

AGRICULTURAL BEST PRACTICES REPORTS

Kenya report

Lead Beneficiary: Rezos Brands S.A.

Authors: Dr. Christiana Genethliou

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Table of Contents

List of Figures	3
1. Introduction	4
1.1 Background	4
1.1 Objectives	4
2. Understanding Kenya's Agricultural Context.....	6
2.1 Kenya's Diverse Climatic Zones	6
2.2 Agricultural Practices.....	7
2.3 Socio-Economic Role of Agriculture.....	7
3. Climate-Smart Agricultural (CSA) Practices for Kenya	9
4. Agripreneurship practices	24
5. Conclusions.....	35
References	36

List of Figures

Figure 1. Drought-tolerant vegetables.	9
Figure 2. Sand dam during drying seasons in Kenya.....	10
Figure 3. Micro-irrigation systems.	11
Figure 4. Agroforestry; planting alternative rows of trees and crops.	12
Figure 5. Examples of heat-sensitive and heat-tolerant genotypes after heat stress under field conditions.	13
Figure 6. Agrivoltaic farming.	16
Figure 7. The Red Maasai sheep slow food presidium.	17
Figure 8. Anaerobic digestion process for biogas production.	18
Figure 9. Riparian Buffer installation ‘.....	19
Figure 10. Sharing seed diversity in a Community Seed Bank.	20
Figure 11. Vertical Farming.	22

1. Introduction

1.1 Background

Agriculture is not merely one of many sectors in Kenya; it forms the cornerstone of the nation's economy and acts as the mainstay for most of its population. This sector is a major contributor to Kenya's Gross Domestic Product (GDP) and is the primary source of livelihood for a substantial portion of the workforce. The vast influence of agriculture extends beyond economic contributions; it is pivotal in ensuring food security and shaping the social fabric of the country.

However, this vital sector faces increasing threats from climate change, which poses significant challenges through more frequent and severe droughts, unpredictable rainfall patterns, and an increase in the prevalence of pests and diseases. These environmental challenges are forcing a reevaluation of traditional farming practices and necessitating a shift towards more sustainable and innovative agricultural approaches.

To address these pressing issues, there is an urgent need for a transformative strategy in Kenya's agricultural framework. This involves integrating modern technologies and sustainable practices to enhance resilience against climate variability. The focus must also be on innovation, not just in terms of technological adoption but also through the development of new agricultural models and the improvement of supply chain efficiencies. This dual approach of sustainability and innovation is essential for maintaining the sector's productivity and for safeguarding the livelihoods of millions who depend on agriculture for their survival.

By embracing these changes, Kenya can not only mitigate the impacts of climate-related challenges but also enhance its agricultural productivity, ultimately leading to greater economic stability and improved national food security. The evolution of this sector is crucial for the country's overall development, impacting everything from economic growth to social stability and environmental sustainability.

1.1 Objectives

This report focuses on two critical themes essential for the transformation of Kenyan agriculture: Climate-Smart Agriculture (CSA) and Agripreneurship. These themes are crucial for addressing the dual challenges of climate change and economic development within the agricultural sector.

Climate-Smart Agriculture (CSA) aims to enhance agricultural productivity and resilience while simultaneously reducing greenhouse gas emissions. This approach directly confronts the climatic challenges impacting agriculture by integrating techniques that are environmentally sustainable and climatically adaptable.

Agripreneurship, on the other hand, introduces a dynamic element to the sector by focusing on business development, market access, and technological innovation. It aims to transform

agriculture into a more economically viable and technologically advanced sector, fostering growth and sustainability.

The primary objectives of this report are to:

- **Identify and Analyze:**

This report aims to thoroughly explore and detail at least 20 climate-smart agricultural practices and 20 agripreneurship practices that are optimally suited to Kenya's diverse ecological and socio-economic contexts. This comprehensive examination will highlight practices that effectively merge environmental stewardship with economic opportunity.

- **Evaluate and Recommend:**

This report will critically assess these practices based on criteria such as effectiveness, scalability, and sustainability. This assessment will leverage both local insights and global examples to illustrate successful implementations and potential for replication within Kenya.

- **Strategize and Advise:**

The report will develop actionable strategies and provide robust policy recommendations that will assist stakeholders—including government agencies, non-governmental organizations, and the private sector—in adopting and scaling these practices. The aim is to facilitate a smoother integration of innovative agricultural methods into the mainstream sector.

