muriuki, J., Okello, J., & Mowo, J. (2016). Does strengthening technical capacity of smallholder farmers enhance adoption of conservation practices? The case of conservation agriculture with trees in Kenya. *Agroforest Syst*, *90*, 1045–1059. https://doi.org/10.1007/s10457-015-9882-y

Wainwright, C. M., Black, E., & Allan, R. P. (2021). Future Changes in Wet and Dry Season Characteristics in CMIP5 and CMIP6 Simulations. *American Meteorological Society*, 2339–2357. https://doi.org/10.1175/JHM-D-21-0017.1

Zulu-Mbata, O., Chapoto, A., & Hichaambwa, M. (2016). *Determinants of Conservation agriculture adoption among Zambian Smallholder Farmers* (pp. 1–22) [Working Paper No. 114]. http://www.aec.msu.edu/agecon/fs2/zambia/index.htm

Abdulai, A. N., Abdul-Rahaman, A., & Issahaku, G. (2021). Adoption and diffusion of conservation agriculture technology in Zambia: The role of social and institutional networks. *Environmental Economics and Policy Studies*, *23*, 761–780.

Abebaw, D., & Haile, M. G. (2013). The impact of cooperatives on agricultural technology adoption: Empirical evidence from Ethiopia. *Food Policy*, *38*, 82–91.

Agundez, D., Lawali, S., Mahamane, A., Alia, R., & Solino, M. (2022). Development of agroforestry food resources in Niger: Are farmers preferences context specific? *World Development*, *157*(105951), 1–12.

Ainembabazi, J. H., & Mugisha, J. (2014). The Role of Farming Experience on the Adoption of Agricultural Technologies: Evidence from smallholder Farmers in Uganda. *Journal of Development Studies*, *50*(5), 666–679. https://doi.org/10.1080/00220388.2013.874556

Ajayi, O. C., Akinnifesi, F. K., Sileshi, G., Chekeredza, S., & Mgomba, S. (2008). Payment for Environmental Services (PES): A Mechanism for Promoting Sustainable Agroforestry Land Use Practices among Smallholder Farmers in Southern Africa. *Conference on International Research on Food Security, Natural Resource Management and Rural Development*, 1–8.

Akpo, E., Ojiewo, C. O., Kapran, I., Omoigui, L. O., Diama, A., & Varshney, R. K. (2021). *Enhancing Smallholder Farmers Access to seed of improved legume Varieties Through Multi-stakeholder Platforms; Learning from the TLIII Project Experiences in Sub-saharan Africa and South Asia*. Springer International Publishing. https://doi.org/10.1007/978-981-15-8014-7

Alexander, M., Forastiere, L., Gupta, S., & Christakis, N. A. (2022). Algorithms for seeding social networks can enhance the adoption of a public health intervention in urban India. *PNAS*, *119*(30), 1–7.

Alpizar, F., Del Carpio, M. B., Ferraro, P. J., & Meiselman, B. S. (2022). *Exposure-enhanced goods and technology disadoption*.

Amadu, F. O., McNamara, P. E., & Miller, D. C. (2020). Understanding the adoption of Climate-Smart agriculture: A farm-level typology with empirical evidence from southern Malawi. *World Development*, *125*(104692). https://doi.org/10.1016/j.worlddev.2019.104692

Andersson, Jens. A., & D'Souza, S. (2014). From adoption claims to understanding farmers and contexts: A literature review of Conservation Agriculture (CA) adoption among smallholder farmers in southern Africa. *Agriculture, Ecosystems & Environment*, *187*, 116–132.

Assogbadjo, A. E., Glele Kakai, R., Djagoun, C. A. M. S., Codjia, J. T. C., & Sinsin, B. (2012). Biodiversity and socioeconomic factors supporting farmers choice of wild edible trees in the agroforestry systems of Benin (West Africa). *Forest Policy and Economics*, *14*, 41–49.

