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Investigation of the Viability of Smart Agriculture in Ethiopia

Ethiopia

2024/25 KSP POLICY BRIEF

Presented by the MOEF, Republic of Korea



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Investigation of the Viability of Smart Agriculture in Ethiopia

Ethiopia



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Preface

Agriculture is the backbone of Ethiopia's economy, contributing over 32% of GDP and employing more than 80% of the population. However, this sector faces significant challenges from climate change impacts, including erratic rainfall, droughts, and floods, which undermine food security and agricultural productivity. To address these issues, the Ethiopian government has placed a strong emphasis on adopting climate-smart agriculture (CSA), which aims to enhance agricultural resilience, improve productivity, and mitigate the effects of climate change (FAO, 2021a).

Smart agriculture, integrating innovative technologies such as IoT, automated irrigation, and digital climate prediction systems, is central to Ethiopia's strategy to overcome these challenges. The CSA approach is tailored to Ethiopia's diverse agro-ecological zones, with key strategies including small-scale irrigation, improved soil fertility management, and the development of climate-resilient crop varieties. Despite these efforts, significant barriers remain, including limited infrastructure, fragmented smallholder systems, and low technology adoption.

The collaboration between Ethiopia and Korea in smart agriculture, particularly leveraging Korea's advancements in ICT integration and mechanization, offers valuable lessons. Korea's experience in transforming its agricultural sector through technology and policy reform provides a model for Ethiopia to follow. The focus of this partnership is to address Ethiopia's agricultural vulnerabilities and ensure the adoption of CSA practices across various agro-ecological zones.

Key CSA strategies for Ethiopia include enhancing water management systems through small-scale irrigation, promoting sustainable soil management practices, and developing climate-resilient crops. Pilot projects, particularly in Ada Woreda, which is earmarked as a Smart Agriculture Innovation Cluster, aim to combine crop production, livestock, and value-added processing, supported by precision agriculture technologies.

The CSA Investment Plan (CSAIP) for Ethiopia outlines a clear roadmap for scaling these practices across the country. It emphasizes the importance of building local capacity through farmer training, establishing public-private partnerships, and securing diversified funding sources to support CSA initiatives. This plan not only aligns with Ethiopia's national climate goals but also with its broader development objectives.

Policy Recommendations:

- Establish a dedicated national body for CSA coordination to ensure the integration of CSA practices across regional and national levels.
- Promote smallholder-inclusive models through access to finance, technology, and training.
- Strengthen public-private partnerships to mobilize resources and enhance technological transfer.
- Implement policies that support risk mitigation, including insurance schemes, early warning systems, and farmer education programs.

In conclusion, Ethiopia's shift toward smart agriculture provides a transformative opportunity to increase agricultural productivity, strengthen food security, and build resilience against climate change. By leveraging international collaboration and aligning efforts with global best practices, Ethiopia can create a sustainable, climate-resilient agricultural system that benefits both its rural communities and national economy.

Ku, Kyoyoung

CEO

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Summary

Agriculture is the backbone of Ethiopia's economy, employing approximately 80–85% of its population and accounting for around one-third of the national GDP. Despite its economic significance, Ethiopia's agricultural productivity and food security are increasingly threatened by recurrent droughts, erratic rainfall, limited mechanization, and fragmented smallholder systems. Recognizing these critical challenges, Ethiopia has prioritized the adoption of smart agriculture practices that integrate climate-resilient technologies and modern digital solutions.

Given the diversity of Ethiopia's agro-ecological conditions, a tailored, region-specific approach to smart agriculture is essential. A detailed analysis across Ethiopia's nine distinct agro-ecological zones identified Moist Weyna Dega as particularly favorable due to its stable rainfall, relatively advanced infrastructure, and high potential for precision agriculture technologies such as smart irrigation. Meanwhile, regions with harsher conditions require targeted interventions: Dry Berha and Dry Kolla demand solar-powered irrigation and drought-resistant crops; Moist Kolla and Wet regions require automated drainage and integrated pest management systems; and mountainous regions necessitate compact, agile machinery tailored to challenging terrains.

Ethiopia's efforts to transform its agricultural sector can benefit significantly from Korea's historical agricultural development and technological advancements. Korea successfully transitioned through distinct agricultural phases—from achieving basic food security through mechanization and high-yield varieties (1965–1994), to enhancing competitiveness amid global trade liberalization (1995–2014), and ultimately to embracing sustainability and digital transformation through advanced ICT, big data, and AI-driven smart farming (2015–present). Ethiopia, facing similar historical and structural challenges, can draw valuable lessons from Korea's experience by focusing on establishing robust institutional frameworks and national smart agriculture policies, introducing affordable, modular technologies adapted to local contexts, investing in capacity-building initiatives and youth engagement, and fostering public-private partnerships with diversified funding sources.

Reflecting these insights, a strategically selected pilot site, Ada Woreda in Oromia, near Addis Ababa, has been identified as an ideal location for Ethiopia's first integrated Smart Agriculture Innovation Cluster. The 30-hectare pilot will incorporate horticultural crops (tomatoes, strawberries, avocados), staple grains (maize, wheat, teff), and livestock operations alongside comprehensive facilities for processing, storage, and entrepreneurial incubation. Leveraging

advanced technologies including IoT-enabled precision agriculture, automated irrigation, and integrated livestock management systems, the project will be operated under a public-private partnership model involving local cooperatives, private technology providers, and government institutions.

Economic feasibility analysis confirms the project's viability, demonstrating a Net Present Value (NPV) of \$166,599, Internal Rate of Return (IRR) of 15.5%, and Return on Investment (ROI) of 97.5%, with a projected break-even point within six years. Strategic risk mitigation measures, including diversification, digital monitoring, cooperative management structures, and ongoing capacity development, are designed to ensure long-term sustainability.