Through detailed analysis and strategic recommendations, the current report will contribute significantly to the efforts aimed at modernizing Kenyan agriculture. It seeks to make the sector more productive, resilient, and sustainable, thereby better equipping it to handle both current and future challenges. The subsequent sections will provide a comprehensive framework that includes a diverse range of practices, all grounded in empirical research and tailored to meet the specific needs and circumstances of Kenya. Ultimately, this report aims not just to inform but to catalyze action towards a more sustainable agricultural future in Kenya.

2. Understanding Kenya's Agricultural Context

2.1 Kenya's Diverse Climatic Zones

Kenya's agricultural landscape is profoundly influenced by its diverse climatic zones, shaped by the country's varied geographical features ranging from coastal plains and central highlands to expansive arid and semi-arid regions. Each of these areas presents unique conditions that dictate the types of agricultural activities that can be successfully cultivated:

- **Coastal Plains:** Along the coast, the climate is predominantly humid and tropical, ideal for growing tropical crops such as coconuts and cashew nuts. This region also supports tourism-driven agroforestry, which integrates tree farming with crop production in a way that not only enhances biodiversity but also attracts tourism, adding an additional revenue stream for local farmers. The humid climate, coupled with the rich, alluvial soils, makes this area highly suitable for these types of agricultural endeavors.
- **Central Highlands:** The central highlands of Kenya, encompassing the regions around Mount Kenya and the Aberdare ranges, benefit from a temperate climate that provides favorable conditions for the cultivation of high-value crops such as tea, coffee, and various horticultural products. These areas are the backbone of Kenya's agricultural output, thanks to their fertile volcanic soils and relatively consistent rainfall patterns. The temperate climate allows for the growth of crops that demand specific growing conditions, making the highlands critically important to both local consumption and international exports.
- **Arid and Semi-Arid Lands (ASALs):** Covering approximately 85% of Kenya's land area, the ASALs represent a significant portion of the nation's geography, characterized by low rainfall and harsher climatic conditions. These areas predominantly support pastoralism and subsistence farming, which are continually at risk due to frequent droughts that threaten both food security and the livelihoods of local communities. The vulnerability of these regions to climatic fluctuations calls for innovative agricultural practices and sustainable resource management strategies to improve resilience and productivity.

The contrasting climates across Kenya's regions highlight the necessity for tailored agricultural practices and policies that can adapt to each area's specific needs. The sustainability of Kenya's agricultural sector depends on the ability to understand and harness the potential of each climatic zone while mitigating the risks posed by climate variability. Developing and implementing climate-smart agricultural strategies in these diverse zones is crucial for enhancing productivity, ensuring food security, and supporting the livelihoods of millions of Kenyans dependent on agriculture.

2.2 Agricultural Practices

Agricultural practices in Kenya showcase a remarkable diversity, adapted to the varied climates across the country, from fertile highlands to arid regions. In the high-potential areas of the central highlands, intensive farming is prevalent with cash crops such as tea, coffee, and various horticultural products dominating the agricultural landscape. These regions leverage advanced agricultural techniques including the use of irrigation systems, greenhouse technology, and the application of agrochemicals. While these methods significantly enhance productivity and economic output, they also pose sustainability challenges and environmental concerns, necessitating careful management and integration of eco-friendly practices.

In contrast, the arid and semi-arid lands (ASALs) embody a different set of agricultural practices primarily focused on pastoralism and agro-pastoralism. Here, communities predominantly rely on livestock rearing as their primary source of livelihood, complemented by subsistence crop farming during favorable weather conditions. The inherent variability of the climate in these areas demands agricultural strategies that are resilient and adaptable to harsh conditions. Practices such as the cultivation of drought-tolerant crops and the implementation of integrated livestock-crop systems are critical, as they maximize the efficiency of the scarce resources available.

2.3 Socio-Economic Role of Agriculture

Agriculture is indisputably the backbone of Kenya's economy. It plays a pivotal role, contributing significantly to the Gross Domestic Product (GDP) and employing a substantial portion of the country's workforce. Notably, the sector is a livelihood source for approximately 80% of the Kenyan population, particularly impacting rural areas profoundly. Furthermore, agriculture accounts for over 65% of Kenya's export earnings, with primary exports including tea, coffee, and fresh produce. This highlights its crucial role in the economic stability and growth of the nation.

