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Article

Scaling Climate Smart Agriculture in East Africa: Experiences and Lessons

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Abstract: Climate-smart agriculture (CSA) responds in order to sustain agriculture under a changing environment, and is a major priority in the development sphere. However, to achieve impact at scale, CSA innovations must address agricultural systems' context-specific and multi-dimensional nature and be purveyed through feasible scaling processes. Unfortunately, knowledge on the scaling of CSA innovations under smallholder farming systems and in the context of developing countries remains scant. Understanding scaling processes is essential to the design of a sustainable scaling strategy. This study aimed to draw lessons on scaling from 25 cases of scaling CSA, and related projects in Ethiopia, Kenya, Uganda, and Tanzania implemented by public institutions, local and international research organisations, Non-Govermental Orginsations(NGOs), and community-based organisations. Generally, scaling follows a linear pathway comprising technology testing and scaling. Most cases promoted technologies and models geared towards climate change adaptation in crop-based value chains, and only a few cases incorporated mitigation measures. Efforts to engage the private sector involved building business models as a potential scaling pathway. The cases were very strong on capacity building and institutionalisation from local, national, and even regional levels. However, four critical areas of concern about the sustainability of scaling emerged from the study: (i) There is little understanding and capture of the dynamics of smallholder farming systems in scaling strategies; (ii) climate data, projections, and impact models are rarely applied to support the decision of scaling; (iii) considerations for the biophysical and spatial-temporal impacts and trade-offs analysis in scaling is minimal and just starting to emerge; and (iv) there are still challenges effecting systemic change to enable sustainable scaling. In response to these concerns, we propose investment in understanding and considering the dynamics of the smallholder farming system and how it affects adoption, and subsequently scaling. Programme design should incorporate climate change scenarios. Scaling programmes can maximise synergies and leverage resources by adopting a robust partnerships model. Furthermore, understanding the spatio-temporal impact of scaling CSA on ecological functioning deserves more attention. Lastly, scaling takes time, which needs to be factored into the design of programmes.

Keywords: climate-smart agriculture; scaling; partnerships; East Africa

1. Introduction

There is a wealth of evidence that the climate is changing and negatively impacts agricultural production [1–3].Therefore, CSA was introduced ca. 2010 as a concept to orient agriculture towards a world acknowledging the changing climate. The concept seeks to increase agricultural production sustainably, and develop resilient systems, while reducing green-house gas (GHG) emissions. Climate-smart agriculture as a concept enhances the resilience of agricultural systems by balancing the priorities of adaptation, mitigation, and food security [4].

Since its inception in 2010, African countries and regional bodies have developed policies and frameworks to promote and scale CSA. In 2014, The Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods prioritised developing resilient agriculture as development agenda [5]. During the same summit, Vision 25 × 25 was launched, with the target of at least 25 million farm households practising CSA by 2025. The East Africa Climate Change Policy provides a framework that prioritises adaptation, and mainstreams climate change into development plans [6]. Additionally, the International Center for Tropical Agriculture(CIAT) (2015) has developed CSA country/sub-county profiles to help countries adapt to and mitigate climate change, and target investment [7]. Individual countries, e.g., Kenya, have developed CSA strategy plans to guide actions towards sound and effective investment in CSA. The Climate Change Agriculture and Food Security (CCAFS) programme of CGIAR and partners aims to marshal the science and expertise needed to scale practices, technologies, and institutions that enable agriculture to meet the triple goals of food security, adaptation, and mitigation.

Despite its relevance and promotion, wide-scale adoption of CSA innovations remains a challenge, especially amongst small-holder farmers in East Africa [8]. CSA initiatives cut across biophysical, socioeconomic, and institutional dimensions, which present different issues at different scales, creating transitional bottlenecks, and are sometimes exacerbated when scaling [9]. To achieve impact at scale, i.e., on a broader and higher scale, e.g., sub-national or national level, integrated, multi-objective, and multi-stakeholder approaches that could support scaling CSA interventions are needed but lacking [10].

This calls for a shift to a more outcome-oriented scaling, what Schut et al., (2020) describes as the third wave of scaling [11]. Their proposal is based on the fact that the foundational work for the implementation of CSA is already in place. For example, there is a lot of research testing CSA on a pilot basis for their suitability across different regions, including East Africa [12–15]. Additionally, various frameworks, tools, and methods on how to scale exist [8,16–21].

Scaling strategies in the third wave need to be hinged on evidence, and be sensitive and responsive to the socio-economic and agro-ecological dynamics, accounting for synergies and trade-offs between CSA's three pillars across scales [10,22–26]. Moreover, such strategies ought to be responsible, because the impact should be socially desirable and acceptable [27]. Finally, scaling strategies must create a supportive environment through institutions, partnerships, and monitoring and learning that allows for iteration and adjustment conforming to the contours of the context of intervention [11].

The literature on the practical experiences of scaling CSA needed to guide the third wave in scaling is starting to emerge [28–30]. However, questions around the scalability and sustainability of interventions persist [27]. There is still a gap in knowledge regarding whether, and how, these frameworks and critical elements can be translated to operationalised scaling, especially in the East African context. This knowledge is critical in developing sustainable strategies for scaling. This dearth of lessons and experiences from interventions constrains our understanding of how scaling happens, the contextual limitations, and the sustainability of the scaling process. This study responds to this gap by assessing interventions implemented by various bodies in research (local, regional, and international), national governments, and non-governmental organisations. Therefore, this study evaluates and highlights how projects operationalise scaling in their implementation, drawing on cases from Kenya, Uganda, Tanzania, and Ethiopia. The study addresses the following central question;

How is scaling understood and implemented in CSA-related projects in East Africa?

a. What strategies are used to facilitate the scaling of CSA solutions?

b. What are the enabling and hindering factors that influence scaling in CSA projects in EA?
c. To what extent do CSA-related projects consider future climate change scenarios and biophysical aspects in scaling?

The study highlights the experiences and critical lessons learned from the scaling of CSA, and guides decision-makers in formulating specific and inclusive scaling strategies that are sustainable in a developing country's context. This paper also aims to develop guidelines for the inclusive and sustainable scaling of CSA. A case study approach was used to answer the questions highlighted above. In addition, a literature review was conducted, which informed the development of a conceptual framework used to explore the qualitative data collected from the interviews with key informants. A total of 38 interviews were conducted online (Skype, Teams, and Zoom), on WhatsApp, by mobile phone and two in-person) with project managers and/or technical personnel and their implementing partners.

The remainder of this article is divided into four sections. Section 2 elaborates on the conceptual framework to operationalise scaling CSA. The methodology section briefly introduces the case studies examined, data collection methods, and analysis. Section 4 presents the results of the study. It highlights scaling strategies in use, and factors hindering and enabling scaling, and describes the sustainability of the strategy in use. The results are discussed in the Section 5. This section also answers the research questions above and presents recommendations for scaling.

2. Conceptual Framework

2.1. Small Holder Farming in East Africa

The economies of East African countries are agro-based. About 70% of the population is engaged in farming. Together, smallholder farmers account for over 75% of the total agricultural output [31]. In Kenya, the smallholder population is approximately 5 million [32]. These small-scale farmers operate on fragmented portions of land between 0.2 and 3 ha, often for home-consumption and as the primary source of livelihood [33,34]. Smallholder systems are often associated with mixed farming systems incorporating crops and livestock that are complimentary. For example, livestock offers traction, ploughing, and manure, and acts as insurance and banking, while crop residues are used as livestock feed [26].

Smallholder farmers face myriad challenges, including access to quality seeds, fertilizer, and pesticides, resource trade-offs, poor transport infrastructure, inadequate technical skills, inadequate access to post-harvest storage facilities, the provision of credit, insurance, and payment facilities [31,35]. Additionally, there is declining cheap labour, land degradation, and an over-reliance on unstable weather conditions. The reliance on rainfall, and the adverse effect of climate change make the smallholder system vulnerable, and the many challenges reduce the potential to adapt [26,36].

In response, and with the risks involved in farming, farmers take mitigative measures even at high costs, as it is crucial to their survival [37]. These include crop diversification, changing plant days and mixed cropping, mixed livestock herd, dispersion of fields cultivated by a single household, and seeking off-farm employment [1].

Externally, there are calls to commercialise smallholders, with a view to more streamlined value chains and targeted support regarding access to credit and other critical production resources, strengthening institutions and improving market access [38]. However, this call also emphasises the need to stratify smallholders due to the heterogeneity in their typology (subsistence, transitioning, and commercial), agro-ecological conditions, and socio-economic constraints [39], therefore demanding a different support system [38].

The decision to adopt risk management strategies is influenced by many factors, including risk perception, age, marital status, children, education, farming experience, time spent on a farm, economic contribution, attitude, ownership of assets, income, farm size, family [37] structure, networks [40–42] and complex community dynamics [43].These factors make smallholder systems complex and dynamic, and this needs to be captured for any interventions to be sustainable.

