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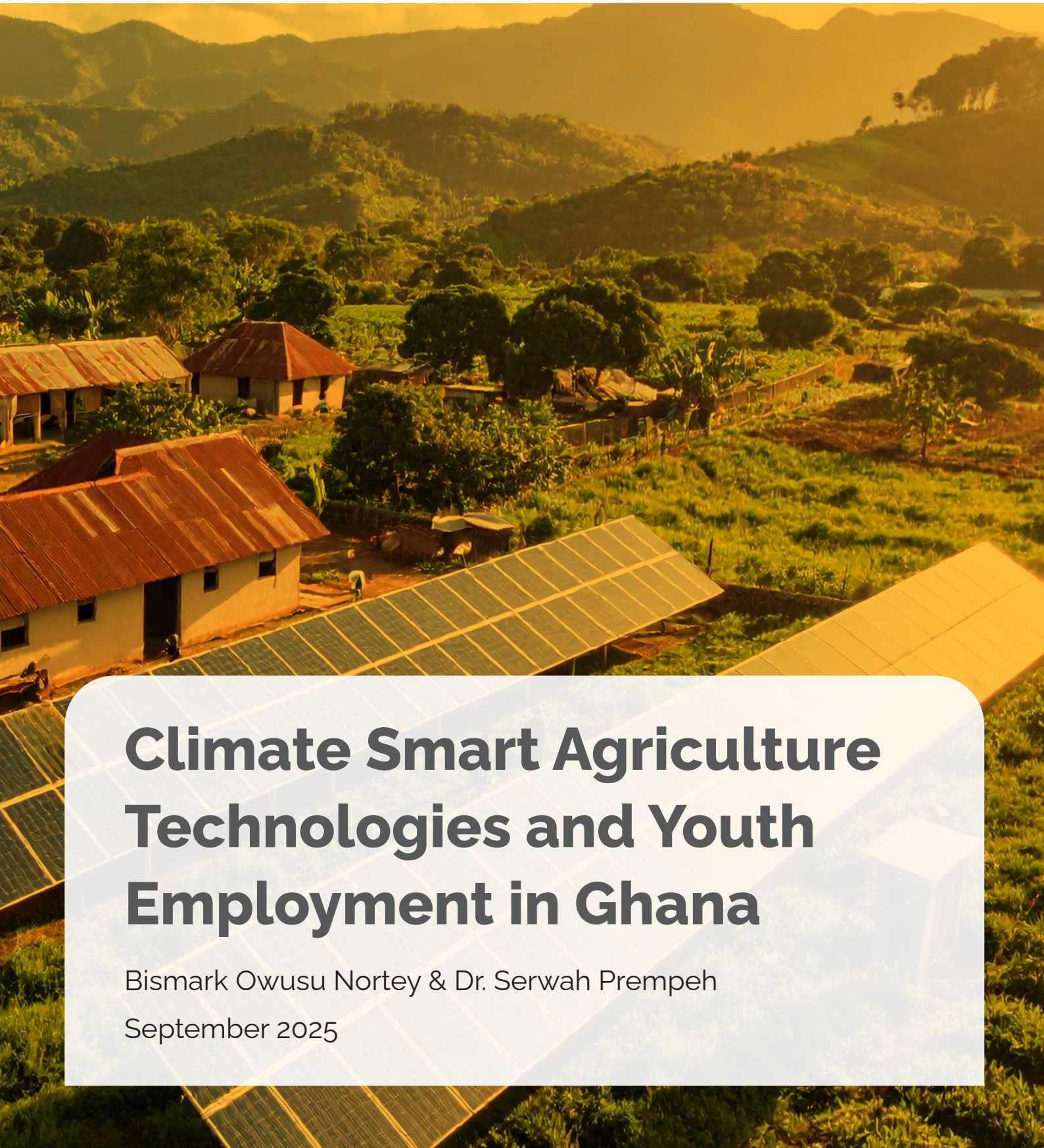

Climate Smart Agriculture Technologies and Youth Employment in Ghana

Bismark Owusu Nortey & Dr. Serwah Prempeh

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Dr. Serwah Prempeh is the Senior Fellow and Head of APRI's Just Green Technology Transition Programme, which is focused on aligning African technology innovation priorities with its development goals and bridging Africa-Germany-EU relations on just green technology innovation and development.

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Abbreviations

AFAWA	Affirmative Finance Action for Women in Africa
CAADP	Comprehensive Africa Agriculture Development Programme
CEO	Chief Executive Officer
CPESDP	The President's Coordinated Programme of Economic and Social Development Policies
COTVET	Council for Technical, Vocational Education and Training
CSA	Climate Smart Agriculture
CSA Techs	Climate Smart Agriculture Technologies
CSA-FSAP	Climate Smart Agriculture Food and Security Action Plan
CSAIP	Climate Smart Agriculture Investment Plan
CSOs	Civil Society Organizations
DP	Development Partners
EPA	Environmental Protection Agency
ESO	Enterprise Support Organization
FDA	Food and Drugs Authority
FSAP	Food and Security Action Plan
GHG	Greenhouse Gas
GRA	Ghana Revenue Authority
GSA	Ghana Standards Authority
GSS	Ghana Statistical Service
GYEEDA	Ghana Youth Employment and Entrepreneurial Development Agency
ICT	Information and Communication Technology
IFJ	Investing for Food and Jobs
IK	Indigenous Knowledge
ILO	International Labour Organization
IMF	International Monetary Fund
IPR	Intellectual Property Rights
KIC	Kosmos Innovation Center
MELR	Ministry of Employment and Labour Relations
MESTI	Ministry of Environment, Science, Technology and Innovation
MGCSP	Ministry of Gender, Children and Social Protection
MMDAs	Metropolitan, Municipal, District Assemblies
MOFA	Ministry of Food and Agriculture
MOFEP	Ministry of Finance and Economic Planning
MoCD	Ministry of Communications and Digitization
NABCO	Nation Builders Corps
NEIP	National Innovation Entrepreneurship Program
NCCA	National Climate Change Adaptation Strategy
NCCP	National Climate Change Policy
NDCs	Nationally Determined Contributions
NDPC	National Development Planning Commission

NGO	Non-Governmental Organization
NITA	National Information Technology Agency
NMTDPF	National Medium-Term Development Policy Framework
NSS	National Service Scheme
NVTI	National Vocational Training Institute
NYA	National Youth Agency
NYEP	National Youth Employment Programme
OICG	Opportunities Industrialization Centre Ghana
PFJ	Planting for Food and Jobs
PPRSD	Plant Protection and Regulatory Services Directorate
PWDs	Persons with Disabilities
SDGs	Sustainable Development Goals
SME	Small Medium Enterprise
SSA	Sub-Saharan Africa
STEM	Science, Technology, Engineering and Mathematics
UNEP	United Nations Environment Programme
UNCTAD	United Nations Conference for Trade and Development
TOR	Terms of Reference
TVET	Technical and Vocational Educational and Training
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
WIPO	World Intellectual Property Organization
YEA	Youth Employment Agency
YIAP	Youth in Agriculture Programme

Definition of key terms

Climate Smart Agriculture (CSA) is an integrated approach to managing landscapes; cropland, livestock, forests and fisheries that address the interlinked challenges of food security and climate change.

Debt financing is a form of business finance that involves a company borrowing money from a financer, like a bank or working capital funding organization. It entails entrepreneurs taking loans that must be repaid within a predetermined time period, subject to an agreed-upon interest rate.

Equity investment is money that is invested in a company by purchasing shares of that company in the stock market. It involves investors putting money into a startup company in exchange for a portion of the company's share.

Indigenous Knowledge (IK) is defined as the knowledge, innovations, and practices of Indigenous and local communities that have been developed over generations and passed down orally or through practice.

Grant funding is a general term for funds that organizations receive for a specific purpose that are not expected to be repaid. They are used mainly to support various activities like education, research, community development, or the arts. To receive a grant, organizations must compete for funds by submitting an application and undergoing an evaluation process.

Green technologies refers to the development and use of technologies that minimize the negative impacts of human activities on the environment and society. It encompasses a wide range of products, services and practices that support a more sustainable future.

Mezzanine financing is a hybrid instrument that sits between equity and debt financing. It can be structured either as preferred stock or as unsecured debt, and it provides investors with an option to convert to equity interest. Mezzanine financing is usually used to fund growth prospects, such as acquisitions and expansion of the business.

Executive Summary

Green technologies offer a unique opportunity to address high youth unemployment and climate change. Green technology applies scientific innovation to develop resource-efficient and environmentally friendly commodities and processes. These technologies can create jobs in industries such as waste management, transportation, agriculture, and renewable energy. However, the adoption of green technologies in developing countries like Ghana comes with several constraints, barriers, and opportunities.

This study examines the relationship between youth employment and green technologies, particularly Climate Smart Agriculture Technology (CSA Tech) in Ghana, emphasizing policy and regulatory frameworks that promote youth employment and CSA tech development. It also explores the perspectives and experiences of policymakers, technology startups, accelerators, and other stakeholders. The goal is to understand the key actors, policy context, barriers, and enablers in the nexus between CSA Tech and youth employment in Ghana, leveraging Indigenous and traditional knowledge to enhance technological innovation for startups.

Despite the youth population in Ghana, estimated to constitute about 38% of the national population (Ghana Statistical Service, 2021), and the potential for green energy, there are substantial obstacles impeding the expansion of CSA tech as a means to absorb the burgeoning youth population. According to the Ghana Statistical Service, the national youth unemployment rate for young adults aged 15-35 years stood at 21.7% in 2023, with the risk of escalation if immediate action is not taken.

Ghana faces climate crises, manifested in extreme weather conditions, temperature increases, unpredictable rainfall patterns, pests, and disease influx, among others, and along with a high unemployment rate. CSA tech thus provides an avenue to mitigate the impact of climate crises while offering sustainable employment for the youth. However, stakeholders, particularly CSA tech startups, face enormous challenges in establishing, growing, and expanding to address these twin challenges. These challenges range from poor policy implementation and inadequate infrastructure to low financial and technical support and limited consumer demand, which restrict the influence and effectiveness of these tech startups in providing jobs and addressing the climate crisis.

This study therefore focuses on two areas:

- Assessment of how current policies in Ghana support the goals of green technology, with an emphasis on CSA, tech, and youth employment, using a combination of top-down and bottom-up policy analysis and stakeholder assessments. Specifically, the assessment focuses on the current national strategies and policy framework for CSA tech and youth employment opportunities in Ghana.
- In-depth exploration of the experiences of tech startups in scaling up CSA tech in Ghana and increasing youth employment. This approach also examines the roles of young people, particularly women, in this space, aiming to identify the factors that either hinder or encourage their contributions to innovation. It assesses the role of other critical stakeholders, including accelerators, in promoting and expanding tech startups in Ghana. It further examines the essential elements, tools, and policy initiatives needed to enhance the adoption of locally developed technologies and Indigenous knowledge systems.

The methodology adopted in developing this report comprised qualitative, quantitative, and analytical methods. To undertake this, we first conducted an extensive literature review to understand the current policy and regulatory regime of CSA Tech in Ghana, as well as the gaps and opportunities it presents to stakeholders. We also identified the main stakeholders and their responsibilities in these processes. Subsequently, we conducted selected stakeholder interviews with individuals and organizations engaged in CSA tech, including policy actors, CSA tech startups, accelerators, and other relevant stakeholders.

The research was followed by an analysis of the information received from the respective stakeholders, which allowed us to identify existing gaps, barriers, and opportunities. These formed the basis for proposing recommendations for consideration in each thematic area.

Key Findings

a. Policy Coherence between CSA Tech and Youth Employment

1. There are adequate public policies and programs addressing CSA tech policies and youth employment in Ghana, though few explicitly highlight and promote CSA Tech. However, some of these policies are not reflective of or responsive to the current developmental and aspirational needs of CSA Tech startups. The National Climate Change Policy (NCCP), for instance, developed in 2013 as Ghana's overarching response to climate change, does not emphasize CSA tech or identify the key role the youth can play in this regard, falling short of modern approaches.
2. The National Green Jobs Strategy, developed in 2023, is the foremost and most progressive policy document that promotes sustainable and competitive green enterprises and provides a framework for empowering tech companies to create opportunities for youth employment. However, the policy is set to expire at the end of 2025, with most of its strategies and initiatives yet to be implemented.
3. There is limited participation of stakeholders, particularly CSA tech youth startups, in the policy formulation process in Ghana. This limited participation accounts for the lack of awareness, engagement, interest, and involvement of youth startups in the policy process.

b. Policy Environment and Indigenous Knowledge

1. Indigenous knowledge has gained increasing recognition over the past decade, acknowledged by the government and mainly advanced by NGOs and community-based organizations. The National Climate Change Policy, for instance, acknowledges the role of traditional knowledge in conserving natural resources, protecting the environment, making farming decisions, predicting weather, managing health, and coping with extreme climate variability. However, there is no evidence of a comprehensive framework to document Indigenous knowledge as envisioned in the NCCP.

c. CSA Tech Landscape in Ghana

1. CSA tech, while common in Ghana, is closely associated with general technologies and innovations in the agricultural sector. Therefore, although there are several CSA tech companies in Ghana, they have been subsumed under "agri-tech," which are largely focused on the general agriculture sector. Consequently, except for the National Green Jobs Strategy, which specifically supports CSA tech, most policies, frameworks, and support mechanisms for agricultural innovations are geared toward "agri-tech." This makes it difficult to estimate the specific policy, program, and logistical support available to CSA Tech in Ghana.
2. Several CSA tech companies are creating opportunities to address climate crises through various innovations, youth employment, and skills development. However, they are constrained by several barriers, including inadequate financial avenues, limited awareness and involvement in the policy process, and a lack of capacity and skills that restrict their ability to expand and secure their business. They are further hampered by challenges related to regulation, market access, limited infrastructure, and high costs of doing business. The assessment reveals that, although several state agencies and programs provide support for CSA tech companies, only 10% of these companies were able to secure funding from state institutions to enhance their work, with the majority securing funding and support from accelerators, primarily donor partners and foreign entities.

d. Recommendations

Based on the findings, the paper makes the following recommendations:

- Review existing policies to reflect current developments in climate change, especially the role of startups. For instance, the NCCP needs to be revised to incorporate modern developments.
- Urgently implement the initiatives and programs captured under the Green Jobs Strategy, before its expiration.
- Review the approach to policy formulation by deliberately involving youth startups in the policymaking process; simplifying and streamlining policies to be user-friendly and providing clear and concise information for the youth.
- Establish a CSA tech hub to provide access to policy information, resources, and support services for the youth.
- Provide enhanced access to financing, other incentives and skills development opportunities for tech startups in CSA tech.
- Regarding Indigenous knowledge (IK), the paper identifies a clear understanding of youth tech companies in combining local knowledge with foreign knowledge to design innovative products and services but notes a disconnection between policy and practice. The paper therefore recommends intentional documentation of Indigenous knowledge practices and incorporating it into educational curricula to enhance its adoption.

1. Background and Context

a. Introduction

Ghana is experiencing changes in temperature, rainfall patterns, and an increased frequency and intensity of extreme weather events such as floods, droughts, and storms. Climate change data from 1961 to 2016 show progressive increases in temperatures and a decline in mean annual rainfall across all six agro-ecological zones (UNEP & UNDP, 2017). Ghanaian farmers are already experiencing the effects of climate change, including erratic rainfall that deviates from historical patterns, high and increasing temperatures, longer periods of "harmattan" (dry winds), shorter dry seasons, frequent droughts, ecosystem deterioration, and concomitant losses of arable land through desertification. Additionally, there are outbreaks of crop and livestock pests and diseases, an increase in post-harvest losses, and in coastal areas, salinization of agricultural soils due to sea-level rise and tidal flooding, which render land unproductive. This situation is compounded by increased harmful environmental practices and unsustainable agricultural practices that have led to declining soil quality, while accelerated erosion has reduced crop yields and viability (MOFA, 2022). Although there have been several coping strategies, the sector is still dominated by poor farmers who are vulnerable to the effects of climate change. The 2018 Ghana Climate Change Risk Index value of 68.33, which measures the country's capacity to anticipate, cope with, resist, and recover from the impacts of climate change, indicates that Ghana faces a high level of exposure and vulnerability to climate-related events. This is evident in the low investment in various climate change mitigation and adaptation measures. For instance, only 230,008.85 hectares, representing 12.15% of cultivated land, are irrigated in Ghana, despite a potential irrigation capacity of up to 1.9 million hectares (GIDA, 2023). This has serious implications for food security and the livelihoods of farmers, as improved irrigation can increase farmers' incomes by up to 20% (IMWI, 2010). These challenges exacerbate the growing constraints that have diminished the potential of the agricultural sector to be a driver of economic growth and to address rising youth unemployment in the country.