By systematically aligning the lessons learned from Korea's agricultural transformation with Ethiopia's unique regional and structural realities, the Ethiopia-Korea Knowledge Sharing Program (KSP) aims to establish a resilient, sustainable, and locally-adapted smart agriculture model. Ultimately, this bilateral collaboration seeks to significantly enhance Ethiopia's agricultural productivity, climate resilience, food security, and economic stability.

1. Introduction

Agriculture is critical to Ethiopia's economy, employing about 80–85% of the population and contributing roughly one-third of GDP. However, productivity and sustainability are threatened by recurrent droughts and erratic rainfall, causing significant economic losses and food insecurity (MoA, 2020). To address these challenges, Ethiopia is prioritizing smart agriculture, integrating climate-resilient practices and modern technologies. This brief introduces the rationale, context, and objectives of the Ethiopia–Korea Knowledge Sharing Program (KSP), a bilateral effort aimed at sustainable agricultural transformation.

Ethiopia's agriculture faces critical challenges due to high climate vulnerability, fragmented smallholder systems, and limited mechanization and technology adoption. Over 12 million smallholders cultivate fragmented plots averaging less than two hectares, impeding mechanization and efficiency (CSA, 2021). Less than 1% of farmland uses advanced machinery, and digital agricultural services have very limited reach, restricting timely access to inputs, markets, and critical information. Moreover, Ethiopia's diverse agro-ecological zones (from arid lowlands to humid highlands) require tailored strategies rather than generic solutions. Effective agricultural development must therefore consider local conditions, climate variability, and distinct regional needs.

The Ethiopia KSP Smart Agriculture Project focuses explicitly on developing tailored smart agriculture solutions rather than importing generic technologies. Ethiopian and Korean experts will collaboratively assess agro-ecological zones, crop systems, and technological readiness to co-design region-specific approaches. Leveraging Korea's historical success in overcoming food insecurity and its advanced agricultural technologies (e.g., information and communication technology (ICT), mechanization, greenhouse automation), the initiative emphasizes capacity-building, training programs, and pilot projects. Crucially, it aims to establish sustainable, long-term cooperation between Ethiopian and Korean agricultural institutions, creating a locally adapted, resilient roadmap for Ethiopia's agricultural future.

2. Situation Analysis on Smart Agriculture in Ethiopia

Ethiopia's agriculture sector, central to its economy and livelihoods, faces significant challenges due to climate vulnerability, fragmented smallholder systems, and low mechanization levels. To strategically address these issues, the viability of smart agriculture was investigated through an agro-ecological approach, dividing the country into nine distinct regions and thoroughly analyzing each region's agricultural conditions, import/export status, optimal crops, and smart farming needs.

2.1. Regional Agricultural Analysis, Climate Change, Mechanization and Infrastructure, Trade and Economic Implications

The Ethiopian agricultural landscape is highly diverse, with regions classified into nine agro-ecological zones, each with distinct climate conditions, challenges, and strategic needs (Alemayehu, 2022). Dry Berha and Dry Kolla are severely affected by water scarcity, which makes the adoption of smart irrigation, solar desalination, and drought-tolerant crops such as quinoa, sorghum, and sesame particularly critical. Dry Dega, on the other hand, is characterized by high frost risk, requiring the introduction of frost prediction systems and greenhouse cultivation, especially for crops such as potatoes and barley. Moist Kolla, Wet Kolla, and Wet Weyna Dega receive abundant rainfall, yet they face persistent difficulties in water management and pest control, creating a demand for automated drainage, pest monitoring, and precision agriculture technologies (FAO, 2021a). Moist Dega and Dry Weyna Dega require integrated agricultural strategies that combine crop and livestock management, supported by precision fertilization and advanced monitoring for wheat, barley, and mixed farming systems. Among all zones, Moist Weyna Dega has emerged as the most suitable region for smart agriculture due to its relatively stable rainfall, better infrastructure, and strong adaptability to precision agriculture and smart irrigation systems.

Climate change has contributed to declining productivity across all zones, with the impact particularly severe in the dry regions. Nevertheless, the introduction of smart agriculture technologies is expected to bring significant productivity gains across the country. Mechanization levels remain very low, with the national mechanization rate still under ten percent, and regions require tailored mechanization strategies (Hello Tractor, 2023). Dry regions need access to basic irrigation equipment and small-scale mechanization, while moist and wet regions hold potential for adopting precision agriculture and automated systems. Alpine areas, in contrast, demand small and agile

machinery to address terrain-related challenges.

Agricultural exports remain stagnant, constrained by climate impacts, structural limitations, and inadequate infrastructure. The adoption of smart agriculture is therefore essential not only to stabilize production and reduce losses but also to strengthen Ethiopia's ability to expand high-value crop exports (Abegaz et al., 2024). Within this context, the KSP Smart Agriculture Project identifies Moist Weyna Dega as the most suitable area for the implementation of smart farming. The region's favorable climatic conditions, its crop diversity including rice and corn, and its export potential provide strong foundations for the introduction of precision agriculture and smart irrigation systems.