2.2. The Concept and Trajectory of Scaling of CSA Innovations

The concept of scaling has moved beyond technology adoption (first wave) [44–46] and the scaling of innovation (second wave) [27,47]. The work set out in [48] defines scaling up as "expanding, adapting, and sustaining successful policies, programs, and projects in different places and overtime to reach a greater number of people". This broader definition is more outcome-oriented and emphasises sustainability, which the authors of [11] describe as a third wave in scaling. In their submission, moving forward, efforts towards scaling should focus on (a) understanding the factors, conditions, and dynamics affecting the innovation and scaling processes in a more realistic environment, a point earlier raised by Wigboldus and Leeuwis, (2013), who noted a lack of/poor consideration of environmental impacts on scaling CSA innovations; (b) grounding scaling based on evidence by developing and testing new approaches, concepts, and tools; (c) moulding a conducive environment for scaling innovations, focusing on institutions, partnerships, and monitoring and learning. This next phase must acknowledge the complexity and dynamic nature of scaling processes, given the multi-dimensional and multi-objective nature of the process, and the aspirations of broader stakeholders that are often involved in the process [30,49].

This paradigm shift in scaling means that scaling strategies should respond not only to niche-level requirements, but also the interventions that can feasibly be integrated at the regime- and landscape levels [11,47].

2.3. Strategies for Scaling CSA

The literature identifies three scaling strategies. Firstly, piloting involves testing innovation with a few participants within a limited geographic area. Promising innovations are then applied to a broader scale to create more impact [50]. This practice is common and encouraged by the short lifespan of most projects, averaging 3–5 years [51,52], however, it suffers from transitional challenges associated with the context specificity of innovations overlaid over new spatial spaces with heterogeneous biophysical and socio-economic conditions [23,33]. Secondly, business-led scaling is a market-led strategy [17,46] that provides opportunities to commercialise sustainable innovations [53]. The grounding conditions for a business model are the perceived value of service/product which must be targeted, support systems, and client base to justify investment [16,54]. However, the profit motive may make the strategies unsuitable for addressing gender and equity concerns [55,56]. Thirdly, the United Nations Development Programme (UNDP), (2013) identified a public/policy-driven scaling strategy, for example, through a presidential decree/act of parliament, or a practice adopted from the internationally accepted best practice. Within these scaling strategies, development, and research and development (R&D) practitioners have employed different mechanisms to scale, for example, partnerships [49], farmer field schools [57], and institutionalisation [58], and in most cases, scaling in practice may involve a combination of these mechanisms as a result of different interactions and the complexity of the process.

2.4. Sustainability

Sustainability means successful policies, programs, and projects must be feasible and operationalizable in different spatial settings and over time [59]. The sustainability of successfully piloted CSA innovations beyond the project life cycle is limited [60], suggesting inherent challenges in the scaling process. Scaling occurs across a wide range of socio-economical and agro-ecological contexts, perpetuating the complexities of the process. de Roo et al., (2019) reported that socio-political dynamics are important and influence access to technology, which may complicate the scaling process. Therefore, other scholars have stressed that scaling should be a stakeholder-driven process with participatory platforms that are easy in order to mobilise members, flexible in order to integrate new members, and able to facilitate shared learning among multiple stakeholders with diverse skills [58,61]. Such platforms must inculcate a learning system that catalyses continuous feedback of data and information to identify and close gaps in performance in order to institutionalise the scaling process [52,62,63]. At broader and higher scales, e.g., regional, there is a need for integrated approaches that are multi-objective and multi-stakeholder, which strive to balance agricultural production, climate adaptation, mitigation, and environmental and other livelihood needs [10]. Therefore, a careful and realistic assessment of impacts of innovations on livelihoods, resilience and adaptive capacity, and the ecosystem is critical to ensure responsible scaling [58,64].

Such assessments, according to Lobell (2014) and Harvey et al., (2014), need to account for spatial variability when scaling CSA, and target locations that maximise synergies and minimise trade-offs in agricultural systems [22,65]. Additionally, innovations should be subjected to future climate scenarios to assess their environmental sustainability, given that the climate impact varies temporally [62,66].

Lan et al., (2018) emphasised the need for commercial feasibility at different levels and scales to justify sustained financial investment in any scaling process. Additionally, scaling is long-term, often 10–15 years [67]; therefore, mechanisms to maintain the momentum, mobilization of resources, and monitoring and learning are crucial elements for consideration.

3. Materials and Methods

3.1. Selection of Cases

This study reviewed CSA and CSA-related projects, focusing on scaling, and cutting across private and public implemented projects within East Africa, including Kenya, Tanzania, Uganda, and Ethiopia. There was no preference for a particular country, farming system, value chain, or implementing organisation. The cases were identified through three methods. Firstly, internet searches were conducted using broad terminologies for scaling to capture related words that connote scaling (see Table 1 below).

Table 1. Terminologies/search strings used.

Broad dissemination of CSA interventions
Dissemination of agricultural interventions
Dissemination and landscape/large scale implementation,
Dissemination of agricultural technologies
Dissemination of CSA interventions
Expansion of agricultural projects
Expansion of CSA interventions
From small scale to landscape
From pilot to scale
Out-scaling agricultural projects scaling out CSA
Out-scaling development projects
Reaching many people
Reaching more farmers
Scaling up agricultural projects/CSA
Scaling up CSA
Up-scaling agricultural projects
Up-scaling CSA
Wide-scale adoption of agricultural projects
Wide-scale adoption of CSA technologies/innovations
Wide-scale adoption
Widespread change

We further filtered the outputs, restricting them to (a) those with scaling as part of the implementation strategies; (b) those which were either closed or on their last years of implementation; and (c) those with easily accessible documentation and a website for ease of referencing (Figure 1).

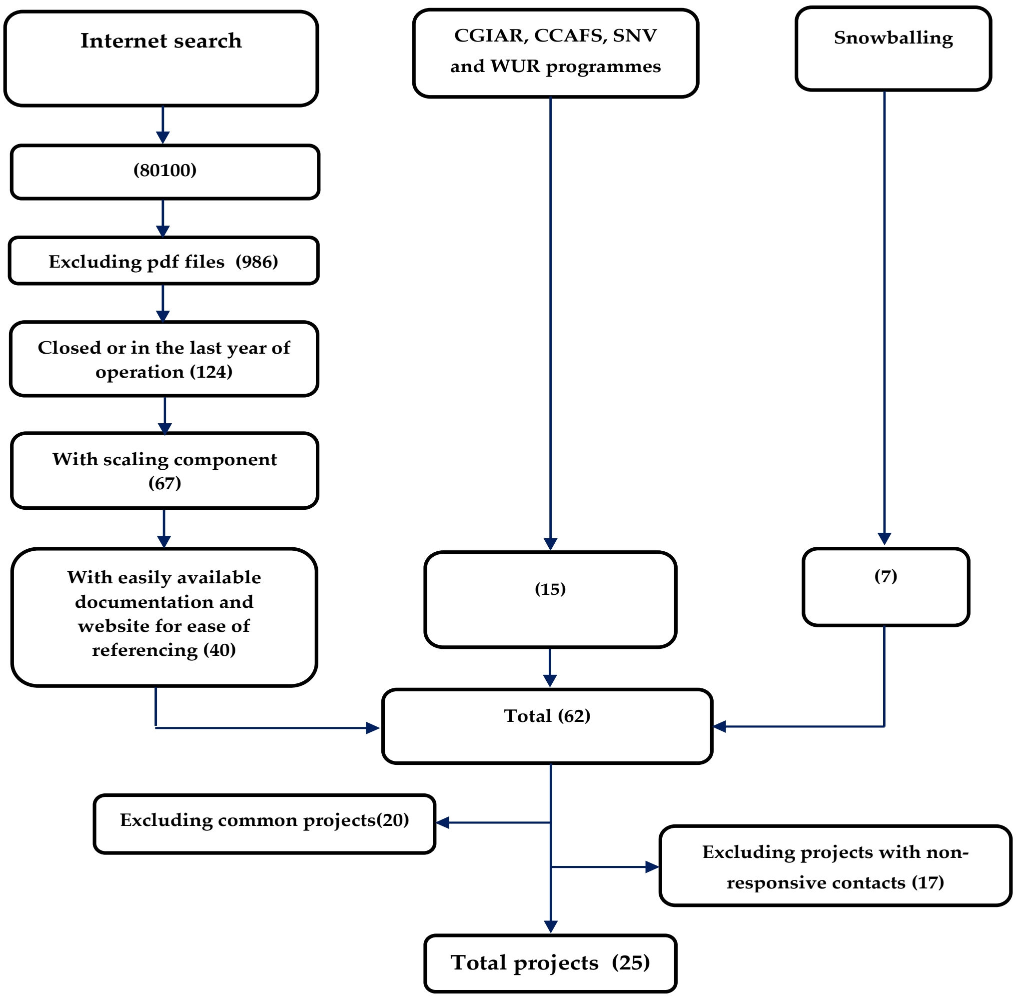

Figure 1. Case identification process.

Secondly, we used CRAFT consortium partners who are very active in the scaling landscape, including Wageningen University and Research, CGIAR's CCFAS programme, and SNV. Thirdly, a snowballing method was used to identify more projects [68]. We further checked for common projects identified through the three methods. Finally, projects whose contacts were non-responsive to our request for interviews were excluded.

Twenty-five cases (Table 2) were identified and implemented by local and international research institutions, development organisations, and local governments, e.g., CGIAR, NGOs, governments, and international public institutions such as the UN and other development agencies. The cases represent different spatial scales, research, and research and development-oriented projects across different value chains. Thirty-four interviews were conducted with the projects' technical or management staff. A semi-structured format was adopted for the study, with questions developed from research questions and literature reviews (Annexe i).

Table 2. General description of case studies.