Conversely, youth employment has emerged as a prominent theme in global and African development discourse, with many individuals of productive age remaining unemployed due to widespread socio-political and economic issues. The International Labour Organization (2022) estimates that nearly 13 million African youth are unemployed, excluding about 60 million more youth who are neither enrolled in school nor working but wish to work and are unable to find employment. In Sub-Saharan Africa, the youth unemployment situation is slightly better compared to other regions, with 11% of the youth population unemployed (International Labour Organization, 2022). However, this is partly because youth in the region often work in unstable, low-productivity occupations to make ends meet, as they cannot afford to be jobless.

Youth unemployment remains alarmingly high in Ghana, exceeding 14.7% in the first three quarters of 2023, according to the Ghana Statistical Service (GSS). The number of unemployed youth (defined as individuals aged 15 to 35) rose from approximately 1.2 million to over 1.3 million during the same period, with the rate among females consistently higher than that among males. In 2022, youth unemployment declined only in the second quarter. However, a sharp increase in female unemployment between the fourth quarter of 2022 and the first quarter of 2023 widened the gender gap. Consistently, more females than males have been unemployed, with the difference averaging about 600,000 in 2022 and 900,000 in 2023. The number of employed persons in urban areas remained nearly constant in the first three quarters of 2023, following quarterly variations in 2022. The economic downturn post-COVID-19 and Ghana's engagement with the International Monetary Fund (IMF) have further strained the government's capacity to generate public sector employment.

Green technologies can tackle the aforementioned problems simultaneously and, if implemented correctly, can generate new jobs and income opportunities for young people. Environmentally sustainable policies and climate change mitigation or response measures, including green technologies, have been adopted by several countries, including Ghana, to address the challenges posed by climate change and youth unemployment. While it is difficult to provide data on how climate change initiatives have addressed youth unemployment in Ghana, initiatives such as the Boosting Green Employment and Enterprise Opportunities in Ghana (GrEEN), which aims to provide at least 5,000 jobs for the youth (UNCDF, 2020), UNDP's Young African Innovates, which equips youth with digital skills, and the Kosmos Innovation Centre (KIC) Agri-tech Challenge, which supports youth entrepreneurs with skills and financial assistance to create enterprises and job opportunities, are noteworthy. Green technologies apply scientific knowledge and innovation to create products, processes, and services that are environmentally friendly and resource-efficient (Rana, Sufang, Jamil, Jaffri, & Hamid, 2021). A technology readiness index ranking of 166 countries based on five building blocks of ICT deployment, skills, research and development (R&D) activity, industry activity, and access to finance shows that Sub-Saharan Africa is the least ready to use, adopt, or adapt to frontier technologies and is at risk of missing current technological opportunities (United Nations Conference on Trade and Development, UNCTAD, 2023).

Despite the enormous potential that green technologies hold for addressing environmental issues and creating jobs for Africa's rapidly growing youth population, progress in their adoption remains limited. In Ghana, CSA tech has received little prominence and attention, as it has been lumped together with various CSA and technology approaches. This is evident from policy formulation to the rollout of interventions, making it difficult to distill the specific support, challenges, and nuances associated with CSA tech alone. Though this presents challenges for CSA tech in terms of tailored support, it can be argued that this approach may also be strategic in integrating all CSA interventions into one pool of resources, which may lead to more available support. From the policy environment, one key document that attempts to target climate-smart technologies with a focus on youth employment is the National Green Jobs Strategy; however, the effectiveness of this policy and its impact on youth employment and climate change is yet to be assessed. Moreover, several green tech startups have emerged, providing services that reduce the impacts of climate change and create opportunities for the burgeoning youth population. However, do these policies and regulations promote green jobs? What have been the effects and impacts of these policies on their operations, growth, and expansion? What has been the role of various stakeholders in providing a conducive environment for the success of these green jobs? What are the practical realities and constraints that inhibit them from achieving their full potential, and what are the opportunities for scaling up innovation among the youth in green technology in Ghana? Indigenous knowledge has also been identified as an excellent source of local information that can be adapted to foreign technologies in rolling out interventions for CSA tech. However, the extent to which Indigenous knowledge are recognized, utilized, and integrated by these tech startups remains unclear. There is also a need to assess how CSA-related policies highlight the role of Indigenous knowledge and the measures in place to encourage its adoption in the CSA technology space.

b. Report Approach

Purpose and Scope

This study investigates how the tech startup scene can foster the scaling of CSA tech and youth employment. It engages with the practical realities and challenges of the CSA tech startup scene to develop a call to action for policymakers, young innovators, and other stakeholders to leverage the technological innovations already existing in the country, as well as the role external actors can play in supporting them. It also conducts a deep dive into Ghana's CSA tech and youth employment policy space to understand its linkages with Indigenous innovation capacities and knowledge and

how such capacities and knowledge can be scaled up to become avenues for youth employment. Based on the Terms of Reference (TOR), the study examines how current policies can be re-engineered to support CSA and youth employment and how Indigenous knowledge can enhance technological innovation.

Research Questions

- What are the existing policy frameworks and initiatives supporting climate-smart agriculture technologies (CSA tech) and youth employment in Ghana?
- Is the policy space responsive to young people's local innovation and employment needs and priorities?
- What are the practical realities and challenges of entrepreneurs operating in the CSA tech space?
- How can Indigenous knowledge be leveraged to enhance technological innovation in CSA?
- What opportunities exist, and what policy reforms are required to scale up local innovation among Ghanaian youth in CSA?

Approach and Methodology Behind the Study

To gain a comprehensive insight into CSA tech and youth employment in Ghana, the research adopted both quantitative and qualitative approaches and employed multiple research methods, including:

- A review of literature and relevant information, reports, and documents on climate change, youth employment, and CSA tech in Ghana.
- An analysis of existing policies, strategies, and frameworks on climate-smart agriculture, CSA tech, youth employment, and green technologies in Ghana. This was done to understand the policy environment, stakeholders, their roles and responsibilities, and the responsiveness of these policies, regulations, and frameworks to CSA tech and youth employment.
- Mapping and consultation with relevant stakeholders, including policy officials, CSA tech companies, and hubs, to understand their experiences in the CSA tech and youth employment space.
- Analyzing information received from the respective stakeholders, which allowed for the identification of existing gaps, barriers, and opportunities. These formed the basis for proposing recommendations for consideration in each thematic area.

Data Collection Exercise

Primary data were gathered through questionnaires for targeted stakeholders. The research employed purposive and snowball sampling techniques to achieve its objectives. Purposive sampling was used to select stakeholders, especially from state institutions, accelerators, and other experts based on their expertise and relevance in CSA. The snowball sampling technique was employed to engage CSA tech startups, through referrals from initial respondents to identify additional ones. In selecting startups the following areas were focused on, and respondents were deliberately chosen from each:

- Stages of their innovations: ideation, implementation, and expansion stage.
- Diversity of their innovations across the value chain (production, manufacturing, or service provision).
- Location of their innovations to avoid concentration in one geographical area.

The research had a pool of prospective respondents mainly from referrals and recommendations (by industry professionals, accelerators, and some CSA tech companies) and the web, and based on the above matrix, the sampled individuals were selected.

Interviews were conducted through various approaches, including face-to-face and virtual meetings via applications such as Google Meet, WhatsApp calls, and Zoom.

Scope of Study

This research targeted all institutions, officials, industry experts, and stakeholders relevant to CSA tech in Ghana. Due to this approach, the respondents were spread across all geographical locations of the country. This data was primarily collected from state institutions, including the Ministry of Food and Agriculture (MOFA), the Ministry of Environment, Science, Technology and Innovation (MESTI), the Ministry of Finance and Economic Planning (MOFEP), the Ministry of Communcation and Digitization (MoCD), the National Innovation Entrepreneurship Program (NEIP); ten (10) CSA technology startup founders, one accelerator, and other expert interviews.

Data Analysis

The data underwent qualitative analysis using a mixed-method approach. Quantitative data were analyzed using descriptive statistics, while qualitative data were analyzed using a thematic approach that involved categorizing and interpreting open-ended responses, identifying recurring themes, and extracting meaningful insights.

c. Report Structure

The report begins with the executive summary and is further organized into five main chapters. Chapter One highlights the background and context of the climate change situation in Ghana, key findings and recommendations, the problem statement, and the justification for the research and report approach.

Chapter Two provides an overview of CSA tech and the youth employment situation in Ghana. It also details the CSA tech ecosystem in Ghana, including the main actors and trends. The chapter further outlines the policy and regulatory framework for CSA tech and youth employment, analyzing the coherence of existing policies. Additionally, it addresses the integration of Indigenous knowledge with policy.

Chapter Three presents findings from the main actors: tech startups, policy officials, and accelerators, among others. It focuses on the barriers and enablers based on responses from the respondents.

Chapters Four and Five summarize the conclusions and recommendations for consideration.

2. Mapping the Climate Smart Agriculture Technologies and Youth Employment Policy Landscape

a. What are Climate Smart Agriculture (CSA) Technologies?

CSA is an approach that aims to enhance the resilience, productivity, adaptability, and sustainability of agricultural systems while reducing greenhouse gas emissions, increasing carbon sequestration, and promoting food security and rural development (Chevallier, 2022; Wahabu & Patel, 2020). The Food and Agriculture Organization (2010) provides the most common definition of CSA as "*agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances the achievement of national food security and development goals*."

CSA Technologies are therefore the various technological approaches and interventions that assist farmers and businesses in optimizing their inputs and outputs, managing and adjusting to climate and environmental disruptions, and contributing to the mitigation of climate change (World Bank, 2024). Asante, Ma, Prah, and Omphile (2024) referenced several empirical studies examining the benefits of CSA tech on a range of economic and environmental outcomes, such as improvements in food security and crop yields for farmers in Ghana, Mali, and Nigeria; improvements in soil fertility and dietary diversity in Ethiopia; and increased maize productivity. These benefits have made a strong case for promoting and adopting CSA tech as a major climate action strategy in Africa, exemplified in Ghana, where CSA tech is actively promoted as a means of adapting to climate change among Ghanaian farmers (Zakaria, Azumah, Appiah-Twumasi, & Dagunga, 2020).

These CSA technologies are a subset of agricultural technologies commonly referred to as 'Agri-tech,' which encompass a broad range of disciplines and devices that improve agricultural output, including vehicles, robotics, computers, satellites, and other software to make agriculture work more efficiently and conveniently (EOS Data Analytics, 2024). The adoption and expansion of different technologies, practices, and policies can assist farmers in optimizing their inputs and outputs, managing and adjusting to climate and environmental disruptions, and contributing to mitigating climate change. Beyond increasing agricultural production levels, CSA tech also promises to create job opportunities for young people in Ghana (National CSA-Food Security Policy Action Plan, 2016). As reliance on CSA tech increases, so does the demand for trained technicians to operate and maintain them, creating job opportunities from training and equipment sales to other supporting services that can address the 12% youth unemployment rate in the country (World Bank, 2022). Another key objective of CSA tech is to create job opportunities for young people, most of whom do not see farming as an appealing career option for various reasons, including low profitability, difficult access to land, finance, and markets (Gyekuni-Bell, 2019). However, the complexity of some CSA practices, high labor costs associated with their implementation, lack of government support and credit, difficulty in accessing weather and climate data, and a high rate of illiteracy among smallholder farmers pose significant obstacles to adoption (Agyekum, Antwi-Agyei, Dougill, & Stringer, 2024).

Innovation is therefore crucial among entrepreneurs and industry professionals to devise technologies that meet the needs of farmers in terms of cost, efficiency, and reliability. With a strong involvement of young people in driving these innovations, it is essential that policies and regulations are responsive to the needs and priorities of these young entrepreneurs to encourage and sustain these innovations.

b. The CSA Tech Ecosystem in Ghana

According to the World Bank, CSA tech are a set of technologies and practices that simultaneously boost productivity, enhance resilience, and reduce greenhouse gas emissions. In Ghana, CSA techs, while common, are closely associated with general technologies and innovations in the agricultural sector. Thus, although there are several CSA tech companies in Ghana, they are often subsumed under the broader category of "*agri-techs*," which primarily focus on the general agriculture sector.

A tech startup is an entrepreneurial venture in the early stages of operation, with a business model primarily anchored in a technology or software product (Cooper, 2023). These ventures are mostly technology-focused, have the potential for scalability, and adopt lean and agile methodologies (Appetiser, 2023). They differ from traditional businesses in many ways, including their focus on large-scale growth, aiming to reach as many users as quickly as possible to establish a dominant market presence, often leading to prolonged periods of unprofitability (Cooper, 2023).

Since 2013, Ghana has developed one of the strongest startup ecosystems in Africa, aided by foreign direct investment and the formulation and implementation of several policies (Startup Universal , 2024). These initiatives have supported these "agri-techs" in providing agriculture and agribusiness-related services through several business models, including business-to-business, farmer-to-business, farmer-to-consumer, business-to-enterprise, and business-to-consumer. Tracxn Technologies Limited (2024) identifies approximately 74 agri-tech startups in Ghana, which provide innovative agriculture and agribusiness-related services, some of which are focused entirely on CSA tech.

These CSA technologies are involved in various approaches and interventions that assist farmers and businesses in optimizing their inputs and outputs, managing and adjusting to climate and environmental disruptions, and contributing to mitigating the effects of climate change. Their activities span the value chain from planting, harvesting, storage, and preservation to marketing and agro-processing. For example, solar-powered irrigation technologies may be used for planting, while solar dryers and cold storage technologies are employed for preservation and storage. Digital technologies assist with crop monitoring (improving crop yield and survival) and marketing (reducing off-take times and thereby minimizing the risk of post-harvest losses or degradation of perishables). Weather-index insurance may also be used to protect against the risks of droughts or floods, among other applications.

CSA technologies offer a wide range of employment opportunities, especially for youth, who can engage in various roles, including field officers, technicians, agronomists, project managers, data analysts, software engineers, and marketing and communication specialists.

Key actors in the CSA tech ecosystem include tech hubs and accelerators that provide technical and logistical support to these tech startups. The Ghana Tech Lab[1] estimates that there are approximately 140 tech hubs and accelerators across Ghana, as of 2021, providing these support services to startups. The state also plays a crucial role in developing the policy and regulatory framework to encourage and regulate the growth and innovation of these tech startups.

Key state agencies involved include the Ministry of Employment and Labour Relations, the National Development Planning Commission, the Ministry of Food and Agriculture, the Ministry of Environment, Science and Technology, and the Ministry of Finance and Economic Planning. The role of development partners, Non-Governmental Organizations (NGOs), Civil Society Organizations (CSOs), and Metropolitan, Municipal, and District Assemblies (MMDAs), is also pronounced in this space, along with donor partners, financial institutions, and academia, who provide technical and logistical assistance for the growth of these tech companies (Table 1). However, not all state agencies are involved in the direct formulation and roll-out of these policies; some provide either supervisory or auxiliary support. For instance, the NDPC has the overarching mandate to provide a national development policy framework and to coordinate economic and social activities country-wide in a manner that ensures accelerated and sustainable development of the country to promote continuous improvement in the living standards of all Ghanaians. Hence, they do not develop and implement direct policies but provide guidance. This is similar to other agencies that coordinate, partner, and support the lead ministries in the implementation of specific CSA-related policies. While Table 1 provides a list of all relevant state institutions in CSA approaches, the MOFA, MELR, and MESTI are the main implementers of relevant policies and programs.

Table 1

List of Relevant Stakeholders and their Roles

No.	Stakeholder	Summary of Key Finding
1	National Development Planning Commission (NDPC)	responsible for the harmonisaton of national development planning, monitoring and evaluation at all levels.
2	Ministry of Finance	responsible for fiscal and economic policy management and mobilisation of funds for the implementation of policies and strategies.
3	Ministry of Food and Agriculture (MOFA)	responsible for ensuring food security through the adoption of innovative technologies.
4	Ministry of Employment and Labour Relations (MELR)	responsible for the coordination of employment opportunities and active labour market policies
5	Ministry of Gender, Children and Social Protection (MGCSP)	responsible to adopt green skills approaches develop alternative livelihoods for the vulnerable.
6	Ministry of Environment, Science, Technology and Innovation (MESTI)	responsible for policy oversight for the protection of the environment and promotion of green technological innovations.
7	Environmental Protection Agency (EPA)	technical wing responsible for the enforcement of standards and policies for the protection of the environment.
8	Ghana Standards Authority (GSA)	responsible for the maintenance of standards in the productive sectors for the assurance of consumer protection and value for money.
9	Metropolitan Municipal and District Assemblies (MMDAs)	MMDAs are requird by law to support LED to accelerate private sector growth and poverty reduction.
10	Private Sector Entities and Entrepreneurs	the private sector propels economic growth by taking initiatives or developing businesses for economic returns.
11	Development Partners (DPs)	DPs complement development efforts of Government through technical and financial support.
12	Council for Technical, Vocational Education and Training (COTVET)	responsible to lead implementation of this component by streamlining green skills training in every aspect of TVET.
13	National Youth Authority (NYA)	coordinates green skills training initiatives for economic empowerment of the youth at all levels.