Table 1.
Applicability and Potential of Smart Agriculture by Agro-Climatic Zone

Agricultural Climate Zone	Status	Applicability of Smart Agriculture	Core Technologies for Smart Agriculture Application
Dry Berha	Precipitation <200mm, Lack of Infrastructure, Focus on survival agriculture	★☆☆☆☆ (Very Low)	Solar desalination, Drip Irrigation
Dry Kolla	Worsening drought, Low acceptance of technology by farmers, Focusing on single crops	★★☆☆☆ (Low)	Precision irrigation, Soil sensor
Dry Dega	High slope, Frost damage frequent, Low accessibility	★★☆☆☆ (Low)	Frost prediction, smart greenhouse
Moist Kolla	Crop diversity, Many diseases and pests, Suitable for irrigation and sensor technology	★★★★☆ (High)	Pest monitoring, Automatic irrigation
Moist Weyna Dega	Active technology introduction, Major grain zones, Excellent Infrastructure	★★★★★ (Very High)	Precision agriculture, Smart irrigation, AI climate prediction
Moist Dega	Mixed agricultural structure, Middle mountain highlands, Long-term education required	★★★☆☆ (Medium)	Recycling Agriculture and Livestock ICT System
Wet Kolla	Serious flooding problem, Many export crops need to be stored and transported	★★★★☆ (High)	Fruit tree-Coffee processing, Storage linkage
Wet Weyna Dega	High precision in climate prediction, There is an ICT infrastructure	★★★★☆ (High)	Smart drainage, soil sensor
Wet Dega	Combined risk of frost and flooding, Limited access to high-altitude areas	★★★☆☆ (Medium)	Automatic greenhouse, Climate prediction-based seeding system

Sources: USAID (2024), and FAO Ethiopia (2016a; 2016b).

2.2. Implications of Korea's Smart Agriculture Development for Ethiopia

Korea's agricultural policy and technological advancements provide crucial insights as Ethiopia considers adopting smart agriculture. Korea's smart agriculture evolved through three distinct phases: productivist (1965–1994), competitiveness enhancement (1995–2014), and digital-sustainable transition (2015–present). Initially driven by food security needs, Korea introduced large-scale mechanization, irrigation, and high-yield varieties. With globalization in the 1990s, Korea transitioned to improving product quality, market competitiveness, and structural adjustments. Recently, the focus shifted to sustainability, smart agriculture, and digital transformation using advanced ICT, big data, and AI-driven technologies

Ethiopia faces critical challenges including climate vulnerability, fragmented smallholder systems, limited infrastructure, and low mechanization. Like Korea, Ethiopia's agriculture is dominated by small-scale farms that limit economies of scale and present barriers to technology adoption (EIAR, 2021). However, Ethiopia has vast potential to increase productivity and resilience through targeted smart agricultural interventions tailored to regional agro-ecological conditions

Drawing from Korea's experience, Ethiopia should prioritize the following strategies:

- **Institutional and policy framework:** Establish clear national policies and dedicated organizations (similar to Korea's Rural Development Administration) to guide smart agriculture initiatives, foster coordination, and streamline implementation.

- **Localized and phased technology deployment:** Emphasize affordable, modular technologies adaptable to Ethiopia's varied agricultural zones rather than costly, sophisticated equipment. Korea's smart farm pilot projects highlight the effectiveness of incremental adoption supported by tailored extension services.

- **Capacity building and youth engagement:** Invest heavily in human resources, digital literacy, and training programs for farmers, extension workers, and young entrepreneurs, replicating Korea's model of Smart Farm Innovation Valleys which integrated training, R&D, and business incubation to nurture skilled agricultural workers.

- **Public-private partnerships and financing:** Leverage diverse funding sources, including international support, concessional loans, and private investment, alongside public sector commitments. Ethiopia should build an integrated support system incorporating maintenance, technical advisory, and aftercare services.

- **Infrastructure and data management:** Develop rural digital infrastructure, improve connectivity, and build comprehensive agricultural data platforms. Establishing data standards and governance similar to Korea's approach will facilitate effective data-driven decision-making and climate-smart management.

In conclusion, Ethiopia can effectively adapt Korea's smart agriculture lessons by carefully aligning technological advancements with its local context, institutional capabilities, and regional agricultural priorities, ultimately achieving sustainable growth and resilience in its agricultural sector.

Table 2.
Key Smart Farming Technology, Key Organizations, Implementation Details and Limitation by Value Chain

Value-Chain Stage	Main Digitalization Technologies & Systems	Key Initiatives & Platforms	Performance & Indicators	Key Limitations & Challenges
Input Management	<ul style="list-style-type: none"> - Online input marketplaces - Data-driven input optimization (soil/weather sensors, mobile apps) 	Farm Morning, NongHyup e-Market, agri-data apps	<ul style="list-style-type: none"> - Improved resource efficiency, digital procurement 	Low adoption among smallholders
Production (Smart Farming)	<ul style="list-style-type: none"> - IoT/sensor automation - AI-based growth prediction - Robotics, drones - Mobile remote control 	Smart Farm 2.0, RDA big data platform, innovation valleys	<ul style="list-style-type: none"> - 6,485 ha smart greenhouses, 4,743 smart barns (2021) - Yield increase 30–50% 	High initial investment, limited adoption in small farms
Post-Harvest & Processing	<ul style="list-style-type: none"> - Automated sorting/grading - IoT cold storage - Data-linked APCs 	Smart APCs, automated sorting & packing systems	<ul style="list-style-type: none"> - Improved product quality, reduced loss - Data feedback to farms 	Lack of standardization, limited scale-up
Distribution & Logistics	<ul style="list-style-type: none"> - Online wholesale/retail - Smart cold-chain logistics - Digital traceability 	aT Online Wholesale Market, traceability systems	<ul style="list-style-type: none"> - 24–25% of agri-food sales online - Distribution cost reduction 	Limited farmer participation, interoperability gaps
Consumption & Marketing	<ul style="list-style-type: none"> - QR/blockchain traceability - Direct e-commerce & subscription models - Data-driven marketing 	Traceability platform, online direct markets	<ul style="list-style-type: none"> - 3–4% direct online sales (2020), target 10% by 2027 - Higher consumer trust 	Limited data integration for consumer feedback
Traceability & Data Utilization	<ul style="list-style-type: none"> - Data standardization - Big data & AI analytics - Open APIs 	RDA/MAFRA big data platforms, SmartFarm Korea	<ul style="list-style-type: none"> - Expansion of data-driven management - AI-powered consulting services 	Data quality/standardization issues, privacy concerns

Note: APCs: Agricultural Products Processing Centers

Source: Reorganized by the author based on information from MAFRA (2022), RDA (2023), and SmartFarm Korea (2023).