Case #	Title	Objective/Description	Type	Organisations	Value Chains	Key CSA Pillar Addressed	Countries
CS1	Toward Sustainable Clusters in Agribusiness through Learning in Entrepreneurship (2SCALE)	2SCALE is an incubator program with a focus on public-private partnerships (PPPs). The objective is to strengthen collaboration in public-private partnerships (PPP), to help farmers and other local small and medium agri- businesses become more competitive.	Development	The International Fertilizer Development Center (IFDC), BoP Innovation Center (Bopinc), SNV Netherlands Organisation (SNV)	Tomatoes and onions	Adaptation and mitigation	Kenya and Ethiopia
CS2	3R (Robust, Reliable and Resilient) from the Aid to Trade project	The 3R project assessed and validated lessons on market-led approaches to aquaculture, dairy and horticulture sectors' development in Kenya. Objective: To draw lessons from market-led projects in agriculture and Food and Nutrition Security (FNS), and develop an innovative business solution to drive competitive agri-food sectors in Kenya.	Research and Development (R&D)	African Centre for Technology Studies (ACTS), Wageningen University and Research (WUR), Jomo Kenyatta University of Agriculture and Technology (JKUAT), and Egerton University	Horticulture, dairy and aquaculture	Adaptation	Kenya
CS3	Africa Research In Sustainable Intensification for Next Generation (Africa Rising)	The project aimed to develop technological innovations to enable sustainable intensification of production from small-scale, crop−livestock farming systems. Objective: To establish best-bet technologies for small-holder farm families.	R&D	International Institute of Tropical Agriculture (IITA)	Maize, sorghum, millet, rice) and legumes (groundnut, beans, cowpea, soybean, pigeon pea). Livestock is mainly cattle, poultry, and small ruminants.	Adaptation	Tanzania
CS4	Realising Sustainable Agricultural Livelihood Security in Ethiopia' (REALISE). Part of Capacity building for scaling up of evidence-based best practices in agricultural production in Ethiopia (CASCAPE)	The project goal was to contribute to sustainable livelihoods and strengthen the Productive Safety Net Programme (PSNP). Objective: To create enhanced human, organisational, and institutional capacities to adapt, validate, and scale best-fit practices to improve the resilience of chronically food-insecure households in PSNP woredas.	R4D	WUR. ALTERRA Ethiopian universities (Addis Ababa, Bahir Dar, Haramaya, Hawassa, Jimma, Mekelle)	Livestock and cash crops	Adaptation	Ethiopia
CS5	Climate Change Adaptation and Mitigation Project (CAMP+)	The project aimed to employ innovative ways to improve sustainable and nutritious food production and environmental conservation in a refugee context. Objective: To address natural resources and environmental degradation, and promote sustainable food production by refugees and host communities.	Development	Care International, Community Development Resource Network		Adaptation and mitigation	Uganda
CS6	Climate-smart financial diaries for scaling in Kenya	The project is an offshoot of the Incentives and Innovative Finance for Scaling CSA Up and Out project. The aim was to contribute to developing and upscaling business models, addressing issues related to the financial environment, value chain, partnerships, and policy interventions at a landscape level.	R&D	Amsterdam Centre for World Food Studies, Vrije Universiteit, University of Nairobi Vi Agroforestry Eastern Africa International Livestock Research Institute (ILRI) Kenya (CCAFS partner)	Dairy goats, horticulture, and agroforestry.	Adaptation	Kenya

Table 2. *Cont.*

Case #	Title	Objective/Description	Type	Organisations	Value Chains	Key CSA Pillar Addressed	Countries
CS7	Enhancing resilience of agricultural landscapes and value chains in eastern Uganda—scaling up (CSA) practices	The project supports adoption of CSA practices and technologies among co-operatives and schools, and mainstreams climate change in national policies, strategies, and development plans.	Development	Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)	Maize, beans and bananas	Adaptation	Uganda
CS8	Strengthening Capacities to Implement Priority Actions for Food Resiliency in Tanzania	The project aimed to address the capacity gaps within the country to effectively respond to the challenges climate change poses to agriculture. Objective: To strengthen the capacity of public institutions to achieve agricultural resilience under climate change.	R&D	International Livestock Research Institute (ILRI), International Food Policy Research Institute (IFPRI), World Agroforestry (ICRAF), IITA, the Ministry of Agriculture (MoA) and the Ministry of Livestock and Fisheries (MLF) and Zanzibar's Ministry of Agriculture, Natural Resources, Livestock and Fisheries (MANRLF), Tanzania's Meteorological Agency (TMA), and the President's Office of Regional Administration and Local Government (PORALG)	Maize, rice, sorghum, pearl millet, beans, cowpea, bambara nuts, Pigeon pea, sunflower, cassava, yam, and banana	Adaptation and mitigation	Tanzania
CS9	Healthy Food Africa	The project aimed to create more sustainable, equitable, and resilient food systems in 10 African cities. Objective: To improve nutrition in Africa by strengthening the diversity, sustainability, resilience, and connectivity of food systems.	R&D	The University of Helsinki	African leafy vegetables (ALV) and fish, food legumes, vegetables, fish, and small livestock	Adaptation	Ethiopia and Kenya
CS10	Horticultural Livelihoods, Innovation and Food safety in Ethiopia (HortiLIFE)	HortiLIFE II focused on scaling Farmers Field School (FFSs), Spray Service Providers (SSPs) and support to A-TVETs, and institutionalising experiences from phase I. Objective: To increase the involvement of smallholders in innovative and viable horticulture production systems that improve food security and food safety, and with access to high-end local and export markets.	Development	SNV	Horticulture	Adaptation	Ethiopia
CS11	Integrated Seed Sector Development Programme (ISSD)	ISSD focuses on developing a vibrant, pluralistic, and market-oriented seed sector. To achieve its goal the project worked towards increasing the availability and use of new, improved, and farmer-preferred varieties of seeds.	R&D	Government of Ethiopia	Various crops	Adaptation	Ethiopia

Table 2. *Cont.*

Case #	Title	Objective/Description	Type	Organisations	Value Chains	Key CSA Pillar Addressed	Countries
CS12	Bringing Climate Smart Agriculture practices to scale: assessing their contributions to narrow nutrient and yield gaps	It aims to understand and improve the 'scaling readiness' of climate smart, nutrient management decision support tools (DST) in different institutional environments. Objective: Increasing crop yields through smart nutrient management in Eastern Africa.	Research	Climate Change, Agriculture and Food Security Programme (CCAFS), WUR, the International Fertilizer Association (IFA) and International Maize and Wheat Improvement Center (CIMMYT), and the University of Nebraska-Lincoln	Maize and others	Adaptation and mitigation	Kenya, Ethiopia, and Tanzania
CS13	Innovating for Resilient Farming Systems in Semi-Arid Lands of Kenya	The project aimed to develop and scale-up an approach to spur the adoption of agricultural technologies and practices known to be well-adapted to semi-arid conditions.	R&D	Kenya Agricultural Research Institute (KARI), State Department of Agriculture, Cascade Development, Freshco Seed company, Kenya Medical Research Institute (KEMRI), Farmer Groups and Provincial Administration, and McGill University	Amaranth, maize, greengrass, cowpeas, cassava, dolichos lablab, beans, sorghum and millet and indigenous chicken	Adaptation	Kenya
CS14	Kenya Cereal Enhancement Programme Climate-Resilient Agricultural Livelihoods Window (KCEP-CRAL)	To contribute to national food security and smallholder income generation by supporting farmers to increase the productivity and profitability of key cereal commodities in the ASALs.	Development	World Food Programme (WFP), International Fund for Agricultural Development (IFAD) and Food and Agriculture Organisation (FAO), and the Ministry of Agriculture	Maize, sorghum, millet and pulses	Adaptation	Kenya
CS15	Kenya Climate Smart Agriculture Project	Agriculture Sector Development Strategy (ASDS) (2010–2020) and National Climate Change Response Strategy (NCCRS, 2010). Objective: To increase agricultural productivity and enhance resilience in the targeted small-holder farming and pastoral communities in Kenya.	Development	Ministry of Agriculture/county line ministries of Agriculture (Marakwet County)	Maize, sorghum	Adaptation and mitigation	Kenya
CS16	Kenya Resilient Arid Lands Partnership for Integrated Development	The project aimed to increase water governance, access to WASH and livestock service, and improved rangeland management by the community.	Development	Catholic Relief Services (CRS), County Government of Isiolo	Livestock and crops (maize, sorghum, beans, poultry, and fresh vegetables)	Adaptation and mitigation	Kenya
CS17	Partnership for Scaling Climate-Smart Agriculture (P4S CSA)	Aims to develop globally applicable frameworks for CSA planning and implementation.	R&D	Consultative Group on International Agricultural Research (CGIAR), CCAFS	Value chains across crops and livestock	Adaptation and mitigation	Global/Africa/East Africa