Note: Authors' construct. Data adapted from the National Green Jobs Strategy by the Ministry of Employment and Labour Relations, 2021, p 12[5]

In addition, the Ministry of Communication and Digitalisation (MoCD) plays a crucial role in shaping Ghana's digital landscape by formulating policies that enhance ICT infrastructure, digital skills, and innovation. Its goal is to transform Ghana into a knowledge-based society and a smart economy through digitalization (MoCD, 2024). The ministry oversees agencies such as the National Information Technology Agency (NITA) and the National Communications Authority (NCA), which regulate and implement ICT policies. The NITA is the policy implementing arm of the MoCD, responsible for regulating IT service providers and ensuring compliance with ICT standards. It promotes innovation, competition, and transparency within the IT ecosystem. NITA also facilitates capacity-building for local ICT businesses and supports e-government applications (MoCD, 2024).

c. Policy and Regulatory Framework for CSA Tech

There are several policies and frameworks that support CSA practices and programs in Ghana; however, very few of them explicitly highlight and promote CSA tech. Assessments of existing policies in Ghana reveal only a few that adequately address and promote CSA technologies through a set of actionable interventions.

The foremost and most prominent policy on climate change in Ghana is the National Climate Change Policy (NCCP), which serves as Ghana's integrated response to climate change and outlines the vision and goals for establishing a climate-resilient and climate-compatible economy for sustainable development and equitable low-carbon economic growth (Botchway et al., 2016). The Ministry of Environment, Science and Technology and Innovation (MESTI) is the lead institution for climate change and leads in the implementation of this policy (NCCP, 2013). Developed in 2013, the NCCP identifies five priority areas: food security; infrastructure and community resilience; improved environmental management and ecosystems for greater biodiversity; and improved economic growth. There is no specific mention of youth employment through green technologies or CSA, though the policy identifies youth as key stakeholders in the climate change process. Similarly, there is no mention of specific CSA tech. The NCCP has been structured around enablers and investments in efficient systems and upgrades for establishing a climate-resilient economy. Interaction with officials from MESTI revealed that the NCCP provides a broad vision on climate change and does not provide specifics for various sectors, including climate-smart technologies. In that regard, specific sector-related plans and strategies have been developed by the respective ministries to address their unique challenges.

The National Climate Change Adaptation Strategy (NCCAS) is the broad strategy facilitated by MESTI to increase Ghana's resilience to climate change impacts now and in the future (UNEP/UNDP Programme for Sub Saharan Africa, 2010). This is to be accomplished by building Ghana's capacity in the areas of infrastructure and knowledge to deal with climate change impacts and reduce vulnerability in key sectors, ecosystems, districts, and regions of the country. The strategy identifies eight areas – livelihoods, energy, agriculture, health, early warning, fisheries management, land use, and water – which are vulnerable to climate change, and proposes adaptation strategies for each area while identifying ten priority adaptation programs. The strategy does not address the utilization of green technologies or the creation of jobs for youth in its approach.

The Ghana Nationally Determined Contributions (NDCs) under the Paris Agreement is the next plan by MESTI, which envisions building a resilient society that can adequately withstand the impacts of climate change and contribute to mitigating global emissions (Environmental Protection Agency, 2021). The document broadly highlights the need for technology and capacity needs for implementing the measures to deliver Ghana's NDCs. The document outlines 19 policy actions in 10 priority areas to achieve nationally determined contribution goals. These 19 policy actions are translated into

13 adaptation and 34 mitigation programs. Although it identifies technology as a key catalyst for implementing measures to deliver the NDCs, it does not heavily emphasize CSA tech in its approaches. There are also no job creation measures highlighted in this policy.

MESTI recognizes the importance of these policies in addressing the effects of climate change and underlines the role of several stakeholders in achieving this. MESTI is, however, the lead ministry that coordinates the formulation of climate change policies in Ghana, with specific sector-related policies to be led by the respective ministries. Specific CSA policies and technologies are therefore to be spearheaded by the Ministry of Food and Agriculture (MOFA), while the policies on youth employment are to be led by the Ministry of Employment and Labour Relations. MESTI, therefore, exists to provide guidance and support to these ministries in the development of specific climate change-related policies and is available to provide any such support to any ministry when the need arises.

The National Green Jobs Strategy is a strategy derived from the NCCP and provides a framework for the promotion of green jobs in Ghana (Ministry of Employment and Labour Relations, 2021). This is to be accomplished through coherent and effective policy coordination, development of employable skills – particularly for youth, women, and persons with disabilities – supporting the creation of green jobs across sectors through the promotion of sustainable and competitive green enterprises and markets, and mobilizing and facilitating access to sustainable financing for green enterprises through inter-sectoral collaboration and cooperation. Spearheaded by the Ministry of Employment and Labour Relations, the strategy covers four pathways crucial for the promotion of green jobs: building the capacity of state agencies to monitor, regulate, coordinate, and facilitate policy coherence; developing skills for green jobs; empowering the private sector, including small and medium enterprises (SMEs), to expand and create opportunities for employment in green enterprises; and mobilizing sustainable and adequate financial resources to support green enterprises.

Regarding the agricultural sector, led by the Ministry of Food and Agriculture, there are programs, action plans, and strategies on CSA. These include the National Climate Smart Agriculture Food and Security Action Plan (CSA-FSAP) and the Climate Smart Agriculture Investment Plan (CSAIP) 2022, which are sets of frameworks and investment plans that also support CSA tech. The CSA-FSAP facilitates and operationalizes the NCCP for effective integration of climate change resiliency into the development of policies and programs in the food and agriculture sector. The action plan aims to develop climate-resilient agriculture and food systems for all agroecological zones, develop human resource capacity for climate-resilient agriculture, and elaborate on the implementation framework and the specific CSA activities to be carried out at the respective levels of governance. The adoption of CSA tech to promote youth employment in agriculture is encouraged in this policy, but there is no clear roadmap on how to achieve it. Additionally, the policy acknowledges limited financial resources as a major challenge to achieving the action plan. Nonetheless, the plan outlines three core strategies that will mobilize adequate financing: the inclusion of activities in the annual budget cycle; sourcing climate funds; and seeking donor support. The CSA-FSAP policy document defines the strategies and delivery framework that the country should employ to achieve its food security and CSA goals and plans for agriculture under the National Climate Change Policy.

On the other hand, the Climate Smart Agriculture Investment Plan (CSAIP) aims to generate evidence of CSA tech that has the greatest potential to enhance productivity and increase household incomes in Ghana's agricultural sector amidst a changing climate. Furthermore, it presents opportunities to strengthen the resilience of the agricultural system, ensuring that future agricultural practices do not threaten environmental integrity through greenhouse gas emissions, water system pollution, or ecological system destruction. Although no specific youth employment plan for CSA is explicitly outlined in this plan, the CSAIP indicates an investment requirement of $389.5 million for nine CSA projects in Ghana that

can reach at least 1.7 million beneficiaries and their families. The CSAIP outlines supportive actions, such as strengthening the capacities of farmers, infrastructure, and crops and animals to create income opportunities for women and youth.

The Investing for Food and Jobs (IFJ): An Agenda for Transforming Ghana's Agriculture (2021-2025) is also a flagship policy under the Ministry of Food and Agriculture that highlights Ghana's plan to achieve food and nutrition security. Pivoting around the flagship program Planting for Food and Jobs Phase 2 (PFJ 2.0), the IFJ identifies strategies to address Ghana's food and nutritional crises, including the employment of climate-resilient strategies for vulnerable farmers.

In addition to these policies and action plans, broader national frameworks focus on overarching visions and goals for the country but do not provide explicit details on climate change technologies and youth employment. These include the current national strategic framework guiding the government's development agenda, the National Medium-Term Development Policy Framework (NMTDPF), known as the Agenda for Jobs II: Creating Prosperity and Equal Opportunity for All (2022-2025), which serves as the operational instrument for the vision, policies, and programs outlined in the President's Coordinated Programme of Economic and Social Development Policies (CPESDP): Agenda for Jobs: Creating Prosperity and Equal Opportunity.

With regard to ICT, the Digital Economy Policy launched in 2024, by the MoCD aims to leverage digital technologies for economic growth and job creation. Key strategies within the document include universal access and connectivity, digital skills and research, digital government, digital entrepreneurship and data and emerging technologies. Under digital entrepreneurship, this document aims to among others, initiate digital innovative challenges on topical areas such as health, education and agriculture coordinated with the NEIP, responsible state institutions and academia; create a special fund for the development of digital innovation rural incubation hubs; identify and prioritize rural areas with significant potential for digital economy development opportunities to target for the setup of model incubation hubs; and provide incentives or matching funds to encourage private equity financing programs to invest in women-owned digital businesses.

Regarding the regulatory framework, there are no specific laws and regulations that guide the adoption and use of CSA technologies. However, several legal frameworks exist that guide or influence incentives, opportunities, and risks for the actors involved.

The Environmental Protection Agency Act 1994 (Act 490) is a key example that establishes the Environmental Protection Agency (EPA) as the main regulatory body for environmental management and protection in Ghana. It mandates the EPA to issue environmental permits and certificates for projects and activities that may have significant environmental impacts, such as agriculture and land use (World Bank, 2020).

The Plant and Fertilizer Act 2010 (Act 803) also regulates the production, distribution, and use of plant and fertilizer products in Ghana and establishes the Plant Protection and Regulatory Services Directorate (PPRSD) as the competent authority for plant health and quarantine issues (Ministry of Food and Agriculture, 2024).

d. Policy and Regulatory Framework for Youth Employment

Ghana has introduced several policies to guide strategies and implement interventions specific to youth employment issues. With employment creation at the forefront of the Government of Ghana's development agenda, authorities have launched various policy initiatives, both broad and specific, to address the unemployment challenge.

The government launched the **National Youth Employment Programme (NYEP)** in 2006 to provide skills training and jobs for youth as part of its efforts to tackle youth unemployment, underemployment, and food insecurity.

In 2012, the institution was restructured into the **Ghana Youth Employment and Entrepreneurial Development Agency (GYEEDA)**, which was subsequently restructured into the Youth Employment Agency (YEA) under Act 887 in 2015. The agency's objective is to provide skills training and apprenticeship modules to support youth during the transition from unemployment to employment. In 2016, Parliament passed the Youth Employment Agency Regulations, 2016 (L.I. 2231), for the effective implementation of the provisions of Act 887. In 2010, the government launched the National Youth Policy to provide guidelines for all stakeholders involved in the implementation of policies, programs, and projects for youth development.

This was followed by the National Youth Policy Implementation Plan, 2014–2017. The policy has 19 priority areas, which are further categorized into four main areas: human development and technology; economic empowerment (with youth and employment features within this area); youth participation, governance, and leadership; and culture, sports, and national orientation. In the area of youth employment, the policy focuses on building the capacity of youth to discover wealth-creating opportunities by providing them with access to reliable and adequate labor market information; creating opportunities for young people to take advantage of available jobs; training and preparing them for the global market; and incorporating entrepreneurial skills into curricula (Ghana Ministry of Youth and Sports, 2014).

In 2014, the Ministry of Employment and Labour Relations (MELR) launched the National Employment Policy. This policy aims particularly at generating employment opportunities for vulnerable groups, including youth, women, and the disabled. The goal of the policy is to create decent, gainful employment opportunities so that workers in the country's growing labor force can improve their living conditions and contribute to economic growth and national development within the framework of equity, fairness, security, and dignity (Ghana Ministry of Employment and Labour Relations, 2014).

The government launched the Ghana National Social Protection Policy in 2015 to address social inequalities and provide economic opportunities for the extremely poor. The policy seeks to provide effective and efficient social assistance to reduce extreme poverty and promote productive inclusion and decent work. It also aims to substantially reduce the proportion of youth not in employment, education, or training (NEET) by 2020 and increase by 75 percent the number of youth and adults who possess skills relevant to employment, decent jobs, and entrepreneurship, including technical and vocational skills by 2030. Furthermore, it proposes to help the country achieve full and productive employment and decent work for all women and men, including young people and persons with disabilities (Ghana Ministry of Gender, Children, and Social Protection, 2015).

In 2016, Parliament passed the National Youth Authority Act (Act 939), which gave the National Youth Authority the mandate to formulate policies and implement programs that promote youth development and the effective participation of youth in the country's economic development.

The National Youth Policy has since been reviewed with the development of a new ten-year policy (The National Youth Policy 2022-2032). Spearheaded by the Ministry of Youth and Sports, the overall goal of the policy is to develop creative and innovative youth, appropriately equipped with a sense of responsibility, patriotism, and national pride, along with advanced technology relevant to national and global dynamics. Built around ten main policy objectives, the policy highlights four main objectives that are relevant to CSA tech, and youth innovation. These include: (1) promoting decent job creation, employability, and livelihood empowerment for youth; (2) developing institutional capacities and schemes

that support youth skills transfer, creativity, and innovation; (3) enhancing the participation of youth in governance, community development, and decision-making, elevating their sense of civic responsibility; and (4) establishing an institutional framework for the coordination of youth development interventions and mainstreaming.

To undertake this, the policy has developed specific strategies to achieve its objectives. Strategies under Objective 1 include enhancing accessibility to regular labor market services that address the needs of youth, young persons with disabilities, and young women; promoting the implementation of a youth enterprises classification system for Business Development Services at all levels; establishing effective legal structures, frameworks, and initiatives for the protection of creative ideas and intellectual property of young people; creating systems and structures that facilitate the commencement and sustainability of entrepreneurship; enhancing partnerships for the business development of young people; promoting local economic development; and sensitizing young persons on local potentials. Under Objective 2, key strategies to be employed include facilitating access for youth to advanced technical and vocational education for innovative skills and technologies; providing state-of-the-art ICT centers or laboratories in all Junior and Senior High Schools, districts, and communities, focused on Fourth Industrial Revolution (4IR) skills and Artificial Intelligence, integrating the needs of persons with disabilities (PWDs) and other marginalized groups; promoting entrepreneurship education at all levels; encouraging youth participation in climate action, environmental issues, and the "greening" of education, including TVET; and developing business skills for self-employment and employability for all young persons. Objective 3 highlights the following strategies: implementing measures that promote youth participation in governance and decision-making, particularly for young women and young PWDs; institutionalizing structures and systems to ensure effective participation and representation of youth, especially young women and young PWDs, at all levels; implementing sustained sensitization and awareness campaigns aimed at educating youth on youth-related policies and programs; promoting pro-youth programs and policies at all institutions and levels, including political parties; and promoting the institutionalization of mentorship, coaching, guidance, and counseling across public and private institutions at all levels. Under Objective 4, the main strategies include institutionalizing mechanisms at all levels to support youth mainstreaming and coordination of implementation; harmonizing all youth development activities; and establishing a Youth Development Fund.

The policy also acknowledges the need for economic and financial empowerment of young people, youth entrepreneurship and financial inclusion, training and development, education and skills training, information and communications technology, and youth participation in governance. It recognizes the role of youth in agriculture and environmental sustainability and considers various categorizations of youth into male and female, skilled and unskilled, employed and unemployed, among others. As a broad-based policy, it falls short of specific interventions for achieving these objectives and laid-out plans for implementation.

In addition to these policies, several government programs seek to address youth employment and skills development in both the short and long term. Key among them are the Youth Employment Agency (YEA), National Vocational Training Institute (NVTI), Opportunities Industrialization Centre Ghana (OICG), Youth Leadership and Skills Training Institute, Youth in Agriculture Programme (YIAP), National Entrepreneurship Innovation Programme (NEIP), previously Youth Enterprise Support (YES), Rural Enterprises Programme (REP), National Service Scheme (NSS), and the Nation Builders Corps (NABCO).