Comparing the respective strengths and weaknesses of smart agriculture in Ethiopia and Korea, it is clear that Ethiopia can substantially benefit from the experiences and advancements made by Korea. Ethiopia faces substantial challenges, notably limited infrastructure, fragmented smallholder farms, low mechanization rates, and high climate vulnerability. Conversely, Korea has effectively addressed similar issues through systematic policy support, advanced technology adoption, extensive infrastructure development, and targeted capacity-building initiatives.

For Ethiopia, it is advisable to adopt key elements of Korea's smart agriculture

strategy by emphasizing affordable, locally adapted solutions, alongside robust capacity-building programs tailored to local contexts. Specifically, Ethiopia should prioritize the deployment of low-cost, modular technologies suited to its diverse agro-ecological zones, focusing on incremental adoption supported by practical training for smallholders and agricultural professionals.

Conversely, Korea should strategically engage Ethiopia through focused technology and service exports, collaborative Official Development Assistance (ODA) projects, and structured technology transfer initiatives that include localized research and development (R&D). Through joint pilot projects and comprehensive capacity-building programs, Korea can effectively support Ethiopia in creating a resilient and sustainable smart agricultural sector.

By fostering such targeted bilateral cooperation, both countries can maximize mutual benefits. In details, Ethiopia can enhance its agricultural productivity and climate resilience, and Korea can expand its global presence in smart agriculture technology and knowledge sharing.

Table 3.
SWOT of Smart Agriculture in Ethiopia

	Korea	Ethiopia
Strengths	<ul style="list-style-type: none"> - Advanced ICT & smart farm technology - Strong government support - Active youth/entrepreneurship - Rich agricultural data & private sector involvement 	<ul style="list-style-type: none"> - Urgent need for climate-smart agriculture - Abundant arable land & young labor force - Strong international cooperation & support - Government commitment & policy frameworks
Weaknesses	<ul style="list-style-type: none"> - Aging rural population - Low field-level adoption rate - High initial cost for smallholders - Digital literacy gap - Immature agri-tech ecosystem 	<ul style="list-style-type: none"> - Poor infrastructure (irrigation, power, roads) - Low technical literacy - Financial barriers for smallholders - Tenure system & weak institutional capacity
Opportunities	<ul style="list-style-type: none"> - Global demand for agri-tech exports - Ongoing public R&D investment - International standardization leadership - New agri-tech start-ups & models 	<ul style="list-style-type: none"> - Access to global climate funding - Yield gap closing & food security gains - Regional leadership in Africa - Land restoration via smart agriculture
Threats	<ul style="list-style-type: none"> - Rapid aging & depopulation in agriculture - Intensifying climate change impact - International competition - Policy or market volatility 	<ul style="list-style-type: none"> - Severe climate risk (droughts, floods) - Rapid population growth/food demand - Political/social instability - Technology misfit & lack of localization

Sources: Author's modification based on the MAFRA (2022) and FAO (2020a).

3. Pilot Project Recommendations

A pilot project site suitable for Ethiopia's environment was selected by applying lessons from Korea's smart agriculture experience. The selection process was as follows: Ada Woreda in Oromia, Ethiopia, located adjacent to the capital city Addis Ababa, offers excellent conditions for transportation, market access, agricultural infrastructure, labor force, and government support. The selection procedure included: (1) an initial screening and potential assessment based on documentation and data, (2) field visits and consultations with stakeholders, (3) evaluation of the suitability of crops and technologies, economic feasibility, and scalability, and (4) final site selection through consensus. As a result, Ada Woreda was identified as the most appropriate site for the pilot smart agriculture project.

3.1. Ada Woreda Crop Prioritization

Ada Woreda benefits from its proximity to the metropolitan area, a relatively mild climate, and fertile soils. At the same time, the region continues to face important structural limitations, as irrigation coverage remains limited to only 20 to 30 percent, soil drainage constraints persist, and the participation of youth and women in decision-making processes is still low. These factors define the parameters within which agricultural development in the area must progress.

To address these conditions, a crop prioritization framework has been established to guide investment, technology deployment, and market integration in Ada Woreda's transition toward climate-smart agriculture. Core investment crops include tomatoes, onions, dairy, chickpeas, and alfalfa, which are supported by high urban demand and demonstrate strong suitability for smart irrigation and sensor-based management. Scaling crops such as strawberries, paprika, cabbage, and poultry are identified for their compatibility with ICT-enabled greenhouses and digital disease management systems. Traditional climate-adapted crops, including teff, wheat, and barley, remain vital for national food security and climate resilience and will therefore continue to play a significant role. Tropical fruit crops such as avocado, mango, and papaya are positioned as pilot crops (EIAR, 2022), offering long-term opportunities for export and high value-added production, though they require substantial initial investment. Finally, processing-oriented crops such as ginger and processing-grade chickpeas and peppers are included for their suitability in primary processing activities, including drying, cutting, and branding.

This structured prioritization provides a clear basis for investment planning and strategic decision-making, while also creating opportunities to integrate advanced technologies and align market systems with Ethiopia's broader smart agriculture agenda.

3.2. Smart Agriculture Implementation Strategy: A Local–Network Approach

Ethiopia's smart agriculture strategy is conceived not as a single-site intervention, but as an integrated framework that combines localized implementation with network-based dissemination. Within this framework, Ada Woreda has been identified as a primary pilot site. The woreda benefits from its proximity to the metropolitan area, relatively mild climate, and fertile soils, yet faces structural challenges such as low irrigation coverage of only 20–30 percent, persistent soil drainage problems, and the limited participation of youth and women in decision-making processes. These constraints establish the priority areas for smart agriculture intervention in Ada, while also positioning the woreda as a catalytic hub for nationwide scaling.