Beyond its economic contributions, agriculture is vital for food security in Kenya. A significant segment of the population depends on locally produced staples such as maize, beans, and rice. The importance of agriculture in ensuring food security is intensifying in the face of rapid population growth and urbanization, which place additional strains on existing food systems. There is an urgent need for more efficient production and distribution methods to sustainably feed the growing urban and rural populations.

Moreover, agriculture holds a special place in the cultural fabric of Kenya, particularly in rural communities where traditional farming methods and indigenous crop varieties are integral to social cohesion and biodiversity. These traditional practices, however, face threats from modernization, climate change, and globalization, which introduce both challenges and opportunities to the farming communities.

Consequently, the diversity and complexity of Kenya's agricultural practices, shaped by its distinct climatic zones and profound socio-economic significance, present unique challenges and opportunities. An integrated approach that marries traditional knowledge with modern technology is essential. Such strategies must promote resilience, sustainability, and socio-economic benefits,

enhancing the quality of life for Kenya's populace. This deep understanding of Kenya's agricultural context is crucial for crafting effective interventions and paves the way for detailed exploration of tailored climate-smart agriculture and agripreneurship practices in subsequent sections of this report.

3. Climate-Smart Agricultural Practices for Kenya (CSA)

In this section, a meticulously curated selection of 20 climate-smart agricultural practices is presented, each tailored to meet the unique climatic challenges of Kenya's diverse agricultural landscapes. These practices are strategically chosen to increase agricultural productivity, enhance resilience against environmental stresses, and minimize greenhouse gas emissions, ensuring full alignment with the core principles of climate-smart agriculture (CSA) as outlined by the World Bank. This strategic alignment is designed to not only counteract the adverse effects of climate change effectively but also to advance sustainable agricultural development throughout Kenya, adhering closely to World Bank guidelines that emphasize sustainability, economic viability, and environmental responsibility.

1. Drought-Tolerant Crop Varieties

In Kenya's arid and semi-arid regions, the development and adoption of drought-tolerant crop varieties are essential for sustaining agriculture under the harsh climatic conditions characterized by unpredictable rainfall and prolonged dry spells. These varieties are scientifically developed to require less water and endure extreme drought conditions, which significantly enhances their survivability and productivity (Figure 1).



Figure 1. Drought-tolerant vegetables. ¹

¹ <https://globalcharityinitiative.org/drought-tolerant-vegetables-are-saving-farmers-in-sub-saharan-africa/>

Drought-tolerant crops have genetically modified or naturally selected traits that enable them to maintain productivity during water shortages by having shorter growth cycles, deeper root systems to access deeper water sources, and/or regulated stomata (i.e. openings on the surface of the aerial portion of plants). The introduction of such crops can lead to a yield increase of up to 30% during drought periods compared to traditional varieties (Martignago et al. 2020). This substantial improvement not only helps secure the food supply but also increases farmers' incomes during challenging times.

The utilization of these crops aligns closely with the World Bank's strategies aimed at enhancing agricultural resilience and productivity. By incorporating drought-tolerant varieties into their agricultural practices, Kenyan farmers can achieve more stable and predictable crop production, even under significant climatic fluctuations. This strategic adaptation is crucial for advancing sustainable agriculture and bolstering food security as recommended by global agricultural development guidelines.

2. Improved Water Harvesting Techniques

Improved water harvesting techniques are crucial for managing water resources efficiently, especially in Kenya's arid and semi-arid areas. Techniques such as the construction of sand dams (Figure 2), rock catchments, and underground tanks play a pivotal role in capturing and conserving rainwater during the rainy seasons. This stored water becomes a vital resource during dry periods, ensuring a consistent water supply for agricultural purposes.



Figure 2. Sand dam during drying seasons in Kenya.²

These water harvesting systems not only provide necessary irrigation but also mitigate the impact of runoff and soil erosion during heavy rainfall, preserving soil fertility and structure. By reducing

² <http://www.clean-water-for-laymen.com/kenya-sand.html>

water wastage and enhancing water availability, these techniques contribute significantly to agricultural sustainability in regions prone to water scarcity.

Aligned with the World Bank's recommendations for sustainable water management, these practices are instrumental in promoting environmental conservation. They help stabilize the micro-climate around farming areas, reduce dependency on unpredictable rainfall, and enhance the resilience of agricultural systems against climate variability. By adopting improved water harvesting techniques, Kenyan farmers can better manage water resources to support agriculture, thereby reinforcing the overall agricultural resilience and sustainability as advocated by international development agencies.