The key trends and challenges that escalate youth unemployment in Ghana include economic constraints, skills mismatch, technological advancements, and limited access to resources. Additionally, there are several gaps with youth initiatives and policies in Ghana, which have limited their impact and effectiveness. Fragmentation and duplication of policies, resource limitations, and implementation gaps constitute the dominant challenges, while inadequate focus

on TVET and STEM skills, insufficient support for entrepreneurship, lack of collaboration with the private sector, and outdated frameworks further compound the ineffectiveness of youth-related policies and programs in Ghana.

e. Policy Coherence between CSA Tech and Youth Employment

Ghana has introduced several policies, programs, and regulatory frameworks for CSA and youth employment. However, the National Green Jobs Strategy (2021-2025) is the only comprehensive approach that links CSA tech and youth employment. This policy document combines green agriculture with a focus on youth employment, providing clear direction for supporting youth in green technology sectors. The strategy creates proper alignment with relevant sector agencies and stakeholders, including state and non-state agencies focused on youth employment and green technology. It also provides adequate guidance for its implementation. The National Youth Employment Agency (NYEA) plays a crucial role in the strategy, targeting the involvement of youth, women, and persons with disabilities in all its approaches.

The strategy emphasizes skills development, focusing on providing necessary tools, teaching, and learning materials for delivering skills in green jobs. It also details a comprehensive plan for resource mobilization to enhance access for green enterprises. Additionally, it creates avenues for green innovations to secure funding from the Government of Ghana, enjoying incentives such as low-interest rates and tax breaks.

However, the other policies and strategies connected to youth employment and green technology do not provide the needed clarity and coherence to create a conducive atmosphere for implementation. These policies lack clear definitions and indicators for both youth employment and CSA techs. For instance, the National Climate Change Policy, which is Ghana's overarching policy document on climate change, identifies ten program areas that will address critical climate issues in Ghana but significantly ignores youth-related issues. The policy document is silent on the impact of climate change on youth and the role they can play in mitigating its effects. It does not highlight and prioritize the use of technology and innovations in combating the effects of climate change or in creating job opportunities for youth. While state officials believe that the NCCP is the overarching policy document and cannot provide minute details about its approaches, other stakeholders argue that since the NCCP presents the national response, it should comprehensively address all these areas. Since this document was developed in 2013, there have been several calls from stakeholders to review the policy to reflect current developments in climate change, especially the role of tech startups.

In other CSA documents where youth are mentioned as direct beneficiaries or stakeholders (in terms of jobs, entrepreneurship, and skills development), there are no clear, actionable, and time-bound strategies to integrate youth employment into CSA technologies. For instance, the National Climate Smart Agriculture Food and Security Action Plan (CSA-FSAP) (2016–2020), which primarily facilitates and operationalizes the NCCP in the food and agriculture sector, identifies youth employment as a major challenge and recognizes the role of science, technology, and innovation in addressing climate change challenges. It is therefore surprising that youth employment institutions are neglected in the stakeholders mapped for CSA approaches as contained in the plan. This is further evidenced by the absence of clear roles and responsibilities for youth, as well as a lack of detail in promoting innovations and technologies. The Ministry reveals that the primary goals of these documents are to provide a roadmap for the agricultural sector in combating the effects of climate change, which are reflected in the policy. According to them, there are other complementary programs such as the Youth in Innovative Agriculture Program, implemented by the Ministry, that specifically target youth employment in the agricultural sector.

Further assessment of some of these policies reveals a lack of clear budget lines, actionable plans, and timelines for monitoring and tracking some of their interventions. They do not clearly highlight the role of tech startups, their challenges, and recommendations for expansion and growth. Apart from the Green Jobs Strategy, which attempts to address these issues, most policy documents do not offer such elaborate interventions. Engagement with policy officials acknowledged these concerns and indicated that the policy process is dynamic, with new policies and programs always being developed to reflect current issues, including youth involvement and CSA technologies.

However, there also exist some frameworks and support mechanisms for tech startups, including those in CSA technologies. These initiatives are not specifically targeted toward tech startups in CSA technologies but cover all tech startups. The Youth in Innovative Agriculture program is one such example that supports tech startups in agriculture, although it is not specifically aimed at CSA technologies. The Presidential Pitch is another initiative that provides funding, mentoring, and other support to startups; however, it iis implemented by the National Entrepreneurship Innovation Program (NEIP), which is directly under the Office of the President. It is worth noting that these initiatives are not linked to overarching CSA policies and appear to be functioning independently. Ideally, the YEA, under the Ministry of Employment, could harness all youth employment agencies for better coordination and alignment.

The YEA, which is responsible for implementing the National Youth Policy, also has the mandate to empower young people to contribute meaningfully to the socioeconomic and sustainable development of the nation through skills training and internship modules that transition youth from unemployment to employment. They do this through the rollout of at least eleven modules for which youth can apply. These include youth in community service and security, youth in community and health assistance, youth in sports, youth in entrepreneurship, youth in paid internships, youth in agriculture and afforestation, youth in sanitation and coastal assistance, community teaching assistants, youth in apparel and textiles, industrial attachment, and youth in information and communication technology. The module on information and communication technology aims to target and equip youth with information technology skill sets to make them employable in the labor market, while the youth in entrepreneurship module seeks to equip youth with entrepreneurial skills to create a new crop of small business owners. Therefore, the YEA could have harnessed all other interventions on youth employment, such as, the Presidential Pitch, under these models to support youth employment. However, officials from the NEIP indicated the unique nature of the program, which is at the heart of the Presidency and, thus, requires a separate entity to run and report directly to the President.

Regarding the Digital Economy Policy, it highlights various strategies including initiating digital innovation challenges on topical areas such as health, education and agriculture coordinated with the NEIP, responsible state institutions and academia; creating a special fund for the development of digital innovation rural incubation hubs; identifying and prioritizing rural areas with significant potential for digital economy development opportunities to target for the setup of model incubation hubs and providing incentives or matching funds to encourage private equity financing programs to invest in women-owned digital businesses. This paper's engagement with officials from the NITA of the Ministry revealed that the Ministry is now putting in place structures to implement these strategies, including the drafting of a Legislative Instrument (L.I) to guide their implementation. Though there were no specific directions and support towards CSA tech, there are a couple of initiatives such as the Kofi Annan Digital Center of Excellence[2], Girls in ICT[3] program, and the recently launched "One Million coders[4]" program, which all have the potential to build the capacity of young people in IT.

With the exception of the Green Jobs Strategy, CSA technologies and youth employment are not prioritized or closely linked in most public policies and programs. CSA technologies are mostly captured as subsets of CSA practices, with little focus and attention. This is evident in the analysis undertaken by this paper, as most policies and programs

supporting "agri-techs" are geared toward all agricultural technologies and not necessarily CSA technologies. For instance, the policy actions in the NCCP and CSAIP provide broad frameworks for CSA practices and approaches but do not specifically address the technologies. Unfortunately, the Green Jobs Strategy, which adequately consolidates green technologies and youth employment, appears to be on the back burner. Policy actors engaged during this assignment (MOFA, MOFEP and MoCD) were unaware of it. Moreover, none of the ten CSA tech companies, accelerators, and other experts engaged had information about the document. This is a concerning development, as none of these stakeholders referred to the Green Jobs Strategy, revealing its significance in the CSA space, despite the comprehensive approaches captured in the document. This also presents several problems, as some notable interventions in the strategy have not been implemented. For instance, the strategy provides for the implementation of tax reliefs and benefits for individuals involved in CSA technologies; however, this has yet to be considered, with only one year remaining until the expiration of the document. Engagement with an official from the Ministry could not provide any cogent reason for this delay, though he acknowledged the work being done to provide tax reliefs for many businesses.

f. Policy Environment and Indigenous Knowledge

The United Nations Educational, Scientific and Cultural Organization defines Indigenous Knowledge (IK) as the knowledge, innovations, and practices of Indigenous and local communities that have been developed over generations and passed down orally or through practice (UNESCO, 2007). This knowledge is often rooted in a specific cultural and environmental context and encompasses a wide range of fields, including agriculture, health, education, and natural resource management. Warren (1991) defines Indigenous knowledge as the local knowledge unique to a given culture or society. It is the basis for local-level decision-making in agriculture, health care, food preparation, education, natural resource management, and a host of other activities, passed from one generation to the next, mostly by word of mouth. In the agricultural sector, various types of Indigenous knowledge, are used for mixed cropping and forest gardens, tree management, seed storage, ethno-veterinary medicine, and Indigenous crop management, among others. Engagement undertaken by this paper with experts reveals that Indigenous knowledge is critical and relevant to modern innovations and technologies as it blends with modern technology to deliver solutions to farmers. According to an official from the Young Professionals for Agricultural Development (YPARD), Indigenous knowledge encompasses harmonizing existing knowledge for better productivity, including upgrading the method of spraying inputs on farms, from traditional buckets to drone spraying services. Indigenous knowledge is therefore useful and plays a key role in innovations and inventions, especially in CSA technologies.

Recent global, regional, and national policies have highlighted the role and preservation of Indigenous knowledge, though their implementation appears to stagnate in Ghana. At the global level, Indigenous knowledge is inherently encompassed in most aspects and principles of the Sustainable Development Goals (SDGs) and is considered under Goal 15 (Life on Land), Goal 4 (Quality Education), Goal 6 (Clean Water and Sanitation), and Goal 17 (Partnership for the Goals) (UN Department of Economic and Social Affairs, 2024). At the continental level, the Comprehensive Africa Agriculture Development Program Ex-Pillar IV Africa Regional and Sub-Regional Organizations for Africa Research and Innovation (CAADP XP4) is the main project that brings research and innovation institutions together to boost the transformation of innovation in agriculture and food systems to make them more resilient to climate change and better respond to development demands. The project promotes, encourages and extends knowledge and information, including Indigenous knowledge, among leaders, academics, practitioners, and value chain actors (African Forum for Agricultural Advisory Services (AFAAS), 2024).

In Ghana, the concept of Indigenous Knowledge has gained increasing currency over the past decade, recognized by the government and mainly advanced by NGOs and community-based organizations. The National Climate Change Policy, for instance, acknowledges the role of traditional knowledge in conserving natural resources, protecting the environment, making farming decisions, predicting weather, managing health and coping with extreme climate variability. It also emphasizes the importance of documenting Indigenous Knowledge in early warning systems and research to establish its potential for scaling up. This is further advanced in the National Climate Change and Adaptation Policy, which identifies the weak relationship between scientific knowledge and Indigenous knowledge. Together with the National CSA-FSAP, both documents propose to strengthen the relationship between Indigenous Knowledge and scientific knowledge, including the documentation of existing Indigenous knowledge.

However, the National Green Jobs Strategy, which is the comprehensive document for green jobs and youth employment in Ghana, is silent on Indigenous Knowledge and does not provide any connection or relationship between green technology and youth employment. This appears to be a severe anomaly as it displays a lack of coherence among policies that are supposedly connected to each other.

Currently, there is no evidence of a comprehensive framework to begin the documentation of Indigenous Knowledge as envisioned in the NCCP and Food Security Action Plan. This was corroborated by respondents who indicated that there is no evidence to suggest government support and prioritization of Indigenous Knowledge, though one respondent indicated that the introduction of TVET programs was gradually changing that mindset. The official from YPAG, while recognizing the multiplicity of policies that highlight Indigenous knowledge, cited the dormancy and lack of awareness by many actors regarding these policies. This, according to him, is a manifestation of the lack of recognition by key actors of the importance of Indigenous knowledge, citing the lack of a participatory approach in the design of technologies for specific groups of people. He lamented that "*people do not respect the cultural values of Indigenes… they do not integrate the beliefs and practices of local people in the design of innovations and inventions*."

Policymakers from the Ministry of Food and Agriculture (MOFA), Ministry of Finance and Economic Planning (MOFEP), and National Youth Employment Program (NYEP) recognized the role of Indigenous Knowledge (IK) in the tech space and acknowledged its importance. However, they believe that the government can do more to upscale Indigenous knowledge in technology, especially in the areas of documentation and providing support to technologies that rely heavily on Indigenous knowledge. From the assessment, it is unclear what is currently being done by state agencies in documenting Indigenous knowledge, though some academic institutions have developed curricula integrating Indigenous knowledge into their syllabi. The University of Education, Winneba (UEW), for instance, has initiated a program to support the integration of Indigenous Knowledge into Science, Technology, Engineering, and Mathematics (STEM) education (UEW, 2024). This is in addition to the development of some curricula on Indigenous knowledge used in the institution, a copy of which can be accessed here.

Additionally, some non-state institutions, such as the Centre for Indigenous Knowledge and Organizational Development (CIKOD) and the Youth Policy Advocacy Group (YPAG), have begun efforts to document some of these practices and traditions. However, a significant portion of knowledge remains with traditional authorities, including chiefs and community members who transmit it to the next generations orally, usually through socialization, general interactions between masters and apprentices, discussions among peers, and informal consultations (Fusien, 2018).

g. Summary

CSA tech provide avenues for farmers to optimize inputs and outputs, manage climate disruptions, and contribute to climate change mitigation. They offer several benefits, including improved food security and crop yields, enhanced soil fertility, dietary diversity, and increased productivity. However, there are constraints to CSA tech adoption, including the complexity of some CSA practices, high labor costs, lack of government support and credit, difficulty accessing weather and climate data, and high illiteracy rates among smallholder farmers. Despite these challenges, CSA has the potential to create job opportunities for young people in Ghana, addressing the 12% youth unemployment rate.

In bridging this gap, the role of CSA tech startups has become prominent due to their critical contributions to reducing the effects of climate change while providing job opportunities for youth. These startups offer innovative agriculture and agribusiness-related services across the value chain, providing various employment opportunities for youth, including field officers, technicians, agronomists, project managers, data analysts, software engineers, and marketing and communication specialists. Despite their significant role, CSA tech companies in Ghana do not have categorized support, as they are subsumed under general "agri-techs", which focus on the overall agriculture sector.

In Ghana, key actors in the CSA ecosystem include tech hubs and accelerators that provide technical and logistical support to startups; the state, which develops policy and regulatory frameworks to encourage and regulate growth and innovation; and development partners, NGOs, CSOs, MMDAs, donor partners, financial institutions, and academia also play roles in supporting the growth of CSA tech companies.

Regarding the policy and regulatory environment, Ghana has developed several policies and frameworks supporting CSA practices, but few explicitly promote Climate Smart Technologies (CST). There are no specific laws or regulations guiding the adoption and use of CSA tech, though existing legal frameworks influence incentives, opportunities, and risks for involved actors. Concerning youth employment, the National Youth Policy recognizes the role of youth in agriculture and environmental sustainability and considers various youth categorizations. However, as a broad-based policy framework, it falls short of specific interventions to achieve these objectives and lacks laid-out plans for implementation. The National Green Jobs Strategy (2021-2025) stands out as the only comprehensive approach that effectively links CSA tech and youth employment. However, with one year remaining until the expiration of the strategy, most of its initiatives have yet to materialize.

Despite policy recognition, the implementation of Indigenous knowledge preservation and promotion appears to stagnate in Ghana, with no known state-sponsored framework for documenting Indigenous knowledge. Some academic institutions and CSOs have begun efforts to document and promote Indigenous knowledge.

3. Practical Realities and Challenges of CSA Tech Start-Ups

a. Introduction

To delve into the practical challenges, opportunities, and potential of youth-led climate tech innovations, this study reached out to key stakeholders to solicit their input and feedback. The critical responses from these stakeholders provided a roadmap for understanding the current situation and proposing recommendations for consideration. The chapter provides insight into the findings from the respondents relating to the impact of policy and regulations, the scope of their funding and constraints, the factors limiting the growth and expansion of the tech startups, and employment trends. The findings also highlight the technical support and assistance received from partners and their utilization and conclude with the application of Indigenous knowledge to their innovation.

The intersection of CSA tech and youth employment has given rise to a new generation of innovative entrepreneurs in Ghana. This study, therefore, explored the landscape of startup tech companies in Ghana, focusing on those specializing in CSA tech. A tech startup is an entrepreneurial venture in the early stages of operation with a business model anchored primarily on a technology or software product (Cooper, 2023). They are mostly technology-focused, possess potential for scalability, and adopt lean and agile methodologies (Appetiser, 2023). They are distinguished from traditional businesses in many ways including their focus on large-scale growth, aiming to reach as many users as fast as possible to establish a dominant market presence, leading to prolonged periods of unprofitability (Cooper, 2023).