The local implementation strategy for Ada Woreda is structured around five key pillars. The first pillar is productivity enhancement and technology dissemination, which focuses on introducing solar-powered precision irrigation, soil moisture sensors, and smart drip systems, with tomatoes and onions serving as the initial demonstration crops due to their high market demand and suitability for technological applications. The second pillar emphasizes climate risk response and soil improvement, through the adoption of Integrated Soil Fertility Management, AI-based pest and disease prediction systems linked to weather data, and smart crop calendars (EIAR, 2022) designed to reduce risks associated with drought, pests, and climate variability. The third pillar is inclusive participation, achieved through digital agricultural training platforms that incorporate educational e-greenhouses, voice-assisted crop management applications, and women's cooperative-based digital cultivation record systems. The fourth pillar focuses on strengthening distribution and processing infrastructure by establishing QR-based production traceability systems, shared cold storage facilities, and small-scale packaging and processing centers, all of which contribute to reducing post-harvest losses and strengthening linkages with urban and export markets. Finally, the fifth pillar is the development of a data-driven management system through agricultural data hubs, real-time dashboards, and AI-generated analysis reports which collectively enhance monitoring of productivity and resource inputs while providing essential feedback for policymaking. Taken together, these five pillars are designed to transform Ada into a metropolitan-linked smart agriculture cluster that improves farm incomes,

enhances climate resilience, and promotes inclusive growth.

Beyond Ada, the national strategy seeks to expand smart agriculture through a network-based regional portfolio. This approach ensures that Ada does not remain an isolated success story but functions as part of an interconnected set of hubs with complementary strengths. Holeta focuses on post-harvest value preservation by introducing smart greenhouse environmental control technologies and modular storage and packaging facilities for vegetables and cut flowers. Kaliti, reflecting the characteristics of peri-urban agriculture, emphasizes resource efficiency and value creation through wastewater purification systems, low-cost smart timers for cabbage and tomato cultivation, and automated primary processing for ginger and cassava. Hawassa, meanwhile, is oriented toward export competitiveness and digital innovation, applying precision growth monitoring and production history management technologies for avocado and tomato cultivation, and promoting youth-centered digital agriculture and entrepreneurship supported by ICT-based tools such as disease prediction systems and cultivation calendars.

This network-based portfolio underscores the complementary role of each hub: Ada represents climate-adaptive productivity, Holeta post-harvest value preservation, Kaliti peri-urban resource efficiency, and Hawassa export-oriented digital innovation. When these regional strengths are linked, they collectively enhance the resilience and competitiveness of Ethiopian agriculture.

In conclusion, the combination of Ada's localized implementation strategy with the broader regional portfolio forms the basis of a local-network dissemination model. This approach ensures that smart agriculture in Ethiopia will not be defined by isolated pilot projects, but rather by inter-regional solidarity and knowledge sharing. Through the integration of local demonstration, farmer engagement, and specialized regional innovations, Ethiopia will be able to strengthen its national capacity to adopt and scale smart agriculture across diverse agro-ecological zones. This framework provides the foundation for a transformation that is both inclusive and sustainable.

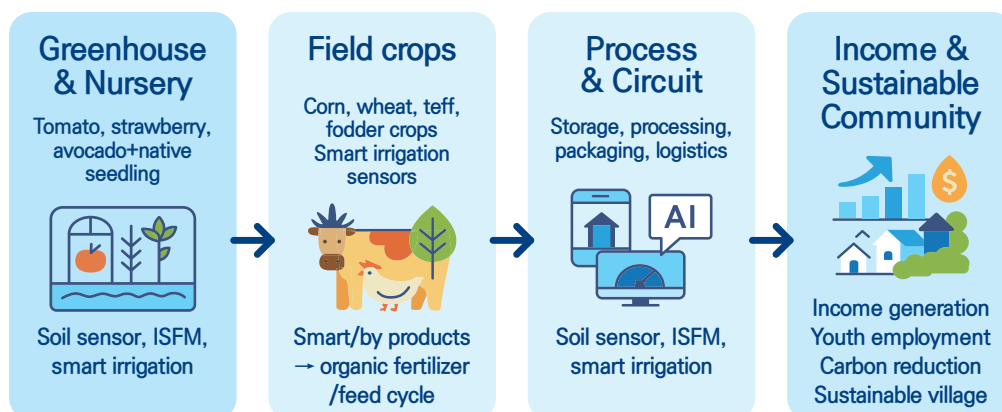
3.3. Ada Mixed-Farming Smart Agriculture Innovation Cluster

Smart agriculture is designed as an integrated model that links production, processing, and community development. At the greenhouse and nursery stage, high-value crops such as tomatoes, strawberries, and avocados are cultivated using soil sensors, smart irrigation, and Integrated Soil Fertility Management (ISFM) to enhance efficiency. At the field crop stage, maize, wheat, teff, and fodder crops are managed with smart irrigation and sensors, while by-products are recycled into organic fertilizers

and feed to establish a circular farming system. At the processing and distribution stage, storage, processing, packaging, and logistics are connected with AI-based data analysis to increase value addition and reduce losses. Finally, at the community level, the model contributes to increasing farm income, creating youth employment, reducing carbon emissions, and building sustainable villages.

From a policy perspective, the following priorities are essential: establishing smart agriculture clusters, promoting circular models through by-product recycling, building digital and AI-based distribution systems, expanding the participation of youth and women, and aligning interventions with national strategies for climate resilience. Through these measures, Ethiopia can increase productivity and income, strengthen food security and employment, and accelerate the sustainable transformation of its agricultural sector.