Awazi, N. P., Tchamba, M. N., Temgoua, L. F., & Tientcheu-Avana, M.-L. (2022). Agroforestry as an adaptation option to Climate Change in Cameroon: Assessing Farmers' Preferences. *Agric Res*, *11*(2), 309–320.

Benjamin, E. O., & Blum, M. (2015). Participation of Smallholders in agroforestry Agri-environmental scheme: A lesson from the rural mount Kenyan Region. *The Journal of Developing Areas*, *49*(4), 127–143.

Benjamin, E. O., Blum, M., & Punt, M. (2016). The impact of extension and ecosystem services on smallholder's credit constraint. *The Journal of Developing Areas*, *50*(1), 333–350. https://doi.org/10.1353/jda.2016.0020

Benjamin, E. O., Ola, O., & Buchenrieder, G. (2018). Does an agroforestry scheme with payment for ecosystem services (PES) economically empower women in sub-saharan Africa? *Ecosystem Services*, *31*, 1–11.

Bouwman, T. I., Andersson, J. A., & Giller, K. E. (2021). Adapting yet not adopting? Conservation agriculture in Central Malawi. *Agriculture, Ecosystems & Environment*, *307*(107224), 1–14.

Brown, B., Nuberg, I., & Llewellyn, R. (2017). Negative evaluation of conservation agriculture: Perspectives from African smallholder farmers. *International Journal of Agricultural Sustainability*, *15*(4), 467–481. https://doi.org/10.1080/14735903.2017.1336051

Buxton, J., Powell, T., Ambler, J., Boulton, C., Nicholson, A., Arthur, R., Lees, K., Williams, H., & Lenton, M. T. (2021). Community-driven tree planting greens the neighboring landscape. *Scientific Reports*, *11*(18239), 1–9.

Centola, D. (2021). Influencers, Backfire Effects and the Power of the Periphery. In *Personal Networks* (pp. 1–13). Cambridge University Press.

Chinseu, E., Dougill, A., & Stringer, L. (2019). Why do smallholder farmers dis-adopt conservation agriculture? Insights from Malawi. *Land Degradation & Development*, *30*(Special Issue article), 533–543. https://doi.org/10.1002/ldr.3190

Djido, A., Zougmore, R. B., Houessionon, P., Ouedraogo, M., Ouedraogo, I., & Diouf, N. S. (2021). To what extent do weather and climate information services drive the adoption of climate smart agriculture practices in Ghana. *Climate Risk Management*, *32*(100309), 1–14.

Djokoto, J. G., Owusu, V., & Awunyo-Vitor, D. (2016). Adoption of organic agriculture: Evidence from coca farming in Ghana. *Cogent Food and Agriculture*, *2*(1, 1242181), 1–16. https://doi.org/10.1080/23311932.2016.1242181

Entz, M. H., Stainsby, A., Riekman, M., Mulaire, T. R., Kirima, J. K., Beriso, F., Ngotio, D., Salomons, M., Nicksy, J., Mutinda, M., & Stanley, K. (2022). Farmer participatory assessment o soil health from conservation Agriculture in three regions of East Africa. *Agronomy for Sustainable Development*, *42*(97), 1–16.

FOLU. (2021). *Accelerating the 10 Critical Transitions: Positive Tipping Points for Food and Land Use Systems Tranformation* (pp. 1–74). The Food and LandUse Coalition, University of Exeter.

Forsythe, L., Nyamanda, M., Mbachi Mwangwela, A., & Bennet, B. (2015). Belief, Taboos and Minor Crop Value Chains. *Food, Culture & Society*, *18*(3), 501–517. https://doi.org/10.1080/15528014.2015.1043112

Giroux, S., Kaminski, P., Waldman, K., Blekking, J., Evans, T., & Gaylor, K. K. (2023). Smallholder social networks: Advice seeking and adaptation in rural Kenya. *Agricultural Systems*, *205*(103574), 1–13.