In that regard, this research focused on ten (10) of these companies working in CSA tech in Ghana, with CEOs mostly below the age of 35 or were less than 35 years old at the time of establishing the company. The research revealed a dynamic and youthful sector, with these startup companies driving innovation and growth. This chapter provides an overview of the key findings, highlighting the contributions of these startups to addressing climate change through technologies and increasing youth employment in Ghana. It highlights the impact of policy on their work, the extent of their involvement in the policy process in Ghana, and the challenges and bottlenecks they face in delivering and sustaining these innovations. It also highlights the various avenues of funding to support their work, the role of the state, as well as the factors that affect their growth and expansion. The final part explores the role of accelerators and tech hubs and the extent to which their support has fostered the growth of these companies. The adoption of Indigenous knowledge and the role it plays in the innovation and invention process is further explored in this chapter.

b. Overview of Tech Startups

The research engaged ten (10) CSA tech startups. All of these companies are less than 6 years old, with four (4) of them established in 2022, three (3) in 2019, and one (1) each in 2021, 2020, and 2018. The mean age for the founders stood at 33.2 years, indicating a very youthful group (Figure 1).

Table 2 shows that out of a total of 124 employees, only two were above the age of 35, representing just 1.6%, with 98.4% of them being youth, while about 65% of the employees are male. Out of this number of employees, 47 of them, representing 61%, are direct jobs, with 39% being indirect jobs.

Unfortunately, none of the founders engaged were female, primarily due to the difficulty in identifying female-led CEOs based on the approach employed by the research. The purposive sampling and snowballing method, which was adopted, led to male-led CSA tech companies. Although deliberate efforts were made to engage female-led companies, none were identified during the data-gathering period.

Table 2

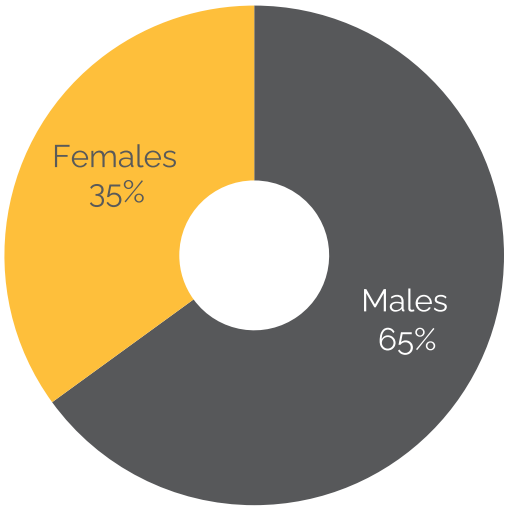
Breakdown of Respondents

No	Name of Startup	Age of CEO	Number of Youth Employees	
			Male: ( ) indirect jobs	Female: ( ) indirect jobs
1	A1 Scarecrow Technologies	35	4(0)	1(0)
2	3 Farmate Robotics Limited	34	13(8)	1(0)
3	SMART Farmer	34	8(4)	6(4)
4	ECOVON Limited	33	11(7)	6(2)
5	GAD-V	40	3(2)	2(1)
6	Ignitia Ghana Limited	38	5(0)	3(0)
7	JAASGROW Limited	27	8(6)	6(4)
8	Kodu Technology	30	12(0)	8(0)
9	Asaase Micromanure	28	1(0)	1(0)
10	Sesi Technologies	33	15(6)	10(4)
			80(33)	**44(15)**

Note: Authors' Construct based on Authors' Fieldwork Research 2024. The numbers in parentheses represent the number of indirect jobs created by these startups. Direct job here refers to employment opportunities created within CSA tech startups themselves. These include roles such as technicians and Engineers, Agronomists and Field Officers, Project Managers and Data Analysts and Marketing and Communication Specialists. Indirect jobs are employment opportunities generated as a result of the existence and operations of CSA tech startups and are not on the payroll of these companies.

It must be noted that while CSA tech have served as an avenue for entrepreneurship and job creation for the founders, only one (1) of the 10 founders interviewed were unemployed before the establishment of their business, emphasizing the low rate of employment opportunities for leaders in CSA tech startups. Four (4) of them were already self-employed, while five (5) were employed by other businesses before the transition.

Figure 1
Gender distribution of employees



Note: Authors' Construct based on Authors' Fieldwork Research 2024

Figure 2
Employment distribution by type

Note: Authors' Construct based on Authors' Fieldwork Research 2024

These companies offer software and hardware solutions to various customers, including farmers, individuals, and businesses. The solutions address several climate crises, such as erratic rainfall and weather unpredictability, using A1-powered irrigation systems. To promote the optimum and timely usage of organic inputs, some of these companies, such as 3 Farmate Robotics, offer precision agriculture services through the use of drones to spray farmers' fields. To promote circularity in agriculture, some of these companies, such as Kodu Technology, have developed innovations and technologies that convert agricultural waste to produce several products. These include the use of banana fiber to produce sanitary pads, coconut husks to produce board panels, and organic waste to produce multi-purpose organic inputs for farmers. In addition, some of these startups provide digital weather information services and digital platforms to offer CSA services to farmers. Out of these companies, nine (9) are already at the implementation stage of their innovation, and one (1) is at the ideation stage. With a combined reach of over 1,000 clients which includes business-to-business (B2Bs) and business-to-customers (B2Cs) with their products and services, these tech startups are providing important and crucial climate-smart solutions through home-grown and imported innovations.

Most of these companies are located in regional capitals, with the Greater Accra Region being the most populated, hosting five (5) of the head offices of these companies. This is followed by the Ashanti Region (2), with Eastern, Central, and Northern Regions having only one representation each. Additionally, most of these companies operate from large cities such as Accra, Kumasi, Cape Coast, and Tamale, even though their clientele base is mostly spread within the region they operate, primarily due to low adoption of their technologies and the high cost involved in reaching other areas. For companies such as Ignitia, which provides weather information services that don't require much locomotion, their services reach farmers in other regions.

c. Policy and Regulatory Challenges and Impact

A supportive policy and regulatory environment is essential for scaling up of CSA tech across all jurisdictions. This is important as it drives and encourages innovation, provides avenues for incentives, facilitates access to finance, and addresses major barriers to adoption. These frameworks include, but are not limited to, standards and certifications, intellectual property protection, and environmental and social safeguards, among others. According to the Food and Agriculture Organization (FAO, 2017), governments can create a conducive environment for producers to adopt CSA practices by providing incentives and removing barriers to adoption. Additionally, to establish an enabling environment for farmers and other private sector stakeholders – including tech startups, financing institutions, and civil society – government can adapt existing policies and regulations, design new coherent policies, strategies, plans, and programs for CSA tech where necessary, and allocate adequate resources for their implementation.

Table 3

Features of tech companies engaged

No	Name of Startup	Products and Services Provided	Stage in Innovation Cycle	Location
1	A1 Scarecrow Technologies	Usage of specialized drones to spray farms with organic inputs and scare birds	Implementation stage	Accra, Greater Accra Region
2	3 Farmate Robotics Limited	Precision farming (use of drone technology to spray farms)	Implementation stage	Cantonments, Greater Accra Region
3	SMART Farmer	Development of greenhouse technologies, drip irrigation, and drip-feeding systems to control temperature	Implementation stage	Kumasi, Ashanti region
4	ECOVON Limited	Utilizing technology to transform agricultural waste (coconut husk) into panel boards	Implementation stage	Amasaman, Greater Accra Region
5	GAD-V	Solar irrigation system (development of moveable tricycle to provide water, test soil moisture, and provide weather information)	Ideation stage	Accra, Greater Accra Region
6	Ignitia Ghana Limited	Provide climate-smart advisory services, including extreme weather alerts for farmers	Implementation stage	Accra, Greater Accra Region
7	JAASGROW Limited	Utilizing technology to transform waste into the production of organic inputs (fertilizer and seeds)	Implementation stage	Cape Coast, Central Region
8	Kodu Technology	Utilizing technology to transform agricultural waste (banana peels) into sanitary pads	Implementation stage	Tamale, Northern Region
9	Asaase Micromanure	Utilizing technology to produce compost and mushrooms	Implementation stage	Kpong, Eastern Region
10	Sesi Technologies	Development of grain content moisture and soil monitoring technology for farmers	Implementation stage	Ejura, Ashanti Region

Note: Authors' Construct based on Authors' Fieldwork Research 2024

However, this situation is far from the reality in several African countries. According to the World Bank, African countries scored low on its CSA policy indicators, especially on Readiness Mechanisms, Services and Infrastructure, as well as the Aggregated Policy Index. This indicates that African governments face critical challenges related to leveraging investments for climate action, promoting the adoption of new technologies, providing enabling services, and creating the necessary institutions for CSA implementation (The World Bank, 2018). This scenario is consistent with the findings of the study from the Ghanaian perspective.

Ghana's youth tech startups are driving innovation in CSA, yet they face significant policy constraints that hinder their growth and impact. This assessment revealed a striking disconnect between these startups and the policy environment governing their work. Despite the existence of policies and frameworks intended to support CSA tech and youth entrepreneurship, the majority of respondents surveyed were unaware of these policies, underscoring a critical gap in awareness and engagement. This chapter explores the policy constraints faced by the ten youth-led tech startups in the CSA sector we studied for this project and examines the implications for policymakers, entrepreneurs, and the broader development agenda.

Firstly, the assessment reveals the lack of awareness about existing policies and frameworks as a major policy gap for many tech startups: eight (8) of the startups were unaware of any public policies related to their work (Figure 4). The only policies they were aware of, were the legal and regulatory requirements they needed to comply with. One respondent noted, "*I do not know about any policies in the sector; what I know is that my products need to be certified and standardized, so I have to adhere to the FDA regulations*". Even for the remaining two, who were aware of existing policies, the maximum number of policies known was only two (2). Two (2) of the respondents also revealed that they were only aware of specific policies related to specific aspects of their work and not necessarily on CSA technology. For instance, one startup was involved with and aware of a policy on crowdfunding, which they rely on for their work, as well as a regulation being developed to guide their work. However, these policies are not specifically related to green jobs.

Another major constraint is the disconnect of these tech startups from the policymaking process. Our assessment showed that about eight (8) of these companies were not involved in any stage of the policymaking process. This is due to different reasons; **they are either unaware of the process, not invited to participate, or simply uninterested, as they do not see it providing reasonable solutions to their problems.** This is in sharp contrast to the responses by policymakers who insist that key stakeholders, including youth tech, are involved in all stages of the policy process. For instance, only one respondent affirmed confirmed being in all stages of policy formulation, regarding the development of the National Climate Change Adaptation Plan. According to him, he participated in the policy development and validation of the plan. Additionally, two respondents, mentioned being involved in other policymaking processes, but these were not specifically related to CSA tech and youth employment (Table 4). One respondent highlighted the challenges of the policy environment: "*The system and infrastructure for agriculture are not in place; things are disjointed, the system does not support anyone, and if you want help, it is you who has to chase the system for support.*"

All state agencies engaged indicated that youth and tech startups were heavily involved in the policymaking process. One official remarked, "*How do we develop a policy involving the youth and startups without involving the key people? They were all involved.*" Another official stated, "*We engage all stakeholders during the policymaking process, including organizations working with the youth, and their views are considered.*"

Table 4

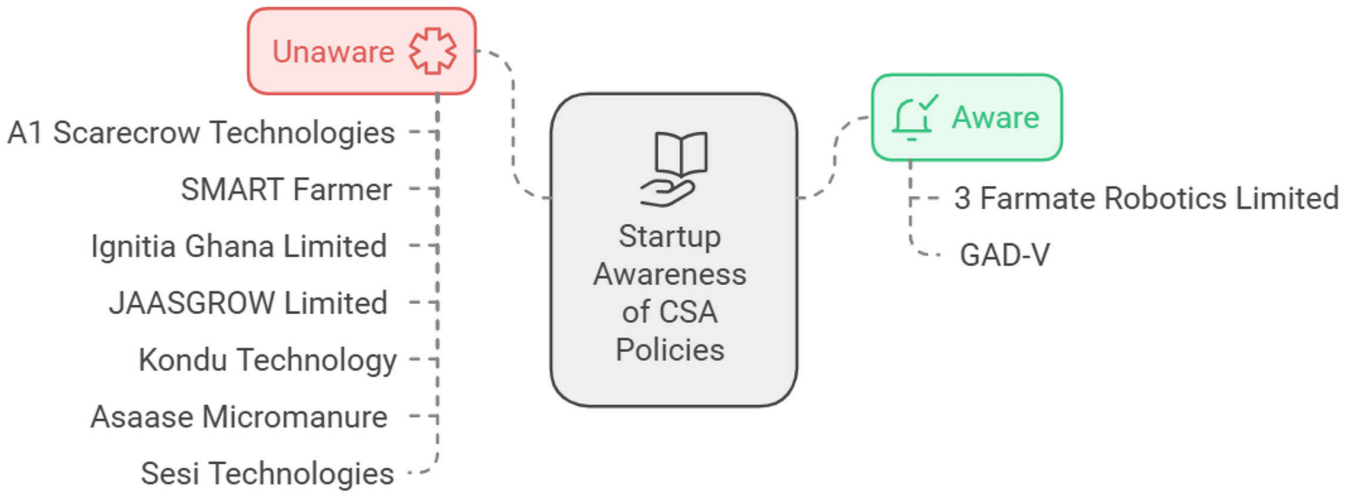
Awareness and Involvement of Startups in the Policy Process

No	Name of Startup	Awareness of CSA Policies	No. of Policies Known	Involved in Policy Advocacy	Involved in Policy Development	Involved in Policy Consultation	Involved in Policy Validation
1	A1 Scarecrow Technologies	No	N/A	No	No	No	No
2	3 Farmate Robotics Limited	Yes	2	No	No	No	No
3	SMART Farmer	No	N/A	No	No	No	No
4	ECOVON Limited	No	N/A	No	No	No	No
5	GAD-V	Yes	2	Yes	Yes	Yes	Yes
6	Ignitia Ghana Limited	No	N/A	No	No	No	No
7	JAASGROW Limited	No	N/A	No	No	No	No
8	Kondu Technology	No	N/A	No	No	No	No
9	Asaase Micromanure	No	N/A	No	No	No	No
10	Sesi Technologies	No	N/A	No	No	No	No

Note: Authors' Construct based on Authors' Fieldwork Research 2024

Figure 3

Startups' awareness of CSA policies



Note: Authors' Construct based on Authors' Fieldwork Research 2024

It is important to note that the policymaking process in Ghana is very elaborate and attempts to consider the views of several stakeholders. From the policy conceptualization to the finalization stage, stakeholders are consulted at various levels of the policy process, especially during the development and validation stages. Our engagement with policymakers regarding the respective policies indicates a very extensive consultation process with all stakeholders, although some of these processes are unable to include all stakeholders due to various reasons, such as budgetary constraints and limited knowledge of all stakeholders in the sector. Therefore, it is not surprising that eight (8) out of the ten (10) companies were not involved in the process.

Some policy officials indicated that, due to their inability to identify all stakeholders, it is incumbent upon these groups to make themselves known to the Ministry so they can be included in the policymaking stages. Moreover, considering the year these policies were developed, it is evident that these startups did not exist at that time. However, this justification cannot be applied to recent strategies, such as the Green Jobs strategy. These lapses sometimes result in the development of policies that do not comprehensively address the concerns of the respective stakeholders. They also create gaps and sometimes misdiagnose the problems, rendering the solutions inadequate. Despite the widely held view that Ghana has well-laid-out policies and programs, implementation remains the biggest challenge. In this regard, startups are encouraged to be proactive in engaging government agencies, seeking information from them, and serving as advocates to highlight their issues.

Another challenge identified pertains to regulation and certification issues for tech startups in the country. Our assessment of these 10 startups revealed that the formal registration process poses significant challenges to these startups we studied, leading many to resort to unconventional approaches that are, surprisingly, effective. The study found that out of the 10 startups engaged, only one had not yet registered with the Registrar General's Department. This was attributed to the long, tedious, and time-consuming nature of the process. According to the founder, he began registration over nine months ago but had yet to complete it due to long queues, unending procedures, and delays at the department. He has therefore, resorted to using an agent for the registration exercise, which has also been ineffective. Notably, the majority of the other organizations interviewed who had completed their registration also used third parties or agents, or went through acquaintances at the Department to facilitate their registration. These organizations concurred that the ease of their registration was due to utilizing individuals instead of the formal process, which could take more than a year, while their approach took less than three months in some cases.

Business registration in Ghana is essential as it provides legal backing for the existence of companies, offers identification and branding for the company, presents opportunities for securing loans and investments, enables other contractual agreements, establishes ownership, and ensures tax compliance. The processes for registration are outlined by the Registrar General's Department of the Ministry of Justice; however, these startups may find the formal registration process off-putting and prefer alternative methods they consider more effective. An official from KIC corroborated this scenario, indicating that youth face challenges in the certification process. He noted that the process is cumbersome, tiring, and time-consuming, frustrating young people who wish to comply with regulations. He called for support for young people in this process to help them understand it better and to provide simplified platforms for undertaking it.