Figure 1.
Key Application Areas of Smart Agriculture

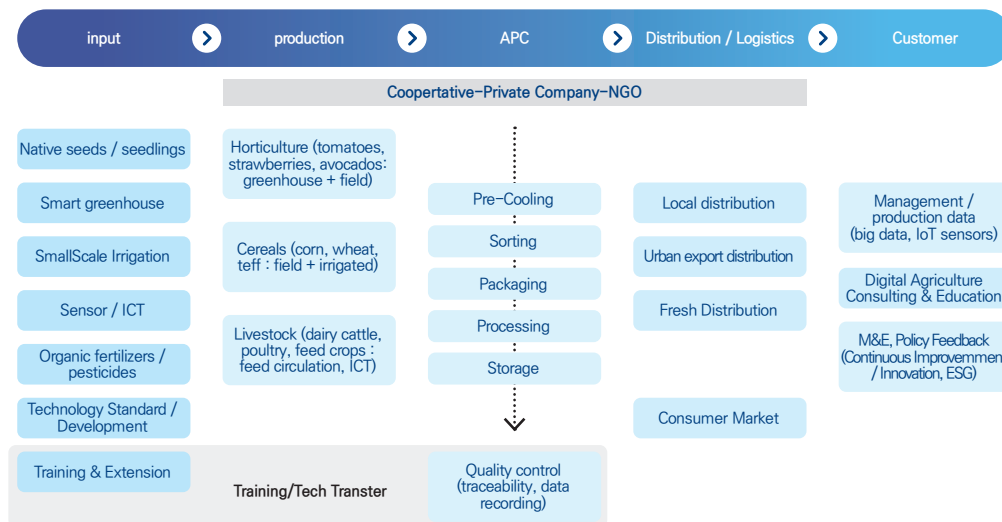


Note: ISFM: Integrated Soil Fertility Management

Source: Author.

The cluster operates as a fully integrated value chain, seamlessly linking crop and livestock production, processing, and marketing through digital platforms. Advanced smart farming technologies, including IoT sensors and precision management tools, are widely deployed to enhance productivity and efficiency. The governance structure is based on a strong public-private partnership, with cooperatives, government, and private agri-tech firms jointly managing assets, facilitating technology transfer, and upholding standards. Continuous entrepreneurial training and mentoring for youth and women encourages the growth of new agri-businesses. Collective procurement, machinery rental, and joint marketing further enhance economies of scale and expand rural market access.

Figure 2.
Smart Agriculture Value Chain Concept



Source: Author.

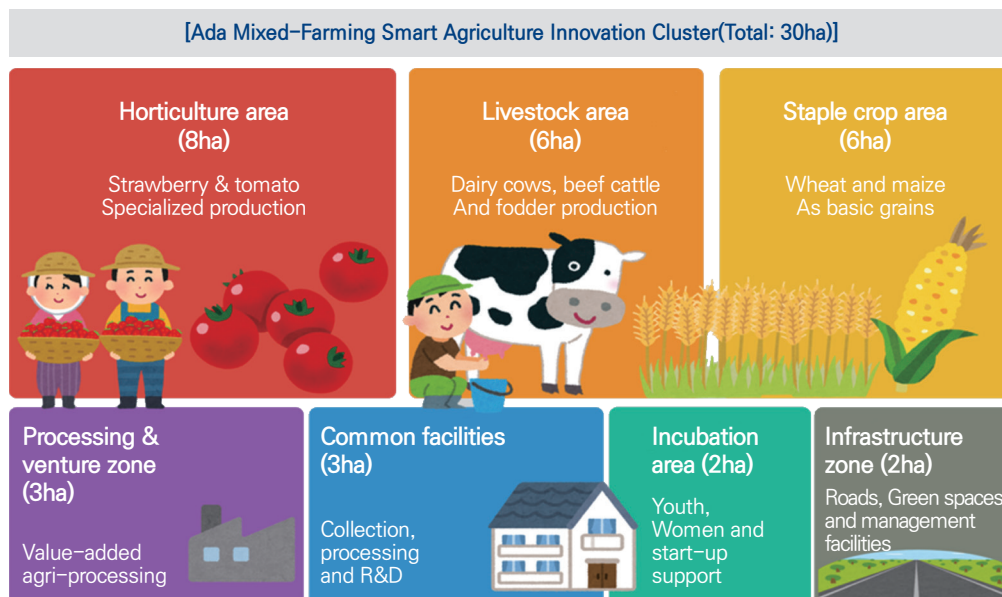
The Ada Mixed-Farming Smart Agriculture Innovation Cluster is a 30-hectare integrated agribusiness platform to be implemented over 10 years in Oromia’s Ada region. Designed to promote sustainable rural transformation, the cluster integrates horticulture, livestock, staple crop production, value-added processing, and entrepreneurial incubation. It aims to serve as a hub for innovation, job creation, and the demonstration of smart farming suitable for Ethiopia’s agro-ecological context.

Table 4.
Cluster Area and Operational Structure

Area	Size	Main Functions
Horticulture area	8 ha	Strawberry, tomato specialized production
Livestock area	6 ha	Dairy cows, beef cattle, fodder production
Staple crop area	6 ha	Wheat, maize as basic grains
Processing & venture zone	3 ha	Value-added agri-processing, business incubation
Common facilities	3 ha	Collection, processing, and R&D
Incubation area	2 ha	Youth and women’s start-up support
Infrastructure zone	2 ha	Roads, green spaces, management facilities

Source: Author.

Figure 3.
Division-Based Smart Agriculture Innovation Cluster (Ada)



Source: Author.