Girvetz, E., Ramirez-villegas, J., Claessens, L., Lamanna, C., Navarro-racines, C., Nowak, A., Thornton, P., & Rosenstock, T. S. (2019). The Climate-Smart Agriculture Papers. *The Climate-Smart Agriculture Papers*, 15–27. https://doi.org/10.1007/978-3-319-92798-5

Grabowski, P. P., Kerr, J. M., Haggblade, S., & Kabwe, S. (2016). Determinants of adoption and disadoption of minimum tillage by cotton farmers in eastern Tanzania. *Agriculture, Ecosystems & Environment*, *231*, 54–67.

Guteta, D., & Abegaz, A. (2016). Fcators influencing the scaling up of agroforestry-based spatial land-use integration for soil fertility management in Arsamma watershed, Southwestern Ethiopia Highlands. *Journal of Environmental Planning and Management*, *59*(10), 1795–1812. https://doi.org/10.1080/09640568.2015.1090960

Habanyati, E. J., Nyanga, P. H., & Umar, B. B. (2020). Factors contributing to disadoption of conservation agriculture among smallholder farmers in Petauke, Zambia. *Kasetsart Journal of Social Sciences*, *41*, 91–96.

IPCC. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability Working Group 11 Contribution to the sixth assessment Report of the Intergovenmental Panel on Climate Change. *Cambridge University Press, Cambridge, UK and New York, USA.* https://doi.org/10.1017/9781009325844.

IUCN. (2021, October 25). *Regenerative agriculture works: New research and African businesses show how | IUCN*. https://www.iucn.org/news/nature-based-solutions/202110/regenerative-agriculture-works-new-research-and-african-businesses-show-how

Kehinde, A. D., & Adeyemo, R. (2017). A probit Analysis of Factors Affecting Improved Technologies Dis-adoption in Cocoa-Based Farming Systems of Southwestern Nigeria. *International Journal of Agricultural Economics*, *2*(2), 35–41. https://doi.org/10.11648/j.ijae.20170202.12

Khoza, S., Van Niekerk, D., & Nemakonde, L. D. (2019). Understanding gender dimensions of climate-smart agriculture adoption in disaster-prone smallholder farming communities in Malawi and Zambia. *Disaster Prevention and Management*, *28*(5), 530–547. https://doi.org/10.1108/DPM-10-2018-0347

Kifle, T., Ayal, D. Y., & Mulugeta, M. (2022). Factors influencing farmers adoption of climate smart agriculture to respond climate variability in siyandebrina Wayu District, Central highlands of Ethiopia. *Climate Services*, *26*(100290), 1–10.

Kouassi, J. L., Kouassi, A., Bene, Y., Konan, D., Tondoh, E. J., & Kouame, C. (2021). Exploring Barriers to Agroforestry Adoption by Cocoa Farmers in South-Western Cote d'Ivoire. *Sustainability*, *13*(13075), 1–16.

Kunzekweguta, M., Rich, M. K., & Lyne, C. M. (2017). Factors affecting adoption and intensity of conservation agriculture techniques applied bu smallholders in Masvingo district, Zimbabwe. *Agricultural Economics Research, Policy and Practice in Southern Africa*, *56*(4), 330–346. https://doi.org/10.1080/03031853.2017.1371616

Kurgat, B. K., Lamanna, C., Kimaro, A., Namoi, N., Manda, L., & Rosenstock, T. S. (2020). Adoption of Climate smart Agriculture Technologies in Tanzania. *Frontiers in Sustainable Food Systems*, *4*(55), 1–9. https://doi.org/10.3389/fsufs.2020.00055

Lenton, T. M., Benson, S., Smith, T., Ewer, T., Lanel, V., Petykowski, E., Powell, T. W. R., Abrams, J. F., Blomsma, F., & Sharpe, S. (2022). Operationalising positive tipping points towards global sustainability. *Global Sustainability*, *5*, 1–16.