Another major regulatory constraint is the issue of Intellectual Property Rights (IPR) and its impact on the ownership and sustainability of tech startups. The country's main legislation governing intellectual property includes the Copyright Act, the Patents Act, the Trademarks Act, the Industrial Designs Act, and the Geographical Indications Act. Additionally, Ghana is a signatory to international IP agreements such as the World Intellectual Property Organization (WIPO) treaties,

further strengthening IP protection within the country. Despite being elaborate, Ghana's policy on IP is largely unknown to many entrepreneurs regarding how to leverage it for their businesses, including tech startups (Citinewsroom, 2022).

It is therefore unsurprising that only two (2) of the tech startups have duly registered and licensed their products, with only one startup fully registered in Ghana, while another secured a trademark license from the United Kingdom. Consequently, eight (8) of the tech startups have not yet registered their IPRs for their products and services, risking the ownership and transfer of their innovations. It is important to note, however, that out of these, only three (3) had begun the process but halted due to difficulties. The reasons attributed to their inability to start or continue vary. However, the high cost of registration, convoluted procedures, and lack of adequate information on the process are the dominant factors. From the assessment, five (5) of the yet-to-be-registered companies attributed it to the high cost, which ranges from $500 to $1,200, depending on the stage of innovation – a cost many cannot bear. This is in addition to other technical and logistical costs, including hiring a legal practitioner to assist in the process. The other five (5) have little or no knowledge about the registration process or what is required of them. Although they have some information, they do not know whom to engage or how to navigate the process. Lastly, the process is very cumbersome, requiring a series of tests and documentation, and could take up to two years to complete, which is not only time-consuming but also strains their finances. It is clear from the assessment that while they recognize the importance of IPR, these factors serve as disincentives for them to pursue the process.

From the above analysis, it is evident that while significant policies and regulations exist, startups are disconnected from the process, which is characterized by inefficiencies and complexities that are not responsive to their needs. The analysis further revealed that these startups distrust the entire policy ecosystem and are unwilling to get involved in any aspect of it. While many believe that these several policies do not address their needs, others are of the opinion that there are no systems in place to support them; hence, they do not recourse to public services for any form of support.

d. Scope of Funding and Constraints

The assessment also examined funding for startups due to its crucial role. Since 2016, there has been an upsurge in funding for tech startups in Africa, but this slowed down in 2023 as global capital shortages began to take effect. Disrupt Africa (2023) revealed that 406 startups raised a combined total of $2,406,914,000 throughout 2023, a significant decline from $3,333,071,000 raised by 633 startups in 2022. **This decline was mainly attributed to a sharper decrease in the number of active investors compared to total funding (Disrupt Africa, 2023)**. Funding for "agri-techs" has generally remained consistent until 2023, which marked the first year on record that funding to the sector declined. "Agri-tech" startups in Africa raised $84,640,000 in 2023, down from $132,825,000 in 2022, representing a 36.3% decline.

According to Disrupt Africa (2023), Ghana was ranked sixth for the number of ventures to gain backing within the continent in 2023, with total funding at USD 27,276,200, representing 1.1% of Africa's total and a massive 81.6% decline compared to 2022, when Ghana raised $148,572,000. The year 2023 marked a significant regression for Ghana, particularly as only two startups, Jetstream and Complete Farmer, an agri-tech company, accounted for 85.8% of all funds raised, with the remainder comprising only small trickles of funding for the other sectors. In terms of funding, non-agri-tech companies raised more than agri-tech companies within Africa and in highly ranked African countries. Disrupt Africa (2023) highlights that despite suffering from significant setbacks, fintech remains the leading sub-sector of the African tech startup ecosystem, with the highest amount of funding, raising USD 963,549,000 in 2023. This is followed by energy which raised $655,863,000; transport, $198,488,000; and e-health $135,810,000. Agri-tech startups in Africa raised $84,640,000,

ranking sixth among the sub-sectors. In terms of the share of funding for various sub-sectors in African countries, fintech greatly dominates, followed by e-commerce and retail, transport, and e-health in Nigeria, which holds the position as the best-funded country. Kenya, the second-ranked country, had the energy sector raising the most funding, followed by agri-tech, e-commerce, and fintech. In South Africa, fintech, e-health, the ed-tech space, and agri-tech followed in that order. Fintech and e-commerce are the most funded in Egypt, while e-commerce and retail, logistics, and the agri-tech sector dominate in Morocco. In Ghana, fintech is the most heavily funded, followed by logistics, agri-tech, and e-health (Disrupt Africa, 2023).

These funding regimes show that fintechs attract more funding compared to agri-techs, which could be attributed to a couple of reasons. Thus, investors generally focus on fintechs over agri-techs due to profitability, faster scalability and lower operational costs associated with fintechs. Additionally, fintechs offer quick returns, due to their digital nature, which allows companies to scale rapidly without the constraints of physical infrastructure. Moreover, they benfit from strong regulatory support and high consumer demand compared to agri-techs (Mhlanga, D. 2023). There is therefore, a need for targeted incentives such as tax breaks and exemptions, infrastructure support, increased access to financing and market linkages for increased funding for not only agri-techs but also those involved specifically in CSA tech due to their critical role.

With capital being the most crucial element to instigate growth and expansion for every company, there is a general lack of financing available for startups across all ecosystems due to existing funding options that are disproportionately concentrated in Accra, leading to increased competition (Turolla, Doshi, & Diaba, 2022). Coupled with current unfavorable macroeconomic indicators, including a 23% inflation rate as of November 2024 (GSS, 2024), a monetary policy rate of 27% (Bank of Ghana, 2024), a weakened currency, and a flurry of taxes for businesses, startup companies face a daunting task of sustaining and expanding their operations in Ghana. Moreover, the tight fiscal space, as occasioned by Ghana's current program with the International Monetary Fund (IMF), means that the state does not possess the financial ability to lend support to these startups during this difficult period.

Table 5

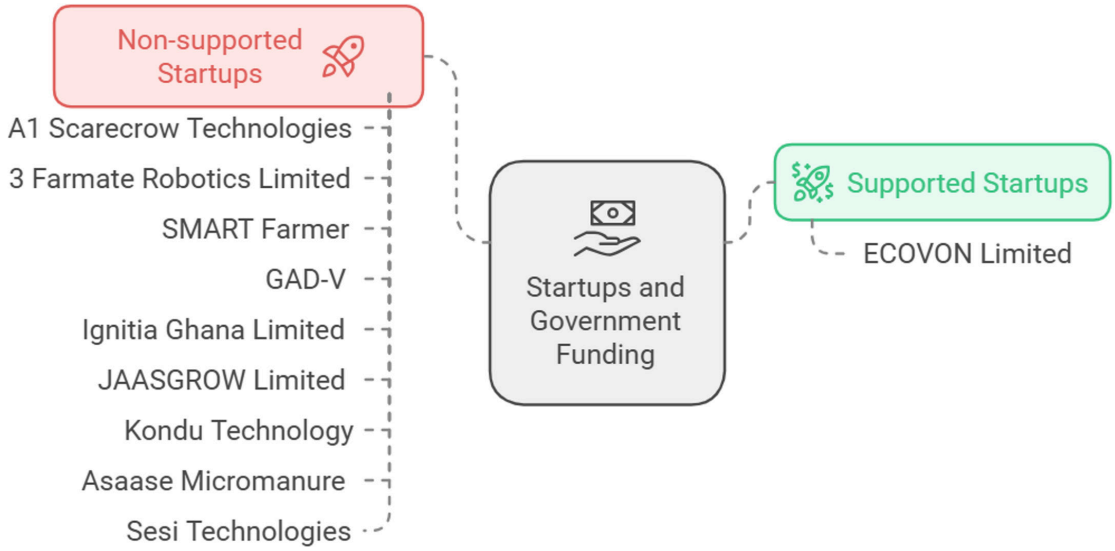
Funds raised by startups

No	Name of Startup	Total amount raised (in USD)	Highest raised	Source	Period	Funding from gov't
1	A1 Scarecrow Technologies	150,000	50,000	KIC	2019	No
2	3 Farmate Robotics Limited	230,000	100,000	REDITT, JICA	2024 2022	No
3	SMART Farmer	445,000	100,000	Crowdfunding	2021	No
4	ECOVON Limited	120,000	40,000	UNDP	2022	Yes
5	GAD-V	N/A	N/A	N/A	N/A	No
6	Ignitia Ghana Limited	8,000,0000	2,500,000	Novastar	2021	No
7	JAASGROW Limited	30,000	30,000	KIC	2023	No
8	Kondu Technology	130,000	50,000 50,000	KIC Goal Getters	2023 2024	No
9	Asaase Micromanure	5,000	2,500	Self-financed	2023	No
10	Sesi Technologies	600,000	300,000	Innovate UK	2022	No

Note: Authors' Construct based on Authors' Fieldwork Research 2024

Figure 4

Startups and government funding



Note: Authors' Construct based on Authors' Fieldwork Research 2024

There are four funding sources for tech startups, which include grant funding, debt financing, equity investments, and mezzanine financing (Vota, 2018). Grant financing includes grants offered by national and international organizations, foundations, prizes and awards from startup competitions, and donation-based campaigns. Debt financing entails entrepreneurs taking loans that must be repaid within a predetermined time period, subject to an agreed-upon interest rate. Equity investments involve investors putting money into a startup company in exchange for a portion of the company's shares, while mezzanine financing is a hybrid instrument that sits between equity and debt financing.

Though there is no literature on the specific funding mix for tech startups at the continental or sub-regional levels, debt financing appears to be the most common (Vota, 2018) form of financing for tech startups. However, this is not the case in Ghana, as per the assessment undertaken; **8 out of the 10 startups interviewed, had grant financing, mostly from private sources including accelerators and donor agencies, with one self-financing and another unable to secure any form of financing to bring their ideas to life** (Table 3). This current scenario aligns with how they sourced their initial funding and reflects their current funding mix. According to them, funding has been one of the most significant challenges they face in providing solutions to their innovations; these funding sources are very limited and competitive. With no support mechanism in place, they must find their own means of funding their innovations. From ideation to the implementation stage, these startups engage in grant or proposal writing, crowdfunding, and participating in competitions such as the "Agri-tech" challenge to raise funds for their innovations. While debt financing in the form of loans is a popular means of raising funds, the unfavorable lending conditions in Ghana (high interest rates, averaging about 30% and collateral demands) render it an unpopular option for these startups. While one of the startups needs funds to bring their ideas to life, the remaining nine (9) need grants to expand their businesses, employ more personnel, and set up in other countries.

The government's role in providing funding is low, as only one startup received government support (Figure 5). This support came from the Presidential Pitch program under the NEIP, where the company received cash amounting to approximately $5,200 coupled with training and mentoring sessions.

e. Factors Limiting Growth and Expansion

To catalyze the growth and expansion of startups, a conducive environment and incentives are crucial. Climate, Insider (2023) identifies several factors that are essential for driving the success of climate tech startups in Africa. These factors include blended finance, which strategically combines public, private, and philanthropic capital; local partnership ecosystems, which provide necessary infrastructure, market access, and local knowledge; regulatory support in the form of favorable regulations that create a more conducive environment; and scaling through innovative tech development. Our engagements with these companies reveal their frustrations and opinions on what constitutes a conducive environment necessary to foster their growth.

The major factor enabling their growth and expansion is capital. These tech companies have ambitious intentions to expand and penetrate new cities and countries. As provided in Table 2, all these companies have only one branch, and their products/services are mostly concentrated within their geographical locations, although a few of them extend the geographical location of their head offices. However, their ability to raise adequate and patient capital remains a major constraint. **This is due to increased competition, limited funding avenues, and high interest rates**. Although these companies have raised substantial capital, the funding appears inadequate considering their plans and vision to expand into other cities and jurisdictions. Their continuous search for funding at every opportunity testifies to the inadequacy of their current funding. Furthermore, the apparent lack of state support exacerbates their difficulties, forcing them to rely on competitive funding from the private sector and accelerators. These startups are at various stages of their innovations, with varied funding needs. From the assessment, it is evident that two (2) out of ten need funding to expand to other jurisdictions, two (2) need additional funding to improve their market viability, two (2) need funding to transition from the ideation to the production stage, while four (4) need funding to enhance their infrastructure and machinery (Table 6). Moreover, the tech startups require additional funding ranging from as low as $2000 to as high as $6 million (Table 6), depending on the stage of their innovation and future plans.

Another major factor that enables their growth is access to the market. While all the startups engaged serve a significant number of clients, they admit that their current and potential clients' adoption and patronage of their innovations will boost their growth. One CEO lamented, "*The farmers are only interested in piloting the drone spraying services; they do not want to pay for the actual services when they need them.*" This lack of commitment to paying for certain services presents growth risks for these companies, as it restricts their ability to expand and develop. Their goods and services are relatively expensive compared to existing ones, making them unaffordable for clients. Additionally, customers, especially farmers, have yet to appreciate these new technologies sufficiently to adapt to and patronize them. Moreover, they face competition from established brands and companies that enjoy a comparative advantage, allowing them to produce in higher quantities at lower costs.

Another key factor highlighted is government support in the form of tax incentives, such as tax reliefs and tax holidays, which are common incentives provided by the state to help companies thrive. While these incentives exist, two major factors inhibit startups from accessing them. The first is a lack of knowledge about these incentives and how to apply for them; the second is the perceived stressful process required to benefit from them. Due to this lack of information, over six (6) out of the ten (10) respondents did not consent to these benefits, believing the system is too cumbersome for them to qualify; hence they would rather prefer adequate financing to propel their growth. For instance, the Minister for Food and Agriculture can grant tax exemptions for the import of agricultural inputs and equipment; however, companies need to apply to the Ministry for approval. This process is generally unknown to these companies, with only one (1) being familiar with the process and taking advantage of it. Education on the tax benefit regime in the country would go a long way to encourage these startups to take advantage of these incentives to ease their cost burden.

Table 6

Funding needs for Startups

No	Name of Startup	Funding Need	Funding Required (USD)
1	A1 Scarecrow Technologies	Currently at the research and development stage, with plans to develop same technology at an affordable cost to farmers	200,000
2	3 Farmate Robotics Limited	Marketing and commercialization stage of product	100,000
3	SMART Farmer	Minimum viable product (MVP), already developed; needs to launch and market the product	100,000
4	ECOVON Limited	Expansion of infrastructure (need for more space for production and storage); need to invest in machinery (hydraulic pressing machine, hot air oven) to increase productivity and automate all machines	200,000
5	GAD-V	Still at the ideation stage; need to build a prototype for innovation	2,000
6	Ignitia Ghana Limited	Expand to new geographies	6,000,000
7	JAASGROW Limited	Expansion of infrastructure (machines, threshers, grinders, solar panels); commercialization of products	100,000
8	Kondu Technology	Increased production, purchase of additional machinery	100,000
9	Asaase Micromanure	Formalize operation, obtain certification and licensing; procure logistical inputs (tricycles)	30,000
10	Sesi Technologies	Expansion to other territories	500,000

Note: Authors' construct based on Authors' fieldwork research 2024

Moreover, public officials from the Ministry of Finance and Agriculture confirmed the existence of some tax reliefs and exemptions for companies, particularly those involved in the agricultural sector. However, accessing and benefiting from some of these incentives is cumbersome, as it involves the presentation of several documents and undertaking multiple errands, which are not feasible for these tech startups. One official indicated, "*There are some tax benefits, but you need to have successfully met some preconditions, which are unreachable for many of the youth.*" For instance, the Ghana Revenue Authority (GRA) grants tax incentives to agro-processing companies; however, to qualify, companies must be established throughout the country. This is virtually an impossible feat for many of the startups. According to the official, several challenges limit the youth from enjoying these tax incentives. He stated that:

> "*Difficulty for these tech startups to design quality and competent proposals that can easily secure funding, lack of marketability of some innovations and the exceedingly high-risk factor associated with agricultural initiatives and programs.*"

The Green Jobs strategy acknowledges this absence and highlighted the need to initiate tax relief mechanisms for tech startups. An official from the NEIP also demanded more effort and sacrifice from the youth to attract support from the state. He opined that the state wishes to see these startups invest in themselves first before the state can provide further support. He cited situations where these startups have not made any personal commitment and sacrifice but demand support from the state. He stated,

> "*The government cannot just give money to individuals, but to businesses, and there's a stage where the youth need to bootstrap to show their commitment to a cause.*"

The state also recognizes the role of innovation and technology hubs and financial institutions in supporting these tech startups through the provision of financing and tax incentives. The Ghana Green Finance Taxonomy, recently launched by the Ministry of Finance and Economic Planning (MOFEP), is an example of tax incentives to guide investments toward a sustainable and climate-resilient economy in the agricultural, transport, and energy sectors. This document aims to provide a framework for identifying and classifying environmentally sustainable activities, offering financial institutions, investors, and policymakers tools to direct capital toward green projects and initiatives in Ghana. Additionally, the NEIP, through the Ghana Economic Transformation program for Enterprise Support Organizations (ESOs), has provided about 7 million USD to support 125 community innovation hubs across the country. This is intended to enable these hubs to support youth startups. However, this variety of support, is not targeted solely at CSA tech companies. None of the companies engaged have information or knowledge of these opportunities.