3.4. Economic and Financial Analysis

The Ada Smart Agriculture Cluster demonstrates strong economic viability. Based on production and price assumptions derived from FAO (2023a; 2024), total annual revenue is projected at approximately USD 320,540. The horticulture sector generates the highest value, with tomatoes, strawberries, avocados, and mangoes contributing more than USD 110,000 annually (EIAR, 2022). Food crops such as wheat, maize, and teff account for about USD 51,500 (CSA, 2021), while the livestock sector—including dairy, beef, and poultry—provides a stable income of roughly USD 118,500 (Medrok Group and Elfora Agro-Industries, 2024). Processing and value-added ventures are expected to contribute an additional USD 40,540, reflecting the benefits of small-scale processing activities that increase returns by 15–25 percent compared to raw product sales.

Capital expenditure (CAPEX) is estimated at USD 757,000, covering land and infrastructure, ICT and sensor systems, shared facilities, greenhouses, livestock housing, and processing units. Annual operating expenditure (OPEX) is projected at USD 154,000, amounting to USD 1.54 million over a 10-year period (Medrok Group and Elfora Agro-Industries, 2024). Operating costs include ICT system maintenance, personnel and management, agricultural inputs, facility operations, education and R&D, and administrative expenses.

Cash flow analysis indicates that revenues begin to scale significantly from the second year, with full revenue realization by Year 4. The cluster is expected to reach its break-even point in Year 6. Over a 10-year horizon, the project demonstrates a Net Present Value (NPV) of USD 166,599, an Internal Rate of Return (IRR) of 15.5 percent, and a Return on Investment (ROI) of 97.5 percent. These indicators confirm the project's profitability and scalability, positioning it as a robust investment model for climate-smart agriculture in Ethiopia.

Beyond financial metrics, the cluster generates considerable social and environmental value. Over 10 years, it is expected to create approximately 108 direct jobs, yielding employment benefits valued at USD 1.62 million. Contributions to food security are estimated at USD 500,000, while climate and environmental benefits, primarily through water savings and carbon reduction, add approximately USD 200,000. When combined with net financial profit of about USD 738,000, the total social return amounts to USD 2.32 million, resulting in a Social Return on Investment (SROI) of 3.03. This means that every dollar invested generates more than three dollars of combined financial, social, and environmental value.

The financial structure of the cluster incorporates dedicated risk costs for each sector to account for potential negative impacts, reflecting historical performance, market volatility, and projected exposure to operational uncertainties. In the horticulture sector, annual risk is estimated at USD 1,000, primarily due to pest and disease outbreaks (e.g., aphids, thrips, blight) and market price fluctuations. For livestock, risk costs are approximately USD 600, linked to infectious diseases such as foot-and-mouth disease and brucellosis, along with feed shortages and rising feed prices. Food crops carry a lower but still significant annual risk of USD 400, mainly due to volatile grain prices and vulnerability to extreme weather events. The highest exposure is observed in the processing and ventures sector, with risk costs of USD 1,300 annually (Medrok Group and Elfora Agro-Industries, 2024), driven by instability in raw material supply, quality and sanitation challenges, and logistical disruptions.

Collectively, these differentiated risk costs highlight the sector-specific vulnerabilities within the cluster. They underscore the importance of tailored mitigation strategies, including climate-resilient technologies, cooperative-based management, improved veterinary services, and strengthened logistics systems. By embedding risk management into financial planning, the project ensures both the stability of returns and the resilience of the overall value chain.

3.5. Conclusion and Policy Recommendations

The feasibility study confirms that establishing a smart agriculture cluster in Ada Woreda is both technically and economically viable, with substantial social and environmental benefits. By integrating EDCF-financed irrigation systems with digital technologies, farmer training, and value chain modernization, the project provides a scalable pathway for agricultural transformation in Ethiopia. Financial results are favorable, with a positive Net Present Value (NPV), an Internal Rate of Return (IRR) of about 15%, and break-even within six years. Social Return on Investment (SROI) analysis shows that every dollar invested could yield approximately three dollars of combined financial, social, and environmental value.

To ensure sustainability, stronger policy and institutional integration is required, aligning the project with CSAIP, Climate Resilient Green Economy (CRGE), and the Ten-Year Development Plan (FAO, 2022a). A dedicated smart agriculture department within the Ministry of Agriculture is recommended to enhance coordination. Climate risk management should be embedded through predictive models and adaptive farm management.

The financing model must be diversified, blending EDCF, KOICA, and multilateral resources (World Bank, International Fund for Agricultural Development (IFAD), Green Climate Fund (GCF)) while encouraging private-sector participation through mechanisms such as Pay-As-You-Grow. Inclusivity is critical, with incubation centers for youth and women, cooperative-led governance, and targeted training in digital agriculture (ILO, 2023).

Implementation should follow a phased approach, starting with the 30-hectare Ada pilot and expanding to the 5,000-hectare irrigation command area. Key constraints—soil degradation, outdated irrigation, certification gaps, post-harvest losses, limited processing facilities, and scarce affordable technologies—must be addressed through precision farming, solar-powered irrigation, certification centers, modular cold storage, value-adding processing, and blockchain-based logistics.

Expected impacts include yield increases of 20–25%, reductions in fertilizer and water use of up to 30%, and income growth of around 40%, alongside significant youth and women employment opportunities and enhanced export capacity. By combining Ethiopia's institutional frameworks with Korea's ICT and smart farming expertise, the project can become a transformative model for sustainable, climate-resilient, and market-oriented agriculture.