Table 2. *Cont.*

Case #	Title	Objective/Description	Type	Organisations	Value Chains	Key CSA Pillar Addressed	Countries
CS18	Participatory investment planning for environment, water, and energy in the dryland of northern Kenya	The project aimed to inform Isiolo County's five-yearly plans and budge and catchment-level planning, and contribute to broader national planning debates, particularly around arid and semi-arid lands.	R&D	International Institute for Sustainable Development (IISD), Adaptation (ADA) Consortium, and Isiolo County's Ministry of Water, Energy, and Climate Change	Livestock, crops	Adaptation	Kenya
CS19	Regreening Africa	To scale-up evergreen agriculture using locally appropriate techniques, including farmer-managed natural regeneration to develop strategic decision-making for scaling.	R&D	ICRAF	Agro-forestry, crops, apiculture, and livestock	Adaptation and mitigation	Ethiopia and Kenya
CS20	Scaling Climate-Smart Villages	The project builds on the Climate-Smart Village project, which identified and tested a portfolio of Climate-Smart Agriculture (CSA) innovations. The Scaling CSA project explores innovations, institutions, and business models for building the network of Climate-Smart Villages in East Africa and supporting local adaptation planning.	R&D	CCAFS	Potato, sorghum, livestock	Adaptation and mitigation	Tanzania, Ethiopia, and Kenya
CS21	Scaling Climate Smart Agriculture CSA/Super	CSASuper bundles Villages Savings and Loan Associations (VSLAs) with farmer field business schools (FFBSs) to support small-scale farmers as a pathway to scale.	R&D	CARE International, International Centre for Tropical Agriculture (CIAT), Sokoine University of Agriculture, and WUR	Various value chains	Adaptation	
CS22	Strengthening Capacities to Implement Priority Actions for Food Resiliency in Tanzania	The project worked towards strengthening the capacity of public institutions in agriculture and natural resources to achieve agricultural resilience to climate change.	R&D	IITA, ILRI, IFPRI, ICRAF, Ministry of Agriculture (MoA) and the Ministry of Livestock and Fisheries (MLF) and Zanzibar's Ministry of Agriculture, Natural Resources, Livestock and Fisheries (MANRLF), Tanzania's Meteorological Agency (TMA), and the President's Office of Regional Administration and Local Government (PORALG)	Maize, rice, sorghum, pearl millet, beans, cowpea, bambara nuts, pigeon pea, sunflower, cassava, yam, and banana	Adaptation	Tanzania

Table 2. *Cont.*

Case #	Title	Objective/Description	Type	Organisations	Value Chains	Key CSA Pillar Addressed	Countries
CS23	Taking Maize Agronomy to Scale in Africa (TAMASA)	TAMASA aimed to use innovative approaches to transform agronomy through geospatial and other data, collaborating with service providers and investing in capacity building.	R&D	CIMMYT, WUR KU LEUVEN, University of Reading, Bavero University, International Plant Nutrition Institute (IPIN), Northern Zone Agricultural Research and Development Institute (NZARDI), and the Ethiopian Institute of Agricultural Research (EIAR), and IITA	Maize	Adaptation	Ethiopia and Tanzania
CS24	Tropical Fodder and forage Programme	The project aims to boost the adoption and integration of improved tropical forages targeting sustainable livestock production system. This is achieved through (1) genetics to improve forage yield, quality, stress resistance; (2) ecological to improve the management of forage systems; and (3) socio-economic to create enabling environments (markets, policies, social, and human capital).	R&D	CIAT	Forage and fodder seed	Adaptation and mitigation	Kenya
CS25	Upscaling CSA with small-scale food producers organised via VSLAs financing for adoption, behavioural change, and resilience in rural Iringa Region in Tanzania	The project worked to support the upscaling of gender equitable CSA/SuPER approaches with small-scale women producers in Iringa Rural District. Objective: Tests new rural development models to enhance agricultural and agri-business knowledge, provide access to finance and empower socially disadvantaged groups, and upscale adoption of CSA practices.	R&D	CARE, the International Centre for Tropical Agriculture (CIAT), Sokoine University of Agriculture, and WUR	Cereals	Adaptation	Tanzania

3.2. Data Analysis

We employed an inductive process for qualitative data analysis, using the Atlas.ti9 coding scheme [69,70]. The analysis was guided by the research questions described in Section 1 and further informed by the conceptual framework in Section 2. Each case study was then evaluated qualitatively regarding the degree to which it addresses each of the four research questions mentioned above. The first round of analysis in Atlas.ti9 involved the coding of the typical and most-often mentioned elements relevant to the questions above, as expressed by the respondents. The second phase merged codes that had a similar message but were coded differently. Finally, the codes were categorised according to commonalities, or whether the statements spoke to a particular theme or general element. For example, living labs, technology testing, and farmer field schools were grouped under piloting. Additionally, business models, institutionalisation, capacity building, and sequencing, integration and layering (SIL) were grouped as scaling pathways (see code frequencies and grouping in Annexe ii). Given that this was exploratory research, the codes and code groups were not categorised in terms of importance, but their frequency distributions and how well they answer the research questions formed the general thematic areas described in the results section.

4. Results

4.1. Operalisation of Scaling of CSA Projects in East Africa

There is mixed understanding and views on the scaling of CSA among the interview participants (Table 3). These perceptions have a direct influence on the scaling process. Interviewees in 15 cases reported that scaling happens by disseminating successful interventions from pilots.

Table 3. Perceptions and views on scaling.

Views/Perception	Type of Scaling	#Cases	Quotes of Respondents Illustrating Their Views on Scaling
Dissemination of results/replication and expansion	Horizontal	19	But then we got a two-year continuation specifically for dissemination (Annexe iii, PG45). Scaling is easy because in the sense that as long as you have budget, you can increase the scale all the time. It is a matter of employing more people and doing the same thing in more places (Annexe iii, PG129).
Securing a new phase of the project	Horizontal/vertical/functional	8	The project is ending this year, actually, but I think the main implementation is ended, but they are extending the project. They created a new project from it, so it will continue in a way under a different name (Annexe iii, PG94)
Developing partnerships to continue with the projects	Political scaling up expands political support (building a supportive network)	22	We linked the group to the county government through the KCSAP project to promote CSA interventions in cereal production, poultry, and small ruminants. WFP came with nutrition components promoting backyard gardens and fish farming (Annexe iii, PG3)
Adopting a programmatic approach	Horizontal/vertical/functional	12	Scaling is embedding successful interventions to other existing projects and with different partners. That way, the impacts are incremental and sustainable (Annexe iii, PG126).

Respondents in 19 cases noted that scaling would be achieved through result dissemination, often from pilots or doing the same thing in different places given an adequate budget. In 8 cases, respondents mentioned that scaling happens when they secure a second phase of the project. This technology-oriented approach tends to narrow the focus on the scaling process and downplay the importance of understanding local farming circumstances. Even though scaling can be achieved through increased incentives, sustainability is only guaranteed when local delivery mechanisms have self-generating financing. Despite its shortcomings, the technology transfer approach has still dominated agriculture research for development. In 22 cases, it was noted that successful scaling would require forging partnerships and networks from the public and private sectors. Acknowledging the time frame needed for scaling, respondents in 12 cases proposed adopting a more programmatic approach with incremental impacts, where projects are embedded into the existing system/programmes for continuation.

4.2. Strategies Facilitating Scaling of CSA Solutions

A mix of strategies was adopted by cases to advance scaling (Table 4 below). Scaling followed the technology, testing, promotion, and scaling approach common among development projects. Twenty cases followed the piloting approach. This process builds on past lessons, using the experiences of previous interventions that have worked and seeking to refine/adjust those that have not worked based on field and implementation realities. Pilots took the form of the farmer field school, a few on-station research projects (CS10) and living labs, e.g., cases CS2 and CS9. A living lab is a real-life place where users (stakeholders from business, society, and academia) co-create innovations in knowledge, products, services, and infrastructure [71]. Pilots often adopt participatory approaches, with platforms/networks as a key component.

Table 4. Scaling and sustainability of the process in projects.

Scaling Strategy	Sustainability	Cases
Piloting technology testing and transfers through farmer field schools, farmer business schools, and living labs	Farmer-to-farmer and community extension system	CS4, CS5, CS7, CS8, CS9 CS10, CS11 CS12 CS13, CS14, CS15, CS16, CS19 CS20, CS22, CS23, and CS24
Capacity building	Institutionalisation	CS1, CS2, CS3, CS4, CS5, CS7, CS8, CS9, CS10, CS11, CS12, CS13, CS14, CS15, CS16, CS17, CS18, CS19, CS20, CS21, CS22, CS23 and CS24
Partnership	New components/phases or projects are embedded in the existing partner system for continuation	CS3, CS4, CS8, CS13, CS17 and CS24
Business models/champions and PPP value chain approach	Market system	CS1, CS2, CS3, CS4, CS6, CS8, CS10, CS11, CS13, CS15, CS16, CS19, nd CS25
Curriculum development	Institutionalisation	CS4, CS8, CS9, CS10, CS11, CS12, CS16, CS18, and CS22
Policy advocacy	Systemic changes	CS3, CS4, CS8, CS11, CS13, CS14, CS16, CS18, and CS22,

In every case, respondents emphasised the need to forge and strengthen partnerships and networks to boost and sustain scaling. The cases demonstrated different functions that networks could play in the scaling process, also reported by [28]. Firstly, platforms help identify local challenges and develop solutions for their feasibility, e.g., in CS9, CS10, and CS20. Secondly, in CS18, stakeholders with different expertise from different contexts and experiences vote on a given innovation as a way of approval. Thirdly, the cross-fertilisation of ideas in the CS18 Farmer Managed Natural Regeneration (FMNR) model was picked up by Catholic Relief Services. They developed it into a whole project in a different geographical area: see [29]. Finally, networks can form the channels for scaling. For example, in CS3, scaling occurred through the networks established by the Tanzania staples value chain (NAFAKA) and other institutional grassroots organisations, and mainstreamed into wider rural development programs.