Other external factors affecting their growth and expansion include high import costs for equipment and machines, high data costs, limited skills, and limited government support systems.

Internally, five (5) of the tech companies are constrained by a high attrition rate among their employees, mainly the youth, who quit in search of better opportunities. According to them, while they spend resources to train and equip employees, over 70% leave their positions within one year. These employees seek higher-paying jobs, which the companies currently cannot offer.

f. Employment Trends

Although they face challenges, these youth startups also create job opportunities for the growing youth population. The assessment reveals that these companies have created job opportunities for over 124 youth, with about 36% being female. However, due to limited financial resources, they are unable to expand and create more opportunities to absorb additional youth. This is evidenced by the fact that all of them have only one branch, which serves as their head office, with over 30% of employees being temporary or casual due to limited capacity to remunerate them.

In terms of skills development, these tech startups provide hands-on training and orientation for their employees to develop and hone their skills. The results show that most of their employees receive informal training, acquiring most of their technical skills during the course of their employment. These companies believe that the youth require more soft skills, such as passion, willingness to learn, and diligence, to succeed in the green space. Technical skills and knowledge in climate change, agronomy, agribusiness, and business development are also additional skills required, and these startups typically rely on available skills training programs for the youth to take advantage of.

g. Technical Support and Assistance

Startups need technical support and assistance to develop, and expand their operations, and meet company goals. This technical support comes in the form of consultations, coaching, training, and other services that help startups reach their objectives. At its core, technical assistance is about providing knowledge, expertise, and resources to startups. This type of assistance helps entrepreneurs overcome common challenges, such as developing new products or services, acquiring customers, and scaling operations. It can be provided by individuals or organizations, such as venture capital firms, incubators, accelerators, or government agencies (FasterCapital, 2024). Our interaction with the tech startups reveals that financial resources and technical know-how constitute the dominant forms of technical assistance needed

by these startups. Out of the 10 respondents, five (5) cited a lack of technical knowledge in their respective innovations as a major constraint. Key competencies for which they need support include knowledge of licensing and intellectual property rights, tax incentives and benefits, and technical skills in areas such as data analysis, sensor reading, product management, marketing, fundraising, human resources and the use of improved equipment. Our assessment reveals that there are partners who provide this technical assistance to startups; however, increased competition and a lack of technical know-how to develop viable proposals account for their inability to attract more support. Our interactions with the startups reveal that despite significant efforts they invest in developing proposals, only 1 out of over 10 proposals receives a favorable response. Our discussions with officials from KIC and NEIP indicate that youth have low capacity in developing strong proposals, leading to rejections from donors. This suggests that these startups need significant technical support in drafting sound proposals to qualify for funding due to the competitive funding landscape.

In addition to technical assistance in proposal writing or pitching, these startups also require training, coaching, and logistics to advance their innovations. Financial support significantly contributes to infrastructure, equipment, and other logistics necessary for the growth of startups, while technical assistance encompasses the building of various competencies, including business development skills, financial management, and market linkages. Consequently, they apply for support from several accelerators, which include donor agencies, private sector actors, and incubation hubs. Key examples of these enablers that provide support to these tech startups include the Step Up Fashion Incubator, Building Resilience and Investing in the Development and Growth of Entrepreneurs in Agriculture ("BRIDGE-in Agriculture") by MasterCard Foundation, Kosmos Innovation Centre (KIC), and United Nations bodies such as UNICEF and UNDP, among others. To do so, these startups respond to calls for applications or proposals from these accelerators and apply for the required support. While some of this support comes in the form of grants from donors such as the Japan International Cooperation Agency (JICA), others come in packages that include financial support, training, and mentorship, such as the KIC Agri-tech Challenge.

The KIC runs two Agri-tech challenges to provide support to these tech startups. The KIC Agri-Tech Challenge is a 7-month program that identifies young people interested in setting up a business and provides them with a system of training, workshops, and support to develop their business ideas. The program uses coaching and market research tours to encourage participants to take a fresh look at the agriculture value chain and identify new areas with potential business opportunities. Conversely, the KIC Agri-tech Challenge Pro is a 5-month acceleration program aimed at equipping existing early-stage teams or Agri-tech startups with the right tools, funding, and support to bring their business ideas or products to market and prepare them to scale (KIC, 2024). While the support is broadly for tech companies in agriculture, the Agri-tech Challenge encourages innovations and technologies in CSA and provides up to $50,000 to each entity, in addition to capacity-building and mentorship programs to encourage entrepreneurship from the ideation stage to actual establishment. This tailored support is a response to the challenges faced by aspiring entrepreneurs in conceptualizing their innovations and securing financing to fully establish their companies. They recognize the potential of the youth and the role they can play in solving agricultural crises while providing employment to their peers, hence the respective type of support.

These accelerators are relevant and important in this space for all stakeholders due to their critical role. They complement government efforts by providing capital to startups and initiating support programs while directly financing these companies. Accelerators are heavily involved in decision-making spaces in Ghana. Especially with donor partners, they may not be responsible for developing policies, but they create an atmosphere to influence policy at all levels. They do this by organizing and funding policy-related programs and workshops, as well as capacity sessions with youth

entrepreneurs on several areas, including policy advocacy to empower youth to advocate for pro-youth policies. Their roles are duly acknowledged by policymakers, as they are often involved in key policymaking spaces. Our engagement with officials from NEIP, for instance, revealed the role these accelerators play in complementing government efforts in organizing some of these policy development processes, their involvement in policy formulation processes, and the support provided by the state to some of these hubs to assist local tech startups.

While, accelerators generally face challenges such as a lack of staff with the right skill set and the business sustainability of the innovations they fund, they are also concerned about government policy inconsistencies that have led to inadequate support for hubs, especially in terms of funding (African ScaleCraft, 2024). This aligns with concerns raised by the accelerators engaged for this research. They are also worried about the commitment of policymakers to implementing programs that support CSA tech in Ghana. One accelerator indicated that there appears to be minimal impact from the policies, as much work remains to support the youth, which is not happening. He cited tax relief regimes that could reduce the burden on youth but are not being applied effectively. He lamented that "*the youth still face challenges in obtaining basic support, such as certification and even tax reliefs*." According to him, the registration process is cumbersome, and applying for tax relief is quite complex, with many youths unaware of how to navigate these processes. He also highlighted the challenge of providing the youth with the expertise to guide and shape them, stressing their willingness to go through the process and become successful, though he admits there are instances where startups receive support but have little to show for it.

While they are satisfied with the innovations being developed, including technologies for climate information and water management, they believe that more training and funding can be provided to enable youth to embrace and fit into the Fourth Industrial Revolution.

h. Innovation Trends and Indigenous Knowledge

In terms of understanding the concept of Indigenous Knowledge (IK), most of the respondents, defined it as a form of traditional or ancient knowledge practiced by forebearers and as environmentally friendly. There is general awareness of IK, and it is mostly incorporated into their work, with an average of 69% local content in their products. This is evidenced by the quantity of locally manufactured items and the locally acquired knowledge that is heavily utilized in their work.

The more pronounced role of Indigenous knowledge was highlighted by these tech startups during the engagement. Kodu Tech relies on Indigenous knowledge for the extraction of fiber from banana plants, which is done by local people using local knowledge. This is primarily performed at the farm level by locals who understand the nature and texture of these raw materials and how to extract the fiber, before it is transported to the company site. For Asaase Micromanure, the collection of raw materials for mushroom and compost production, sorting, and de-husking are all done using Indigenous knowledge. A1 Scarecrow's use of IK hinges on local expertise, in providing information on the timing of planting periods and when to apply interventions. Ignitia relies on Indigenous knowledge to understand the cropping cycle, which helps provide weather alerts to farmers. SMART Farmer uses Indigenous knowledge to develop their irrigation platform to align with local planting cycles. These examples demonstrate the role and importance of Indigenous knowledge for these tech startups.

The reliance on IK is evident from the assessment, given its contribution to promoting the scalability and competitiveness of innovations. Digital technology adoption in Ghana correlates with educational attainment and income levels (Dabelen & Mensah, 2023), which are relatively low; the illiteracy rate stands at 30.2% (Ghana Statistical Service, 2022), and poverty

Table 7

Startups and application of Indigenous knowledge

Name of Startup	A1 Scarecrow	3 Farmate	Smart Farmer	Ecovon Limited	Gad Ventures	Ignitia Ghana	Jaasgrow Ltd	Kodu Tech	Asaase Micromaure	Sesi Tech
Awareness of Indigenous knowledge	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Local Content %	50	60	60	80	60	20	100	90	100	20
% of Informal Workforce	0	10	60	20	25	8	70	50	30	20
% of Importance of Formal Education	50	100	70	80	70	10	20	50	70	90
Significant Value of Informal Workforce	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes

Note: Authors' Construct based on Authors' Fieldwork Research 2024

levels are expected to rise to 31.5% in 2025 (World Bank, 2024). Higher income levels and consistent education are crucial for encouraging the adoption of these innovations. However, many clients, primarily farmers, are often illiterate and have low-income levels, leading them to rely on conventional technologies for fertilizer application, such as manual labor and traditional weather forecasting methods that utilize observation of cloud speed, wind direction, sunrise, and animal behavior, which are more affordable. Neglecting to integrate Indigenous knowledge into innovations may render these innovations appear distant and costly, thus diminishing their appeal. Acknowledging these challenges, these startups have integrated Indigenous knowledge into their innovations to foster connections with farmers and reduce costs, thereby enhancing the marketing and adoption of their products.

To undertake these tasks that rely on IK, informal knowledge and skills are critical. Informal skills account for an average of 30% of the total workforce in the tech startups interviewed. It was also observed that tech companies with higher levels of digitalization rely less on informal workers compared to those with lower levels of digitization.

The application of IK in these companies, however, faces challenges, including the lack of reliability due to uncertainty and time consumption. One respondent noted, "*Local knowledge doesn't have a pattern; it can't be relied upon to produce consistent results*." Furthermore, the absence of documentation means that knowledge transfer can be corrupted, leading to uneven and inconsistent outcomes. Two respondents believe that, applying imported or modern technology to IK poses adaptation challenges, as individuals might struggle to reconcile the nuances of both technologies. For example, while Indigenous knowledge relies on local experience for manure formulation, imported knowledge depends on metrics and standards that may be technical and cumbersome for informal skilled labor.

Despite these challenges, there is a general consensus on the importance of IK and its potential to complement foreign or modern knowledge for the benefit of companies. To achieve this, proper documentation of IK practices is necessary to preserve protocols and prevent corruption. Additionally, there is a need to build capacity and raise awareness, particularly among youth, about IK to promote its practice. Efforts should also be made to integrate IK with imported knowledge,

making these blends affordable and accessible to local communities. There should be a system to reduce the drudgery and time associated with Indigenous knowledge. The state, through educational institutions, particularly Technical and Vocational Education and Training (TVET) programs, should incorporate Indigenous knowledge into curricula, create career opportunities, and raise awareness of the importance of the TVET system while establishing an attractive startup support system to encourage students to combine and acknowledge these forms of knowledge in their innovations.

i. The Role and Participation of Women in CSA Tech

The role of women in technology cannot be overstated, as their active participation can yield significant benefits for the tech industry. The tech sector can gain from innovation, as diverse teams offer unique perspectives that lead to new ideas and solutions. Increased participation of women can boost productivity and result in the development of more inclusive and user-friendly products (Generation Ghana, 2024). Furthermore, Ghana ranks third in Africa, with 37.2% of its businesses owned by women, reflecting relatively high female participation in entrepreneurship (MIWE, 2022). However, women's participation and leadership in the tech and innovation space remain limited, with women holding only 5% of leadership roles in technology (Generation Ghana, 2024). This highlights challenges in engaging women-led entrepreneurs in CSA techs. Fayemi (2024) points out a declining percentage of women in tech-related jobs, now at just 26,7% including agri-techs and computing systems. This trend contributes to societal assumptions and stereotypes regarding the challenging nature of technology and the belief that women may struggle to cope with it.

While there is literature on the factors that limit the adoption of CSA by women, there is limited research on the constraints faced by women entrepreneurs in the CSA tech space. The United Nations University identifies legal discrimination, social norms, access to education and skills training, confidence, risk preferences, access to finance, and networks as key constraints that women encounter in breaking barriers within the entrepreneurship ecosystem (UNU, 2023). These constraints are particularly pronounced in Sub-Saharan Africa, where women earn 34% less profit than men (UNU, 2023). This scenario presents significant challenges for women's participation and involvement in innovation due to these factors. In Ghana, the situation is exacerbated as most women lack financial autonomy, face limited access to finance, and experience financial hardships that restrict many girls' ability to complete secondary education. Additionally, there is a significant deficit in formal career guidance, major technical and digital skills, and social and domestic responsibilities that limit their ability to fully participate in the workforce (ACET, 2022). Babo & Odame (2023) also identify social and cultural stereotypes, safety concerns, the cost of internet and related services, and a lack of role models as factors that deter women from venturing into and participating in the gig economy.

There is a pressing need to encourage and catalyze women's involvement in the tech space, as it promotes economic growth, leads to the creation of more innovative solutions, increases the awareness of women's rights and civic engagement, and helps in reducing inequalities (UNU, 2023). Although these challenges are acknowledged in Ghana's policy and regulatory environment, the responses are inadequate and unresponsive to the specific needs of women. For instance, the National Green Jobs Strategy acknowledges the challenges of women's participation in the tech space and proposes remedies to address them. It recognizes the limited skills of women in green opportunities and outlines specific activities to ensure inclusivity and equal access to green training opportunities. These include conducting specialized training programs for vulnerable youth, women, and persons with disabilities (PWDs), collecting and analyzing gender-disaggregated data on skills training programs and implementing a special inclusive regime (quota) for women, men, and vulnerable groups in green training. However, regarding sustainable funding, which is a major constraint faced by women, the strategy combines the needs of all groups without specifically addressing the challenges confronting

women-led green enterprises. For example, while there is a strategy to develop green enterprise financing schemes, a specialized scheme for women-led entrepreneurs would have been more responsive. Unfortunately, this assessment has yet to receive a response from the lead ministry concerning the rationale and state of implementation of these initiatives.

Notably, some state agencies provide specific support to women-led enterprises to boost their productivity and competitiveness. The Ghana Enterprise Agency (GEA) is the lead state agency mandated to promote and develop Micro, Small, and Medium Enterprises (MSMEs) in Ghana. It initiates projects to support women-led enterprises, including the Women-MSMEs Programme, which provides capacity support and grants to spur women enterprises, innovation, and growth. The Business in a Box Project (BizBox) is also aimed at MSMEs, with a 70% target for women-led enterprises. It should be noted that this support is not exclusive to women-led MSMEs or startups in the CSA technology space but covers all aspects of entrepreneurship, including agriculture, tourism, and the creative industry, as well as building and construction (GEA, 2022).

In terms of technical assistance and support, engagement with accelerators, such as the KIC, indicates that while the programs being rolled out are inclusive and gender-sensitive, they are not solely focused on women. This is due to the low enrollment of women in these programs, resulting from their lower participation in innovation compared to their male counterparts, as stated above. According to one official from these companies:

> "*We have been increasingly trying to get more women involved in the program, and we are being successful at that. As of 2019, 11% of the awardees were women, but this has risen to 33% as of 2022, and we hope to do more.*"

An early tech background, education, and mentorship will therefore, help more women join the tech sector, as this will enhance their skills, empower them, create self-awareness, and encourage females to enter the technology space (Naisubi, 2020). In this regard, the KIC, through the Agri-tech Challenge Classic, is inciting women's participation by providing mentorship and training as part of its package and increasing women's involvement in the program. However, it must be noted that there is some specific support targeting only women. One example is the Affirmative Finance Action for Women in Africa (AFAWA) by the African Development Bank (AfDB, 2024), which seeks to bridge the finance gap for women entrepreneurs in Africa. The extent of awareness among women entrepreneurs, even in the tech space, regarding this opportunity needs to be explored further.