Ethiopia's agriculture faces multiple challenges, including climate change, low productivity, and inadequate rural infrastructure. The country is divided into nine Agro-Ecological Zones (AEZs), each with distinct soil and water characteristics, yet past agricultural policies have been largely uniform, resulting in limited effectiveness. To address this, a region-specific smart agriculture strategy is essential. The priority is to develop and disseminate AEZ-tailored technology packages, such as solar-powered pumping and precision irrigation for arid lowlands and pest prediction and soil

improvement technologies for highland areas. Equally important is the expansion of rural infrastructure, including small-scale irrigation facilities, solar-powered pumping systems, and storage and distribution facilities, which will serve as a foundation for advanced technology adoption. Given the dominance of smallholders, cooperative-based equipment-sharing systems such as machinery banks, leasing, and shared-use models must be introduced. Additionally, a Climate-Smart Agriculture (CSA) data and monitoring system integrating weather, soil, and crop information should be established to enable real-time diagnostics and evidence-based policymaking. Implementing these measures is expected to minimize productivity losses from climate shocks, raise average productivity by 10–18 percent, diversify farmer income through specialized crops, and reduce rural inequality. Furthermore, the adoption of data-based policies will enhance Ethiopia's capacity to attract donor support and international investment.

Korea's agricultural development experience provides important lessons for Ethiopia. Korea advanced through three distinct stages—food security, competitiveness, and smart agriculture innovation—supported by systematic policy and institutional reforms. The establishment of Smart Farm Innovation Valleys and the enactment of the Smart Agriculture Promotion Act represent successful models that integrated policy, technology, and human capital development. For Ethiopia, this experience underscores the need to establish a dedicated smart agriculture unit within the Ministry of Agriculture to coordinate policy, budgeting, and technology dissemination. The creation of smart agriculture innovation hubs, modeled on Korea's valleys, will combine training, demonstration, data centers, and entrepreneurship support, thereby accelerating technology adoption and strengthening youth and women's participation. Financing models should also be diversified, blending public and private resources, including leasing, subsidies, and ODA, to reduce the initial investment burden for smallholders. Finally, a phased roadmap—from pilot projects to medium-term dissemination and long-term institutionalization—should be adopted to minimize risks. These measures will improve policy coherence, enhance budget efficiency, stimulate youth- and women-led agribusiness start-ups, and foster the integration of production, processing, distribution, and data into a unified smart agriculture value chain. Ultimately, this will raise farm incomes and strengthen Ethiopia's export competitiveness.

For practical dissemination, a pilot model is necessary. Ada Woreda has been identified as an ideal site due to its favorable soil and climate conditions and proximity to major markets. The proposal envisions a 30-hectare mixed-farming cluster that integrates horticulture, livestock, staple crops, and processing activities. Crop prioritization within this cluster is essential: core investment crops such as tomatoes, onions, dairy, and alfalfa will serve as the backbone, expansion crops such as strawberries and paprika will be supported for their market potential and adaptability, and food security crops such as teff and wheat will be maintained as a stable production base. Smart technology packages—including

solar-powered precision irrigation, AI-based pest and disease prediction, QR-based traceability, cold storage and processing facilities, and digital applications for youth and women—will be deployed to enhance productivity and efficiency. Sustainable governance and financing will be ensured through Public-Private Partnership (PPP) incubation hubs, Pay-As-You-Grow (PAYG) financing models (Lersha Digital Platform, 2023), and youth- and women-led cooperatives.

The expected outcomes of the Ada cluster are highly favorable. Annual agricultural revenues are projected at approximately USD 320,000, with break-even achieved within six years and a ten-year ROI of 97.5 percent. Social and environmental benefits are equally significant, including the creation of 108 new jobs, employment benefits of USD 1.62 million, food security improvements valued at USD 500,000, and environmental gains worth USD 200,000. If successfully scaled nationwide, this model could increase farmer incomes by up to 40 percent, strengthen the agricultural leadership of youth and women, and expand Ethiopia's export competitiveness.

Table 5.
Thematic Policy Recommendations

Theme	Ethiopia
Situation Analysis of Smart Agriculture in Ethiopia	<ul style="list-style-type: none"> - Establish AEZ-specific smart agriculture strategies, dividing the country into nine Agro-Ecological Zones and introducing technology packages tailored to local climate, soil, and water conditions. - Strengthen rural infrastructure and basic technologies, including small-scale irrigation systems, solar-powered pumping, and storage and distribution facilities. - Promote cooperative-based technology and equipment sharing systems, such as machinery banks, leasing schemes, and shared-use models to improve smallholder access (EIAR, 2021). - Operate a Climate-Smart Agriculture (CSA) data and monitoring system, linking weather, soil, and crop growth data for real-time diagnostics and evidence-based policymaking (FAO, 2019; 2020b; 2021a; 2022a; 2023a).
Application of Korea's Smart Agriculture Experience to Ethiopia	<ul style="list-style-type: none"> - Establish a dedicated smart agriculture unit within the Ministry of Agriculture to coordinate policies, budgeting, and technology dissemination. - Create smart agriculture innovation hubs, modeled after Korea's Smart Farm Innovation Valleys, integrating training, demonstration, data centers, and entrepreneurship support. - Introduce public-private blended financing and subsidy schemes, including leasing, grants, and ODA models, to reduce initial investment burdens and accelerate adoption.
Proposal for Smart Agriculture in Ethiopia (Ada Woreda Pilot)	<ul style="list-style-type: none"> - Develop a 30-hectare pilot smart agriculture cluster in Ada Woreda, integrating horticulture, livestock, staple crops, and processing. - Systematize crop prioritization: (i) core investment crops such as tomatoes, onions, dairy, and alfalfa; (ii) expansion crops such as strawberries and paprika; and (iii) food security crops such as teff and wheat. - Disseminate smart technology packages, including solar-powered precision irrigation, AI-based pest early warning, QR traceability systems, cold storage and processing facilities, and digital applications for youth and women. - Establish sustainable financing and governance structures through PPP incubation hubs, Pay-As-You-Grow (PAYG) financing models, and youth- and women-led cooperatives.

Sources: Author's modification based on EIAR (2021) and FAO (2019; 2020b; 2021a; 2022a; 2023a).

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