Several cases employed the sequencing integration and layering (SIL) modelSequencing inlvolvedphasing interventions through different projects or partners often in the same location. Interventions can also be integrated with different aspects of other projects or rolled out in a layered manner where introduced interventions re-enforces previous effort. The model is incatalytic and fuels scaling by capitalising on synergy and tapping on pooled resources (CS12, CS10). SIL enables the incorporation of different networks, projects in different locations, and components to existing models or processes (Annexe iii, PG97). In CS14, the project was a combination of two projects (the Kenya Cereal Enhancement project and the Climate-Resilient Agricultural Livelihoods project) which targeted the same area. Consequently, the IFAD and FAO partnership resulted in increased financial contributions from EUR 30 million to EUR 153 million, expansion to other counties/geographical areas, the leveraging of more partners, and an increase in the number of beneficiaries (Annexe iii, PG51). In CS15, some of the infrastructure, e.g., farmer groups, was handed over from an ending project, the Livestock Management project in Isiolo. The project incorporated peace and security and CSA components by collaborating with the county government implementing the KCSAP project in the same area. Coca-Cola, the KCB Foundation, and Acacia water came as private entities with business models to improve Water Hygiene and Sanitation (WASH). Different organisations spearheaded the project in each of the four counties in which it operated, including World Vision, Catholic Relief Services, and Care Kenya. Most of the formal womens' groups were merged to form stronger co-operatives, and toward the end of the project, they were registered as businesses. The World Food Programme joined to support nutrition aspects through the same groups.

> *"Many of the results and lessons learned during the Food Africa programme are being integrated into other ongoing work of programme partners."* (Annexe iii, PG68)

Associated with platforms and SIL is capacity building, in order to equip players with the technical skills needed for effective scaling, as reported in eight cases and familiar in development projects. As mentioned earlier, the sustainability of the scaling process can only be guaranteed if the process is locally driven and the leadership is competent and influential enough to push on with the process.

> *"Farmer Business School is a participatory extension approach that helps farmers build skills necessary to increase production, access markets and sell at competitive prices, collaborate, and engage in beneficial and efficient decision-making."* (Annexe iii, PG50)

Apart from embedding scaling in existing platforms and capacity building, institutionalisation took other forms during this study. For example, some cases (CS4, CS7, CS8, CS13, CS16, CS17, and CS22) helped in curriculum development/adjustment for tertiary colleges/universities or government training institutions to incorporate interventions' knowledge and experiences to empower current implementors and potential future decision-makers. It is assumed these individuals will occupy positions of influence and thus can be conduits for scaling. It is also expected that existing institutions will then scale using their resources and systems—for example, the development of a climate fund governance structure to support climate-smart agriculture, i.e., in case C18.

> *"Project results have been included in the curricula of the major regional veterinary science University of West and Central Africa, ensuring they will lead to improved capacity of coming veterinarians and, thereby, be disseminated to key stakeholders beyond project end."* (Annexe iii, PG88)

The business model approach was adopted in 12 cases that had business elements (components that can be commercialised), for example, seed production and distribution (CS3, CS11, CS13, CS14, CS16, CS19, CS22, C23, and CS24), fertiliser management, i.e., fertiliser, and soil testing (CS12 and CS23) and processing (CS1). Respondents reiterated the need to ensure proper linkage with the private sector to increase access to innovations, enhance adoption, and boost scaling.

Respondents in seven cases noted that scaling could be bolstered by creating publicity: CS22, CS20, CS14, CS13, CS10, CS9, and CS8. CS12 used media (radio, TV) to share success stories creating interest that enabled them to forge other partnerships, e.g., with another project, CASCADE. As a result, other farmer groups made inquiries, and the demand for farmer field schools increased and was expanded to areas originally not targeted by the project. CS17 invested in a good communication and consultation system using the stakeholder platforms. This method partly contributed to expansion to other counties/regions that also demanded similar models/projects. CS13 also invested in MEL, shared with donors, and leveraged resources, resulting in an amalgamation of the KCEP and CRAL+ projects, and attracted different donors to their programme.

> *"Communication and sharing of results through media were effective in scaling, and that was not through a million people going to a workshop for a week. That was through good communication."* (Annexe iii, PG82)

In half of the cases, respondents stressed the importance and challenges of creating environments suitable for scaling. For example, in CS13, part of the interventions involved the value addition of sorghum and cassava, e.g., sorghum bread. However, there were no standards for such products under the policy regulations at the time. The project then worked with line ministry and departments to assess and aid in the development of necessary policies and regulations.

> *"You really have to have the institutional stuff in place, and whether you call it the value chain or whatever you call it, but the enabling environment, you also need all of the pieces you have to think about that at the start."* (Annexe iii, PG12)

4.3. Enabling and Hindering Factors That Influence Scaling in CSA Projects

The scaling of CSA generally requires a combination of different activities [55]. Among them are the technologies promoted as a bundle, where an anchor and complementary technology are combined for effective impact [72]. However, the cost of adopting technologies is often increased when bundled, and combined with other bottlenecks, including time, labour, existing supply, and value chains, creating a barrier to adoption. Respondents in CS3, CS4, CS9, CS10, CS12, and CS21 reported challenges in access to seed (which was the anchor technology). Consequently, the adoption of complementary technologies was also relatively low, e.g., irrigation, impacting scaling negatively. In response, adopters only invest as much as they can afford, balancing their needs and priorities (Annexe iii, PG4). On the other hand, some practices are accessible and/or carry multiple benefits, and thus are easy to scale.

For example, CS14 employed a push-pull technology as part of an integrated pest management strategy where legumes were used as an intercrop. The legumes doubled as livestock feed, human food, and soil fertility enhancement, benefits that saw an increase in uptake of the technology.

In 20 cases, a partnership was established with public institutions, creating networks for policy adjustment through multi-stakeholder platforms. Some of the projects reported investment in the capacity building of strategic staff to help in scaling. Sometimes, these staff were transferred, and project implementors had no control of the internal dynamics of organisations. For example, in CS10, where 50% of the 325 extension workers were replaced every year (Annexe iii, PG6). Staff stability, internal decision-making mechanisms, and behavioural aspects strongly affect the performance of stakeholder platforms and could potentially dictate the pace of scaling. To incentivise the private sector, interventions must be technically feasible and commercially viable to allow scaling through business models. For example, in CS23, to promote better fertiliser application rates spatially and achieve environmental benefits, about 11 fertiliser blends were proposed for a district in Ethiopia, given the spatial heterogeneity. However, it was not commercially viable for fertiliser companies to formulate all the blends, as the demand per unit of the blend could not meet the critical mass. In CS13, the availability of drought-tolerant seeds was one of the means to scale. The Kenya Agriculture and Livestock Research Organisation (KALRO) ensured market linkage with the Freshco Seed company, who would buy from seed multipliers/producers for treatment and re-distribution. However, the model was unsuccessful because not enough farmers went into seed production in order to meet the contractual demands to justify continued investment once the provision of seeds was stopped with the project's maturity. Additionally, unless the innovations can influence the dominant policies, procedures, and practices relevant to operations, they may not be sustainable.

Creating an enabling environment was considered necessary for scaling by 50% of the respondents. Those cases involved some form of policy advocacy, e.g., in CS11, traditional non-commercialised crop varieties suitable for local conditions had no foray into the formal seed sector, and no policy framework to support their production. Thus, their main focus was to mainstream seed sector efforts to scale farmer-preferred crop varieties. In some cases, political will was needed to foster change (CS4), and the process takes time given the level of stakeholders involved, especially if there are differing opinions (Annexe iii PG36). In CS23, even at closure, the project had not secured commitment and buy-in from the

Ministry of Agriculture, despite a lot of effort and time (Annexe iii, PG88). Respondents in CS16 also mourned the amount of time and effort needed to develop bills and pass them into policy. There was also no guarantee for budget allocation to implement the policies within the project time frame (Annexe iii, PG88).

> *"Governance and policies are vital for scaling. Political interests may affect scaling if they are not in sync. In that case, politics is the biggest undoing in scaling. So, having a political will is very important. The process of getting influential policymakers also takes time."* (Annexe iii, PG55)

Results show that the SIL model has been applied in many more development projects, in the real sense, than is reported. Two examples are CS12 and CS14. Though SIL has had a positive effect, few have documented the negative impact of subsidies on scaling. The sustainability of programme interventions rarely goes beyond one year after project closure. In CS12, the project implementors, having established infrastructure and scaling systems, assumed beneficiaries would push forward. However, they observed declining numbers of active participants towards the end of the project. It was established that group members belonged to different groups, sometimes 3–4 others. The positive side is that it is easy to pass information by taking advantage of the network. However, the downside is that members often move on to new projects, possibly because subsidies are offered during initial phases, creating a dependency syndrome (Annexe iii PG45).

> *"The expectation of direct financial benefit kills innovation in itself because there is a lot of dependencies syndrome even for us as project Implementors."* (Annexe iii, PG47)

Building infrastructure for successful scaling takes time, especially where policy issues are involved. There is generally pressure to deliver scaling in a project mode, yet successful scaling is a long-term affair. For example, respondents in CS14 and CS23 reported that it took about ten years to start producing substantial evidence of the impact of their interventions. Other scholars have emphasised the need to think long term in scaling [11,39,73] as this may have a direct effect on resource requirement and stakeholder engagement, which are necessary components in scaling.