Maindi, N. C., Osuga, I. M., & Gicheha, M. G. (2020). Advancing climate smart agriculture: Adoption potential of multiple on-farm dairy production strategies among farmers in Muranga County, Kenya. *Livestock Research for Rural Development*, *32*(4). http://www.lrrd.org/lrrd32/4/izzac32063.html

Mambondiyani, A. (2020, May 5). Farmers in Zimbabwe are fighting taboo against growing a drought-hardy crop. *Global Center on Adaptation*. https://gca.org/farmers-in-zimbabwe-are-fighting-taboo-against-growing-a-drought-hardy-crop/

Marrakech Partnership for Global Climate action. (2022). *Sharm-El-Sheilh Adaptation Agenda. The global transformation towards adaptive and resilient development*. https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=0CDcQw7AJahcKEwjQ7JHSoISBAxUAAAAAHQAAAAAQAw&url=https%3A%2F%2Fclimatechampions.unfccc.int%2Fwp-content%2Fuploads%2F2022%2F11%2FSeS-Adaptation-Agenda_Complete-Report-COP27_FINAL-1.pdf&psig=AOvVaw1XKs-wVXCQOlmnGB-3ZmMN&ust=1693480506826579&opi=89978449

Masiga, M., Yankel, C., & Iberre, C. (2012). *The International Small Group Tree Planting Program (TIST) Kenya* (Institutional Innovations in African Smallholder Carbon Projects Case Study, pp. 1–16). CGIAR Research Program on Climate Change Agriculture and Food Security (CCAFS). www.ccafs.cgiar.org

Montt, G., & Luu, T. (2020). Does Conservation Agriculture Change Labour Requirements? Evidence of Sustainable Intensification in Sub-Saharan Africa. *Journal of Agricultural Economics*, *71*(2), 556–580. https://doi.org/10.1111/1477-9552.12353

Moore, M. L., Riddell, D., & Vocisano, D. (2015). Scaling Out, Scaling up, Scaling Deep: Strategies of Non-profits in Advancing Systemic Social Innovation. *The Journal of Corporate Citizenship*, *58*, 67–84.

Mugandani, R., & Mafongoya, P. (2019). Behaviour of smallholder farmers towards adoption of conservation agriculture in Zimbabwe. *Soil Use and Management*, *35*, 561–575. https://doi.org/10.1111/sum.12528

Mujeyi, A., Mudhara, M., & Mutenje, M. J. (2022). Adoption patterns of climate-smart Agriculture in Integrated crop-livestock smallholder systems of Zimbabwe. *Climate and Development*, *14*(5), 399–408. https://doi.org/10.1080/17565529.2021.1930507

Munthali, R., Auerbach, R., & Mataa, M. (2020). 16 Factors Contributing to Adoption or Disadoption of Organic Agriculture in Zambia. In *Organic Food Systems: Meeting the Needs of Southern Africa* (pp. 209–216). CAB International.

Muriith, L. N., Onyari, C. N., Mogaka, K. R., Gichimu, B. M., Gatumo, G. N., & Kwena, K. (2021). Adoption Determinants of Adapted Climate Smart Agricultural Technologies Among Smallholder Farmers in Machakos, Makueni and Kitui Counties of Kenya. *Journal of Agricultural Extension*, *25*(2), 75–85.

Murindangabo, Y. T., Kopecky, M., & Konvalina, P. (2021). Adoption of conservation Agriculture in Rwanda; A case study of Gicumbi District Region. *Agronomy*, *11*(1732), 1–13.

Newton, P., Civita, N., Frankel-goldwater, L., Bartel, K., & Johns, C. (2020). What Is Regenerative Agriculture? A Review of Scholar and Practitioner Definitions Based on Processes and

Outcomes. *Frontiers in Sustainable Food Systems*, *4*(October), 1–11. https://doi.org/10.3389/fsufs.2020.577723

Ngaiwi, M. E., Molua, E. L., Sonwa, D. J., Meliko, M. O., Bomdzele, E. J., Ayuk, J. E., Castro-Nunez, A., & Latala, M. M. (2023). Do farmers' socioeconomic status determine the adoption of conservation agriculture? An empirical evidence from Eastern and Southern Regions of Cameroon. *Scientific African*, *19*(e01498), 1–12.