In terms of employment of women in CSA techs, the assessment revealed that 35% of employees were women, which is quite positive considering that women made up only 28% of the tech workforce as of 2022 (Generation Ghana, 2024). However, it is important to note that there is potential for increased women's participation in the tech and innovation space if the existing challenges are addressed. Babo and Odame (2023) recommend that to improve women's participation in the tech industry, it is necessary to invest in digital skills training, establish mentorship and support programs, create training centers in suburban and rural areas, expand digital infrastructure, and ensure the safety of women online to enhance women's participation at all levels. The recent passage of the Affirmative Action Act (Gender Equity) in Ghana presents a unique opportunity to achieve gender equality in the political, social, economic, educational, and cultural spheres of society. Stakeholders expect that the implementation of the Act will usher in a new era for addressing the challenges that limit the potential of women in all spaces, including tech and innovation.

Summary

Analysis from the study revealed that Ghana's CSA tech startups are driven by young entrepreneurs, with 80% of CEOs studied under 35, who are driving innovation and growth in CSA technology. Despite their potential, these startups face significant challenges, including policy exclusion, regulatory constraints, limited financing avenues, and an unfavorable

working environment. In terms of policy, there is a lack of awareness about existing policies and frameworks, and a disconnect from the policy process, with over 80% of startups studied not involved in policymaking, limiting their ability to shape policies that affect their work. There is a need for policy awareness to promote understanding of existing policies and frameworks among startups, and to create an inclusive policy process that involves startups to ensure their needs are addressed.

Regarding regulatory issues, the study revealed that although most startups are duly registered, they rely on third parties for their registration processes due to the lengthy and cumbersome nature of the formal registration process. Intellectual Property Rights (IPR) registration is low, with 80% of startups studied unregistered due to high costs, convoluted processes, and lack of information. These challenges highlight the need for a more inclusive policy process, streamlined registration procedures, and adequate education and support for IPR registration to foster innovation and growth among Ghana's tech startups.

Concerning finances, funding for African tech startups declined in 2023, with Ghana experiencing an 81.6% reduction in funding (Disrupt Africa, 2023, 29). Increased competition, a decrease in donor partners, and low skills in drafting proposals contribute to the difficulties that startups face in securing adequate grants, which is the most common form of financing for startups in Ghana. This situation is further compounded by existing macroeconomic challenges, making it difficult for startups to sustain, and expand their operations, alongside limited government support, with only 10% of startups receiving assistance, and a complex tax incentive regime. Other notable challenges faced by these startups include limited market access due to low adoption and patronage by clients, high costs for equipment and machines, high data costs, low technical expertise, and high attrition rates among youth employees.

Technical support for climate tech startups manifests in the form of training, coaching, financial, and logistical support, which also poses a significant challenge for startups. Financial resources and technical know-how are urgent needs for startups who require support in areas such as licensing, IPR, tax incentives, technical skills, and fundraising. The roles of accelerators such as the KIC, UNICEF, and UNDP are therefore crucial in providing financial, technical, and logistical support to startups in Ghana. Unfortunately, women's participation in the tech startup ecosystem has been limited, though there are deliberate efforts to increase women's involvement in tech programs, with KIC's Agri-tech Challenge seeing a rise in the number of women awardees.

As highlighted in Table 7, there is a general awareness of IK, with an average of 64% local content in products produced by the CSA techs. The role of IK in CSA tech innovations is crucial in areas such as raw material extraction, production, and weather forecasting. However, the uncertainty and lack of documentation surrounding IK hinder its reliability, while integrating it with modern technology poses adaptation difficulties. Moreover, there is a need to build capacity and create awareness of IK, especially among young people.

Furthermore, women's participation in the tech industry is crucial for innovation, economic growth, and inclusive product development. Despite Ghana ranking third in Africa in terms of women-owned businesses (37.2%), women's participation in tech and innovation is limited due to several challenges, such as societal stereotypes, limited access to education, financial constraints, and social responsibilities. Key barriers include legal discrimination, social norms, lack of access to finance, and deficits in digital skills. Although Ghana's policy, regulatory, and support schemes recognize these challenges, they often lack specificity for women-led enterprises in CSA tech. Therefore, it is crucial to accelerate interventions that address these challenges and empower women to reach their potential in the tech space.

4. Conclusion and Recommendations

Based on the assessment and analysis above, this paper concludes by addressing the following questions as part of the research objectives.

1. Do Ghana's CSA tech policies and regulations promote-green jobs for the youth in CSA tech?

The major overarching policies addressing climate change and youth employment in Ghana are the National Climate Change Policy and the National Youth Policy, respectively. Although these policies do not explicitly highlight or promote green jobs, there are additional frameworks and strategies that significantly support green jobs for the youth. The National Green Jobs Strategy is Ghana's most comprehensive policy tool that recognizes and proposes strategies to support green jobs, with a set of clear plans and activities to achieve its goals. In addition, the National CSA-FSAP provides a framework for supporting CSA tech and innovations while identifying the role of the youth. Furthermore, the Youth in Innovative Agriculture Program captures some support mechanisms for youth startups in general agricultural technologies, including CSA techs. These policy spaces are also supported by various initiatives, such as the National Entrepreneurship Innovation Program, which provides logistical and technical support for youth-led initiatives, including those specific to CSA techs. In this regard, it can be argued that Ghana's policy space promotes green jobs for the youth in CSA techs.

In terms of regulations, there are broad-based regulations that cover general agricultural technology and innovations, but these are not specific to CSA techs.

2. Is Ghana's CSA tech policy space *responsive* to young people's local innovation, employment needs, and priorities?

Policy responsiveness connotes the state's action to respond to the preferences of its citizens. Based on the interactions and responses from the respondents regarding their innovation needs, and priorities, this paper strongly argues that while there are significant policy tools that support CSA techs, the policy space is not responsive to the needs of young people. A summary of young people's innovation, and employment needs, and priorities includes the complex and expensive registration and licensing regime, lack of adequate finance and support, inadequate avenues for knowledge and information sharing, lack of reliable and sustainable markets, and unfavorable macroeconomic conditions, among others. The youth, when faced with these challenges, need to navigate everything on their own, with no tailored or dedicated response mechanism from the state. However, it must be noted that some accelerators and private entities occasionally respond to some needs of the youth through the organization of seminars and workshops, although these initiatives are often not far-reaching for all segments of the youth population.

3. What *opportunities exist for scaling* up local innovation among youth in green technology in Ghana?

Several opportunities exist for scaling up local innovation among youth in green technology in Ghana. At the policy level, the existence of the National Green Jobs Strategy and the Ghana Green Finance Taxonomy serves as a solid blueprint to encourage and support innovations among young people in Ghana. Additionally, national incentives such as the National Entrepreneurship and Innovation Plan (NEIP) and Ghana Climate Innovation Centre (GCIC), which provide training, funding, and mentorship to young people, are existing state initiatives that can be utilized as vehicles to support youth innovation.

Private sector support, led by key accelerators such as Kosmos Innovation Centre, the Mastercard Foundation, and Ghana Tech Lab, along with international bodies and donor partners such as UNDP, UNICEF, JICA, AfDB, FAO, and UNEP, are all existing opportunities to scale up youth innovation. This is in addition to the capacity-building spaces provided by TVETs and institutions of higher learning, such as the University of Education, Ghana Institute of Management and Public Administration (GIMPA), and the University of Ghana, which offer training in entrepreneurship, innovation, IK and climate technology. The current national focus on STEM education is also another avenue for fostering science and technology among young people in secondary education.

The role of non-state actors including civil society organizations (CSOs) and farmer-based organizations (FBOs) such as CIKOD, Peasant Farmers Association of Ghana (PFAG), KASA Ghana and YPAG, as well as the media, to advocate for and disseminate information on climate change and the role of youth innovations can further advance support for local youth innovation.

Additionally, there are other factors that support innovation in the tech ecosystem in Ghana. Key among them is the Ghana Startup Bill, which is currently being drafted with the aim of establishing various principles and supporting legislation required to promote entrepreneurial development in Ghana. The bill is expected to create an enabling environment for startups growth, attraction, and investment protection and will provide an incentive framework for the creation and development of startups in Ghana to promote creativity, innovation, and new technologies in achieving substantial added value and competitiveness (Ghana Innovation and Startups Act, 2020). Stakeholders expect that the passage of the bill will drive and encourage innovation, especially among tech startups.

Lastly, Ghana has a robust digital infrastructure through enhanced ICT access and use, which provides a solid foundation for innovation in the tech ecosystem. The ICT sector continues to be one of the fastest growing sectors of Ghana's economy and ranks 15th out of 47 among African countries for ICT use in the 2024 ICT Development Index (ITA, 2024). The ITA (2024) further states that the government of Ghana and private sector actors provide near-universal broadband (3G and 4G) coverage in the country, with a mobile phone penetration rate of more than 135%, suggesting a strong foundation for the acceleration of innovations and technology in Ghana.

a. Recommendations

Recognizing the barriers, challenges, and opportunities identified, the paper provides the following recommendations.

For policy coherence, alignment, and responsiveness, stakeholders need to ensure the following:

1. **Review and Update Existing Policies**: Review the National Climate Change Policy and the National CSA-FSAP to reflect current developments in climate change, especially the role of tech startups.
2. **Implement the Green Jobs Strategy:** Ensure the implementation of the National Green Jobs Strategy (2021-2025), including the provision of tax reliefs and benefits for individuals involved in CSA techs.
3. **Link Initiatives and Policies:** Link existing initiatives, such as the Youth in Innovative Agriculture program and the Presidential Pitch, to overarching CSA policies to ensure coordination and effective implementation.
4. **Increase Awareness and Coordination:** Raise awareness of the Green Jobs Strategy and other relevant policies among state institutions and stakeholders, ensuring coordination and alignment with existing initiatives and policies. This can be achieved through targeted awareness-raising campaigns to inform youth tech startups about existing policies and frameworks related to CSA tech and youth employment.

5. **Involve Youth Tech Startups in Policymaking:** Encourage and facilitate the participation of youth tech startups in the policymaking process, including consultations, workshops, and other engagement mechanisms.
6. **Simplify and Streamline Policy Information:** Develop user-friendly policy guides and resources that provide clear and concise information on existing policies and frameworks related to CSA and youth employment.
7. **Establish a CSA Tech Policy Hub:** Create a centralized hub that provides access to policy information, resources, and support services for youth tech startups in CSA tech.

To address challenges faced by youth tech startups, the following is recommended:

1. **Improve Access to Financing:** Provide targeted financing options for CSA tech startups, including grants, loans, and equity investments.
2. **Enhance Tax Incentives:** Implement tax incentives, such as tax relief and tax holidays, to encourage the growth and expansion of CSA tech startups.
3. **Simplify Access to Incentives:** Streamline the process of accessing incentives, including tax incentives and funding opportunities, to make it easier for CSA tech startups to benefit from these programs.
4. **Support Skills Development:** Provide training and capacity-building programs for CSA tech startups, focusing on both technical and soft skills, to enhance their competitiveness and growth potential.
5. **Develop a CSA Tech Startup Support Ecosystem:** Establish a comprehensive support ecosystem for CSA tech startups, including incubators, accelerators, and mentorship programs, to provide them with the necessary resources and support to grow and expand.
6. **Enhance Collaboration between Accelerators and Policymakers:** Foster closer collaboration between accelerators and policymakers to ensure that policies and programs align with the needs of startups and youth entrepreneurs.
7. **Provide Expertise and Capacity Building:** Offer expertise and capacity-building programs to support youth entrepreneurs, particularly in areas such as certification, tax relief, IPR, and business development.
8. **Promote Inclusive and Gender-Sensitive Programs:** Ensure that programs and initiatives aimed at supporting startups and youth entrepreneurs are inclusive and gender-sensitive, with deliberate efforts to deepen young women's participation.
9. **Monitor and Evaluate Progress:** Establish a monitoring and evaluation framework to track progress, identify challenges, and adjust policies and programs to support CSA tech and youth entrepreneurship.

For the Integration of Indigenous Knowledge into Innovations:

1. **Document IK Practices:** Enhance collaboration with academic institutions to establish a system for documenting IK practices to preserve protocols.
2. **Incorporate IK into Educational Curricula:** Encourage educational institutions, especially Technical and Vocational Education and Training (TVETs), to incorporate IK into their curricula.
3. **Promote Collaboration between Traditional Knowledge Holders and Modern Technologists:** Foster collaboration between traditional knowledge holders and modern technologists to leverage the benefits of IK.
4. **Provide Support for IK-Based Innovations:** Provide support, including funding and capacity building, for innovations that incorporate IK.

To promote women's participation, the paper proposes the following recommendations:

1. Invest in digital skills training programs for women, focusing on emerging technologies like AI, blockchain, and cybersecurity.
2. Establish mentorship programs that pair women with experienced tech professionals, providing guidance and support.

3. Create training centers in suburban and rural areas, increasing access to tech education for women in underserved communities.
4. Provide access to finance and funding opportunities specifically for women-led tech startups and enterprises.
5. Establish business incubators and accelerators that support women-led tech startups, offering resources, networking opportunities, and funding.
6. Set quotas and targets for women's participation in tech, ensuring that women are represented in leadership positions and decision-making roles.
7. Expand digital infrastructure, including internet access and digital payment systems, to increase women's access to tech opportunities.

The paper also provides some internal strategies these startups can implement to improve their situation:

1. Build capacity on competencies such as grant writing, business plan development, and exploring alternative funding options.
2. Develop business model canvases to visualize business models and identify key activities, resources, and partnerships.
3. Foster a positive company culture that encourages open communication, recognition, and growth opportunities while providing training, mentorship, and opportunities for employees to retain top performers.
4. Leverage various talent management opportunities, including the utilization of social media, networking events, and referrals to attract top talent and support.
5. Stay informed about industry needs through attendance at conferences, webinars, and workshops to learn about the latest developments.
6. Collaborate with complementary startups and organizations to access new markets, technologies, or expertise.

Recommendations for Development Partners in Ghana

Development partners play a crucial role in enabling innovation startup ecosystems. This section recommends how these partners can support sector stakeholders in scaling innovation within Ghana's CSA ecosystem.

1. **Bridging Policy Gaps and Advocacy for CSA Tech Startups**

   This report underscores the disconnect between CSA tech startups and policy frameworks, and how this disconnect is limiting the ability of CSA tech startups to scale. The National Green Jobs Strategy (2021-2025) is the most comprehensive policy linking green enterprises and youth employment, but its implementation has been slow. Moreover, there are growing calls for the review of the National Climate Change Policy and other policy documents to respond to the needs of youth entrepreneurs. Development Partners can support policy advocacy and support services for state institutions to implement the National Green Jobs Strategy. Moreover, they can also support the review of old policies, frameworks, and action plans while ensuring that CSA tech startups and the youth are included in revised national green and employment policy formulation processes.

2. **Expanding Financial and Technical Support for CSA Tech Startups**

   This report also reveals that only one (1) CSA tech startup secured funding from state institutions, with most relying on donor partners and foreign entities. Development Partners can provide financing through grants, equity investments, and blended finance models to help startups operate and scale. They can also fund incubation hubs to build the capacities of these startups. Moreover, to increase demand for innovation, development partners can support farmers and other end users to adopt these technologies to create markets for these startups. Farmer groups and other associations can be supported to undertake this drive.

3. **Enhancing Gender Inclusion in CSA Tech and Green Jobs**
   Despite Ghana ranking third in Africa for women-owned businesses (37.2%) on The Mastercard Index of Women Entrepreneurs (MIWE), women's participation in CSA tech startups remains low. Thus, to improve women's entrepreneurship, Development Partners in the field of youth, gender or both should broaden their initiatives to deliberately fund projects that increase female participation in CSA tech. Additionally, they should ensure that existing programs address the context gender-specific needs of the countries in which they operate.

4. **Leveraging Indigenous Knowledge for Innovation and Sustainability**
   The report highlights the importance of IK in CSA tech, but documentation and integration remain weak. Development Partners could support initiatives that either document and blend IK with modern technology, ensuring locally adapted and scalable solutions for climate resilience.

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Endnotes

1 The Ghana Tech Lab is a collaborative tech-centric company in Ghana that connects youths with digital and technical education as part of its Ghana Startup Ecosystem program. Headquartered in Accra, the lab takes a multi-stage approach to launch startups through training, incubation and seed funding through grants and a network of venture capitals.

2 https://moc.gov.gh/aiti-kace/

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