4.4. Consideration of Climate Change, Bio-Physical Aspects, and Spatial Elements in Scaling

The main focus of the cases was on the productivity and adaptation pillars. Only two explicitly mentioned mitigation as part of their objectives (CS5 and CS18). On the other hand, 60% of the cases incorporated some elements of mitigation, for example, the use of solar water pumps (CS15), solar driers (CS1, CS8) and zero tillage systems (CS21), and efficient fertiliser use (CS23). Only CS8 and CS9 investigated the biophysical benefits and trade-offs of tested CSA technologies to generate evidence for scaling. However, for effective scaling, the authors of [74] suggest proper identification of synergies and trade-offs between food security, adaptation, and mitigation at different scales. For example, in CS9, irrigation would be unsustainable in the long-term due to a mismatch between water demand and the capacity of water resources.

> *"This suggests that the longer-term policy of the government should be to reduce irrigation intensity in the Niayes region and increase it elsewhere in the country where there are more abundant resources to support."* (Annexe iii, PG127)

Additionally, an innovation or its components may fit (be appropriate and scalable) in one context but not another [75]. Therefore, the spatial assessment of suitability is essential. For example, in CS23, business models around fertiliser blends were developed based on a spatial fertility management system.

Despite the significance of the future climate on a smallholder production system [76], and therefore scaling [77], only three cases considered climate change. First, in CS20, the climate analogue model was used to compare sites with similar future climates to promote cross-site learning and scaling of interventions (Annexe iii, PG37). Second, CS2 developed a climate change atlas to indicate the potential impact of climate change on tomato and maize crops in the two regions in which they were working. Finally, CS24 identified and subjected potential fodder production areas to future climate change in order to inform breeding needs.

4.5. Sustainability in Scaling

Embedded in the different scaling strategies mentioned in Section 4.2, the cases attempted to build systems to sustain the interventions. Different challenges were identified through a participatory process, and suitable solutions were proposed. In total, 95% of the cases were engaged in partnerships where capacity building was prominent, especially those working with the public sector. Through the training of extension workers, the cases hoped to institutionalise the scaling process in the public system. Respondents in seven cases went ahead to revise and develop a curriculum integrating CSA for training and extension to have a wider reach, for example, vocational training and universities: see also [29]. They created platforms that provided access to different services, expertise, and resources [17]. According to 13 respondents, several cases used such platforms and partnerships to advocate for policy changes. For example, CS11 advocated for including farmer-preferred seeds in the then-seed policy.

> *"Sustainability is embedded in the County legal framework and community ownership."* (Annexe iii, PG26)

Eleven cases employed a business model that promoted and built the scaling process based on market systems. Adopting the SIL model helped farmer groups and cases exploit additional expertise and learning, as well as the exposure to myriad financial resources often considered a weak link [31]. CS25 included revolving funds system at the community level, where individual/groups of farmers would borrow and return (with interest) money in a joint kitty.

> *"So in our view, we don't want to say that when the pump breaks down, we don't know where to go to get the spare."* (Annexe iii, PG20)

Few (four) cases employed spatial frameworks in managing natural resources to minimise trade-offs in their interventions. CS23 struggled with making agronomy more productive and spatial (Annexe iii, PG2). CS23 proposed a policy change to shift irrigation from one location to another to avoid the overexploitation of underground water reserves. CS16 identified the best location for boreholes and designed a spatial framework for managing rangelands (Annexe iii, PG103). Such spatial framing would best answer scaling questions such as 'how should water use be prioritised between small scale irrigated private sector investors [78]?

Factoring in the smallholders' context increases the chances of success of a scaling strategy. The work in [38] proposes a stratification of smallholder farmers into three categories of subsistence, transition, and commercial with different landholding, livestock, labour, and financial capital endowments [79], thus demanding varying support and determining the relevance and feasibility of innovation options. For example, disinterest, or partial or complete modification of agronomic innovations may be due to competing uses of limited resources [80], or changes in support by external interventions [81]. Smallholders may also prioritise innovations with immediate benefits over long-term benefits, which sometimes may be at the expense of food production [82]. Moreover, Snelder et al., (2017) indicated that 29% of farmers depend on off-farm activities as a risk management strategy [83]; such farmers are less likely to adopt CSA.

Responsible scaling [27], especially when looking at the long-term impact, is an important consideration to avoid the potential negative social and environmental impacts [45]. In CS4, farmers used dangerous pesticides during the scaling process, which was therefore unstainable. Cavanagh et al., (2017) also cautioned that some agroforestry trees might compete with crops for water, and nutrients may not be not well spaced even if well intended.

> *"Pest management became an issue like in the testing phase everything went well, but when we came to scaling, we saw that farmers were using hazardous pesticides, which is a negative effect that we didn't really incorporate at the beginning."* (Annexe iii, PG130)

5. Discussion

5.1. Scaling in Practice

The goal of CSA is to address the fundamental concomitant challenges of food security and environmental sustainability under climate change conditions. However, scaling CSA has remained one of the critical challenges to achieving a sustainable impact. The 25 cases represent research, research and development, and development projects undertaken in different geographical and climatic conditions in East Africa, primarily focusing on smallholder farming systems. The cases adopted different scaling strategies and models, including business models, institutionalisation, public-private partnerships (PPP), farmer field schools, value chain, policy advocacy, and those that are technology-oriented, as well documented in [21,54]. Generally, the scaling strategy employed depended on what was being scaled. For example, scaling new innovations favours piloting, e.g., through farmer field schools. Strategies aiming to create a conducive environment work best through policy dialogues and stakeholder engagement in networks and partnerships [84]. The case study results underscore the importance of having a scaling strategy from the start, as also suggested by [49]. The strategy should be flexible to allow for iteration, and map potential stakeholders to drive the process (Annexe iii, PG59) as reported by the respondents in cases CS13, CS23, and CS4. Additionally, ref [52] further suggests exposing the strategy to real field contexts allowing for the evolution of the scaling process to adapt to the local dynamics.

The case studies show that pilots were the starting point and remained core to any scaling process for almost all the cases. Pilots offer valuable context-specific information [10]. However, they come with challenges. Wigboldus and Leeuwis (2013c) note that pilots often follow a sequential process and may not capture the complexity of scaling in reality. Given their small size, the strategy may not be ideal for initiating regime level stakeholder engagement [9].

Networks and platforms are strongly linked to pilots. In total, 95% of the cases adopted platforms in their scaling, which underpins their significance. These platforms and networks allow for stakeholder engagement and act as capacity building and policy advocacy channels. Scholars have demonstrated that networks are critical for scaling CSA [85] due to social learning among multiple actors [46] and gaining social capital [86]. Van Loon et al., (2020) reported that the lack of such platforms could be a bottleneck for scaling.

The success of such platforms depends on the mutuality of interest among individuals [49], having solid champions of the ideals of the process, and the transfer of responsibilities to enhance local ownership [52]. Smallholders in East Africa often have extended formal and informal networks, e.g., village saving groups. Their interaction between these two categories shapes their decision making and can influence scaling [39]. For example, Seifu et al., (2020) reported that informal channels effectively informed regime administrators about their innovations which helped in scaling. Similarly, in CS13, some of their scaling success was achieved through information exchange via informal channels. Members of farmer groups belonged to other different groups. For example, less tangible elements, values and culture, which potentially influence scaling, are expressed more through informal networks [49]. Contrastingly, by the time of the interview, the number of members dwindled in the farmer groups in CS13, and those who remained were indifferent. In contrast, in CS16, members increased, and an umbrella group was formed to coordinate different activities in the groups. At the same time, the membership moved from informal groups to registered businesses. The only difference was that, in CS16, the group existed before and was formed as a support mechanism for mothers and children, while the group in CS13 was formal and the project bonded the members.

From a resource perspective, partnerships and collaborations expose projects to the diverse expertise and funding streams necessary to sustain scaling [87]. The SIL model, for example, is hinged on partnerships where each successive project intervention is built systematically on the preceding project to create a cumulative impact to reach the scaling goal. For example, in CS16, the Mwangaza women's group was handed over to the Livestock Sector Strengthening project case. By the time of writing, the group was being handed over to WFP and was incorporating aquaculture. As a result, the group expanded by incorporating other smaller groups and diversified economic activities, including training. Most importantly, they grew from social support groups to registered business enterprises.

Capacity building was a vital component of the networks in the cases, and has been shown to enhance their effectiveness [88]. The purpose was to create a shared understanding of the interventions, empower stakeholders, and institutionalise the scaling process. To reach more practitioners due to the increasing demand for County Climate Change Fund (CCCF) mechanisms from other counties, CS18 (which was the pioneer project before CS14), developed a curriculum with tailored training in collaboration with the government training school. Van Loon et al., (2020) also noted that the integration of training materials in vocational training schools proved effective. Many cases used the same platforms to advocate for policy changes. For example, in CS14, the CCCF mechanism piloted in two counties in Kenya was embedded in the county legal framework and expanded to six counties. Other scholars have also reported similar success [88–91]

Business models as a strategy were adopted by half of the cases. Better market systems catalyse new technologies' adoption, replication, and dissemination [92]. However, the private sector focuses on interventions that can be monetised, where the market is guaranteed, such as certified seeds and fertilisers, unlike intercropping or planting on time. In CS13, despite linkage with the Freshco seed company, a source of the inputs and outlet market, due to the low number of farmers willing to engage in seed multiplication, the company did not find it feasible to continue with the business in the area. Due to the nature of their operation (profit-driven), the collaboration between smallholder farmers and the private sector tends to be relatively weak [29]. The private sector focuses on commercial components of projects that take longer to mature, and may not address gender and equity. For example, in CS23, part of the business model involved soil testing as a business element. Respondent reported that the business was mainly picked by men, who had access to motorbikes, could afford initial equipment, and had fewer household responsibilities, unlike women, and therefore could stay out in the field for longer.