Nkonki-Mandleni, B., Nnditsheni, G. M., & Omatayo, O. A. (2022). Factors influencing the adopton of conservation agriculture by smallholder farmers in KwaZulu-Natal, South Africa. *Open Agriculture*, *7*, 596–604.

Noordin, Q., Niang, A., Jama, B., & Nyasimi, M. (2001). Scaling up adoption and impact of agroforestry technologies: Experiences from western Kenya. *Development in Practice*, *11*(4), 509–523. https://doi.org/10.1080/09614520120066783

Oduniyi, O. S., & Tekana, S. S. (2019). Adoption of agroforestry practices and climate change mitigation strategies in North West province of South Africa. *International Journal of Climate Change Strategies and Management*, *11*(5), 716–729. https://doi.org/10.1108/IJCCSM-02-2019-0009

OECD-FAO. (2016). *Agriculture in Sub-saharan Africa: Prospects and Challenges for the next decades* (Part 1: Chapter 2; Agricultural Outlook 2016-2025).

Oladele, O. I., Gitika, M. P., Ngari, F., Shimeles, A., Mamo, G., Aregawi, F., Braimoh, A. K., & Olorunfemi, O. D. (2019). Adoption of agro-weather information sources for climate smart agriculture among farmers in Embu and Ada districts of Kenya and Ethiopia. *Information Development*, *35*(4), 639–654. https://doi.org/10.1177/0266666918779639

Ong, M. K. C. F., Blomsma, F., & Lenton, T. M. (2023). Tipping dynamics in packaging systems: How a bottle reuse system was established and then undone. *EGUsphere*, *2023*, 1–35. https://doi.org/10.5194/egusphere-2023-2361

Owombo, P. T., & Idumah, F. O. (2017). Determinants of agroforestry technology adoption among arable crop farmers in Ondo state, Nigeria: An imperical investigation. *Agroforest Syst*, *91*, 919–926. https://doi.org/10.1007/s10457-016-9967-2

Razafimahatratra, H. M., Bignebat, C., David-Benz, H., Belieres, J.-F., & Penot, E. (2021). tryout and Disadoption of conservation agriculture. Evidence from Western Madagascar. *Land Use Policy*, *100*(104929), 1–13.

Reid, H., & Swiderska, K. (2008). Biodiversity, climate change and poverty: Exploring the links. *International Institute for Environment and Development*, 1–6.

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). FreePress.

Simtowe, F., & Mausch, K. (2019). Whois quiting? An analysis of the dis-adoption of climate smart sorghum varieties in Tanzania. *International Journal of Climate Change Strategies and Management*, *11*(3), 341–357. https://doi.org/10.1108/IJCCSM-01-2018-0007

Teklu, A., Simane, B., & Bezabith, M. (2023). Multiple adoption of climate smart agricultural innovation for agricultural sustainability: Empirical evidence from the upper Blue Nile Highlands of Ethiopia. *Climate Risk Management*, *39*(100477), 1–15.

UNFCCC. (n.d.). *The Breakthrough Agenda*. Climate Champions. Retrieved 30 August 2023, from https://climatechampions.unfccc.int/system/breakthrough-agenda/

Wafula, L., Oduol, J., Oluoch-Kosura, W., Muriuki, J., Okello, J., & Mowo, J. (2016). Does strengthening technical capacity of smallholder farmers enhance adoption of conservation practices? The case of conservation agriculture with trees in Kenya. *Agroforest Syst*, *90*, 1045–1059. https://doi.org/10.1007/s10457-015-9882-y

Zulu-Mbata, O., Chapoto, A., & Hichaambwa, M. (2016). *Determinants of Conservation agriculture adoption among Zambian Smallholder Farmers* [Working Paper No. 114]. http://www.aec.msu.edu/agecon/fs2/zambia/index.htm