Publicity acted as a pull to scaling. For example, in CS13, widespread awareness creation led to partnerships, businesses, and market linkages built through inquiries about the project. The case was built on the farmer-to-farmer extension model to reach scale. However, creating awareness through the media increased the spatial coverage and hence the number of farmers reached and the scaling rate. Monitoring, evaluation and learning (MEL), and publicity have been proven effective in scaling [93,94].

5.2. Scaling Strategy

Through a mixture of strategies, our results show that scaling is a dynamic and complex process that will require not just one but a combination of strategies at once to steer the process to the point of being driven by the regime [49]. In addition, many scholars have stressed the importance of addressing the non-technical aspects of scaling, including financial resources, social networks, political contexts, and institutional aspects [30,95,96].

Many cases favour pilots; however, they tend to treat scaling as a sequential process, limiting their ability to transition to scale [39]. From an ecological perspective, the evidence from niche experiments should form the basis for developing options targeting regime-level scaling, factoring in resource-use interlinkages. Ideally, the scaling strategy should be developed upfront; therefore, scaling should form part of the implementation rather than be treated as an independent phase [52,97]. Robust spatial frameworks can aid the scaling process and ensure that CSA innovations are relevant in local and larger spatial domains [98], as well as allowing for spatially-targeted investment in a landscape [11]. Loon et al., (2018) reported how such a spatial framework had been used in Mexico and Bangladesh to pinpoint areas with a high potential for machinery sales, using geocoded information on wealth and cropping patterns. Lastly, partnership is a significant pillar in any scaling infrastructure, a point also stressed by many scholars [11,28,75]. However, building a cohesive front aligned to actors' interest is a tedious and lengthy iterative process, especially in an agricultural setting, and more so in a smallholder context (Annexe iii, PG12). The proposed solutions ought to be beneficial and sufficiently relevant to their lives. The process requires long-term planning backed by sustainable financial models. Case 17 is an excellent example of demand from the local government to develop the CCCF, which is now embedded in the county's legal framework.

Networks and partnerships are crucial components in scaling. According to Spicer et al., (2014), creating an enabling environment through policy dialogues can be achieved through effective networks. Totin et al., (2020) suggested that innovation platform activities should align with political agendas to increase the chances of success. However, depending on the level of maturity and resource control within a network, some important stakeholders may be crowded out, resulting in a non-inclusive process [99].

5.3. Hindering and Enabling Factors

Scaling occurs simultaneously at three levels: farm level, programme and community level, and regime level. The hindrance and enabling factors of scaling can be considered at these levels. The anchor and complementary technologies are sold as a package in CSA innovation, and the economic benefits are often only guaranteed under full adoption [100,101]. Despite the complement of innovations in the package, farmers rarely apply the whole package [9] due to various factors, including access to the whole package of technologies [89,102] asset base [90], adopter's perception and preferences [91], gender [103,104], and the relevance of the innovation to the target context [75]. In certain cases (CS1, CS3, CS4, CS8, CS10, and CS13), seed availability and CS12 fertiliser were the anchor technologies, and were the key barriers to scaling. In this study, the focus of the cases was biased towards crop value chain (21); three cases had a combination of livestock and crops, and one maintained livestock alone.

In most cases, smallholders operate in mixed farming systems resource flows between the subsector; therefore, their performance is interlinked. Consequently, scaling targeting smallholders must include a broader conceptual understanding of their system to succeed [33]. Additionally, the production pillar of CSA tends to overshadow the other pillars due to the short-term benefits associated with such efforts. In some cases, an overemphasis on production has resulted in better yields, but farmers have halted adoption when faced with the challenges of the market dynamic and institutional failures [9]. Household food security is also related to innovation in complex and possibly bi-directional ways. Food-insecure households are likely not to adopt innovations [105].

Scaling demands a contextual understanding of the niche, both biophysical and socio-ecological, and processes' interactions [11]. For example, gender issues are typically quantitatively captured (number of participants by their gender and age) in projects. However, the qualitative aspects, e.g., perception and roles that could affect scaling, are often missing. Lal (2016) noted that CSA options leading to a shift in crop mix or management practices might result in disproportionate labour or more income for a particular gender. Farmers have been faced with trade-offs between adopting a permanent soil cover as part of conservation agriculture and the need to feed crop residue to livestock [106], or the competition for available labour between on-farm and off-farm activities [80]. Farmers without or with little land tend to favour off-farm income [26]. Wealthier farmers can afford to purchase a whole CSA package and maximise their output [102]. Shikuku et al., (2017) also reported that cases of food insecurity in households and its perception negatively affected the adoption of innovation. These issues point to the complex and dynamic factors that influence decision-making in smallholder systems with the potential to affect scaling.

Technology-oriented interventions require technical backstopping, flexibility, and a high level iterative process that eats into time [107]. Technology-driven scaling undergoes testing through pilots set up and managed in very controlled environments, thus facing unforeseen bottlenecks when scaled to actual field conditions. For example, subsidies act as incentives for adoption [108] but can create an environment of dependency on donor funding that negatively impacts scaling. Kisekka et al., (2017) reported that farmers were waiting on the project to finance their activities, despite training and financial and market linkages. Similarly, in CS12, beneficiaries belonged to 3–4 farmer groups. Though the information flow was effective, an incentive to go to scale was low because farmers jumped from one project to the next depending on the stage, and therefore the number of subsidies provided [109]. Towards the end of projects, there is a high dis-adoption rate due to a reduction in support based on the assumption that scaling infrastructure is mature and can self-sustain [108]. Two approaches were employed to test the sustainability of interventions minus subsidies. In CS13, project and beneficiary contributions were reduced and increased respectively with time, with the latter expected to meet 100% of the cost by the project's third year. In CS15, the project adopted a facilitative approach where beneficiaries were expected to initiate engagement for specific support, and facilitate the logistical needs of the project team/extension if needed. These two approaches tested the target groups' resilience and motives for adoption, and could act as an antidote to the dependency on external support, e.g., donor funding.

The pressure for pilots to succeed [52] leads to an exclusivity in scaling, where the project tends to select households that are likely to adopt [102]. These are the most progressive farmers who may not represent the potential target group [52]. This bias means that the innovations are not subject to realistic field conditions for their scalability to be assessed. Respondents in CS13 belaboured the need to develop a scaling strategy early in the design phase. This gives the advantages of identifying strategic partnerships and pathways, and scaling forming part of the implementation, significantly increasing the chances of success. The lack of a scaling strategy upfront is partly responsible for the low number of projects that ever reach the intended scale [52].

Furthermore, staffing instability in partner organisations negatively affects the positives derived from capacity building and institutionalisation processes [49]. For example, in CS10, half of the 325 Kabele extension workers were transferred during the project period. The project found it challenging to train a new person with every transfer.

Additionally, farmers can be stratified based on resource base, affecting labour dynamics at the community level. For example, poorer farmers work for wealthy ones.

In market-led scaling, e.g., in CS1, business champions working in the same value chain were expected to work together to benefit from value chain transformation, which meant sharing a scaling strategy. However, businesses see each other as competitors and achieving a collective impact is challenging. Additionally, the power imbalance between the business champions and the project meant that the prioritisation of activities was different, as the business constituted a tiny portion of their income. Champions with small businesses tend to tailor their priorities to project requirements, and are likely to re-focus on their pressing needs, consequently hindering scaling.

Building infrastructure to scale takes time, and given that the average lifespan of the projects under study was 3–4 years, there was little time to test scalability and sustainability. The reported success cases have estimated that it took an average of 10 years to go through technology/model testing, promotion, refining, and deployment iteratively through the sequential build-up of projects (e.g., in CS24), a time range also reported by Prain et al., (2020). Cooley and Kohl (2016) estimated that the scaling process could take upwards of 15 years.

As the levels of scale increase, there is more need for vertical collaboration, requiring prolonged investment in forging stakeholder coalitions, market development, and policy advocacy [11,39].Apart from finding the right strategic partners, coordination between them, and synchronising their separate activities becomes challenging [53]. At this level, political, economic, cultural, or social considerations are necessary to scale [30]. Participatory approaches allow for more integration and capture diverse views from a wide range of stakeholders [28]. Cases that focused on creating enabling environments through policy advocacy demanded and benefited from such an approach. However, the development of plans, bills, and policies does not guarantee scale but rather their effective implementation. For example, in CS16, through policy advocacy, three bills were developed to effect sustainable rangeland management by adopting the CSA approach at a regional level (three counties). However, their implementation depended on mainstreaming climate change and CSA into county development plans, and being actualised by budgetary allocation, which in six years had yet to be attained. On the flip side, CS18, a more demand-driven policy intervention, took longer to develop appropriate policies and financial instruments, i.e., theCCCF. However, the Isiolo County government integrated and scaled the CCCF once money was allocated. The same model was demanded by, and replicated in, five other counties.

In most cases, a poor understanding of the context of smallholder farmers by donors and development organisations leads to the well-intended but blind promotion of CSA packages [110]. In our study, 70% of the cases focused on crop value chains. In the context of developing countries, smallholder farming, crops, and livestock production are mutually inclusive, and decisions often see a cross-flow of resources. For example, sometimes livestock are sold to buy crop inputs, animal power is used in land preparation, and crop residues are used as animal feed. This should lead to a greater acknowledgement of the importance of understanding the context for scaling agricultural innovations [107]. However, suppose they and their donors aim to improve the livelihoods of the poorest of the poor. In that case, it is crucial to acknowledge the underlying social and political causes of persistent poverty in poor rural areas. Ignoring this context perpetuates, and perhaps even reinforces, the status quo [102]. The context-specific nature of CSA [10,21] requires that a diversity of options are developed for the various contexts across scales [21]. However, the development of these scalable options is curtailed by the complexity of the agro-ecological and socio-economic landscapes.

A good example is CS23, which aimed to develop spatially appropriate fertiliser blends in Ethiopia in partnership with fertiliser companies. Even within a district, the spatial diversity led to a recommendation for 11 different blends. The fertiliser company would not find a business case (market size) for the high number of blends for a small region.

5.4. Sustainability

There were no reports on the environmental sustainability of interventions except in the CS9, which demonstrated why and how such consideration could have a significant impact on scaling.

Smallholder agriculture is predominantly rainfed, and therefore a combination of various stress factors and climate change makes adoption unpredictable and, therefore, difficult in developing a scaling strategy [39]. Different models were used to assess and integrate climate knowledge in the cases, e.g., climate gaming using historical profiles (Annexe iii, PG37). In practice, the infusion of future climate scenarios in projects is still low (considered in only four cases), yet could be a significant factor in scaling. For example, parts of the East African region could experience increased precipitation [111]. On the other hand, Ochieng et al., (2016) suggest that a temperature rise could be more critical to crop production than rainfall, especially in Kenya. In many cases, drought formed the basis for interventions. Consequently, given the paradox in predicting the climate in East Africa, there is a chance that adaptation strategies are based on assumptions, with potential consequences on scaling, albeit model uncertainty [24]. The need for better quantification of uncertainties focusing on climate hotspots has also been stressed [112].

The literature links sustaining scaling to financial sustainability [94,113]. Business-based models must demonstrate profitability to attract private partner(s), and commercial viability sustains their engagement [114]. A cost-benefit analysis was used to demonstrate financial sustainability. However, it was not possible to establish to what extent subsidies were taken into account. Business models will be successful where there is a business case-assured potential new market with systems in place to amend the market challenges [115].

At a regime level, two potent forces that control the scaling process emerge. First are the technological aspects, including biophysical and social aspects, e.g., stakeholder governance [50]. However, many of these frameworks have emphasised the means (systems, policies, organisation, and processes) aspect of scaling. In contrast, biophysical aspects seem to be neglected, yet sustainability and scalability depend on managing both aspects [22].

Mismatches between the scales of ecological processes and their management [75] have implications for scaling. Bio-physical heterogeneity, gender roles, and equity issues tend to be blurred at larger spatial scales [21]. Spatial frameworks have been used to (a) explore multiple sets of spatial data as in CS3 [98]; (b) maintain local specificity even at the larger spatial scale [23]; (c) detect spatial patches of heterogeneity, multifunctionality, and trade-offs associated with CSA innovations [22]; (d) track changes in socio-ecological processes in socio-ecosystems across scales and different climate change scenarios [20,116,117]. The potential for infusing such frameworks in scaling remains largely unexplored. For example, in CS9, groundwater depletion due to increased irrigation prompted a recommendation for policy changes to shift production to areas with more water resources. Spatial issues such as the impact of such shifts on the environment, and socio-economic factors in diverse agro-ecologies given different climate scenarios, must be addressed [88].

6. Conclusions

Scaling for impact is one of the significant challenges CSA innovation must address. This study sought to shed more light on how CSA is scaled in the East African context, identify gaps and entry points, and contribute to the scaling discourse. Our results show that scaling is a complex, dynamic, and slow process overlapping technology and socio-economic dimensions. There appears to be no single recipe for scaling, but rather a complex transformational and incremental change, a science and management process requiring changes in institutions, leadership, time and funding for learning, and room for experimentation. Stronger partnerships, stakeholder engagement, institutionalisation, and capacity building are promising aspects of scaling. Some cases demonstrated the need for a deep understanding of scaling needs and context, as illustrated by the components of the scaling infrastructure built around their interventions. Despite this, there is still little evidence of sustainability in scaling practices. The situation begs the question of whether those efforts are answering the right question? However, the work has highlighted four areas of concern that scaling ambition should consider going forward: (i) There is little consideration of the smallholder farming context to underpin scaling. Scaling should understand what the end-user values, needs, and prioritises; (ii) climate data, projections, and impacts models are rarely applied to support scaling decisions. The sustainability of scaling has socio-economic, ecological, and spatio-temporal dimensions; (iii) considerations for biophysical and spatial impacts, and trade-offs analysis in scaling are minimal and just beginning to emerge. The potential for scaling CSA is greatly reduced if the spatial variation is ignored, and untargeted implementation may cause unfavourable feedback effects. Ignoring such runs the risk of short-term positive impacts that are counterproductive to the sustainability goal promised by CSA; (iv) creating an enabling environment through systemic change is one of the key challenges to scaling. The latter may be more influential in the scaling process than currently prioritised, especially if pursued through incremental efforts, as demonstrated through the SIL model. The bulk of the work remains in marrying the social, economic, ecological, and technical aspects of scaling in space and time within the realistic realm of the smallholder context. The development of recommendation domains (RDs)—spatial units suitable for scaling a particular CSA innovation—rarely considers socio-economics. On the other hand, most scaling strategies focus on the processes, and have not fully embraced the biophysical aspects. Lastly, scaling is not sequential or a phase in project implementation, but rather should be part of the process from the start.

Practitioners must recognise that testing for innovation and scaling goes hand in hand. This paper contributes to the third wave ideology in scaling by highlighting the scarcity of, and suggesting the consideration of spatio-temporal aspects, biophysical factors, and future climate scenarios in project implementation, and proposes how and why such can and should be infused to develop sustainable scaling strategies. For practitioners, there is no silver bullet, and each scaling intervention must be customised to the context. This requires a good understanding of the social and spatial nuances of the location of operation. Establishing partnerships for scaling seems promising. The SIL model, for example, has demonstrated how systemic change can be incremental and transformative. We assumed that because the cases were focused on scaling, they had managed the transition from adoption. There was little evidence of that effect. It is worth looking into this grey area. Lastly, further research is needed to figure out the poor consideration of the spatio-temporal dimension of scaling, given its importance in sustainability.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agronomy12040820/s1, Excel tables include: Figure S1: Frequency of code; Figure S2: Screen of Atlas.ti9; Table S1: ATLAS.ti—Code Report; Table S2: The list of code.

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Abbreviations

2SCALE	Toward Sustainable Clusters in Agribusiness through Learning in Entrepreneurship
3R	Robust, Reliable and Resilient
ACTS	African Centre for Technology Studies
ADA	Adaptation Consortium,
BoP	Innovation Center (Bopinc),
CAMP+	Climate Change Adaptation and Mitigation Project
CASCAPE	Capacity building for scaling up of evidence-based best practices in agricultural production in Ethiopia
CCCF	County Climate Change Fund
CIMMYT	International Maize and Wheat Improvement Center
CRAFT	Climate Resilient Agriculture for Tommorrow
CRS	Catholic Relief Services
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agriculture Organisation
FFSs	Farmer Field School
FMNR	Farmer Managed Natural Regeneration

FNS	Food and Nutrition Security
HortLIFE	Horticultural Livelihoods, Innovation and Food safety in Ethiopia
ICRAF	World Agroforestry Center
IFA	International Fertilizer Association
IFDC	International Fertilizer Development Center
IFDC	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IISD	International Institute for Sustainable Development
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IPIN	International Plant Nutrition Institute
ISSD	Integrated Seed Sector Development Programme
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KARI	Kenya Agricultural Research Institute(currently Kenya Agricultural and Livestock Research Organisation)
KCEP-CRAL	Kenya Cereal Enhancement Programme Climate-Resilient Agricultural Livelihoods Window
KCSAP	Kenya Climate Smart Agriculture Project
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MANRLF	Ministry of Agriculture, Natural Resources, Livestock and Fisheries
MEL	Monitering Evaluation and Learning
MLF	Ministry of Livestock and Fisheries
MoA	Ministry of Agriculture
NCCRS	National Climate Change Response Strategy
NZARDI	Northern Zone Agricultural Research and Development Institute
PORALG	President's Office of Regional Administration and Local Government
PPP	Public-Private Partnerships
PSNP	Productive Safety Net Programme
R&D	Research and Development
REALISE	Realising Sustainable Agricultural Livelihood Security in Ethiopia'
SNV	SNVNetherlands Development Oganisation
SSPs	Spray Service Providers
TAMASA	Taking Maize Agronomy to Scale in Africa
TMA	Tanzania Meteorological Agency
UNDP	United Nations Development Programme
WASH	Water Hygiene and Sanitation
WFP	World Food Programme
WUR	Wageningen University and Research

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