3. Micro-Irrigation Systems

Micro-irrigation systems, encompassing drip and sprinkler irrigation technologies, represent a significant advancement in precision agriculture. These systems belong to precision water management technologies and are designed to deliver water directly to the plant roots, greatly enhancing the efficiency of water use by reducing evaporation and minimizing runoff. Micro-irrigation can boost production by reducing the requirements for water, fertilizer, and labor (Sheoran et al. 2022). By targeting the water directly where it's needed, these systems can reduce water usage by up to 60% compared to traditional flood irrigation. This precision not only conserves water—a critical resource in arid regions—but also ensures that crops receive the exact amount of water needed for optimal growth, thus reducing stress on the plants (Anjum et al. 2023). Figure 3 shows a typical drip irrigation system's schematic arrangement.



Figure 3. Micro-irrigation systems.³

³ <https://softinsystem.com/micro-irrigation-system.php>

Endorsed by the World Bank, micro-irrigation is a cornerstone of sustainable water management in agriculture. This method is especially crucial in areas facing water scarcity, allowing for the continuation of agriculture by making the best use of available water. It supports sustainable agricultural development and also aligns with global strategies aimed at enhancing agricultural water efficiency and supporting ecosystems.

4. Agroforestry

Agroforestry (Figure 4), the integrated approach of combining trees and shrubs with crops and livestock systems, offers multifaceted benefits to both the environment and the farmers. By integrating trees into agricultural landscapes, this practice improves soil fertility through nitrogen fixation and enhances groundwater infiltration, which is vital for soil health. Trees also provide necessary shade, reducing soil moisture evaporation and protecting crops from extreme heat, thus mitigating the effects of temperature spikes on crop productivity (Johar 2021).



Figure 4. Agroforestry; planting alternative rows of trees and crops. ⁴

Moreover, agroforestry as a land management system supports biodiversity, enhances carbon sequestration, and stabilizes the soil, reducing erosion. It diversifies farmers' income sources through the production of timber, fruit, and fodder, making agricultural operations more economically sustainable. Supported by the World Bank's guidelines for sustainable land use, agroforestry is a robust strategy for ecological balance and increasing the economic viability of farms, contributing to a holistic approach to sustainable agriculture.

⁴ <https://www.state.gov/dipnote-u-s-department-of-state-official-blog/science-speaks-agroforestry/>

5. Conservation Agriculture

Conservation agriculture is a set of farming practices that focus on achieving sustainable and profitable agriculture and includes techniques such as minimal soil disturbance, maintaining permanent soil cover, and practicing diverse crop rotations. This approach is designed to enhance biodiversity and natural biological processes above and below the ground surface, which leads to more sustainable production and increased resilience.

These practices help conserve water, reduce soil erosion, and increase soil organic matter. Improved soil structure from these practices enhances the soil's ability to retain water and nutrients, thus supporting healthier crop growth and resilience against fluctuating weather patterns (Nyanga et al. 2020). Conservation agriculture aligns with the World Bank's objectives to promote sustainable farming practices, supporting long-term agricultural productivity and environmental health, while ensuring food security.

6. Heat-Tolerant Crop Varieties

The development of heat-tolerant crop varieties is increasingly important as global temperatures rise and climatic conditions become more unpredictable. These varieties are bred to perform under higher temperatures, ensuring that yield remains stable even as conditions change (Figure 5). This is particularly critical for crops like wheat and coffee, which are highly sensitive to temperature fluctuations. Some vegetables, such as eggplant, okra and sweet potatoes, are inherently very heat tolerant (Ni et al. 2018).



Figure 5. Examples of heat-sensitive and heat-tolerant genotypes after heat stress under field conditions.⁵

⁵ <https://www.sciencedirect.com/science/article/pii/S221451411730096X?via%3Dihub>

By investing in the breeding and distribution of heat-tolerant varieties, Kenya can safeguard its agricultural output against the impacts of global warming. Ensuring the availability of these crops is vital for maintaining food security and adapting agricultural practices to meet the challenges posed by climate change. This strategic move is also supported by global agricultural policies aimed at enhancing crop resilience to climatic stressors, ensuring sustainable food systems worldwide.

7. Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is a comprehensive strategy that integrates multiple pest control techniques with the goal of managing pest populations in an environmentally sustainable manner. IPM emphasizes the use of biological control agents such as beneficial insects, cultural practices like crop rotation and intercropping, physical barriers such as row covers, and, as a last resort, targeted chemical pesticides. This approach significantly reduces reliance on chemical inputs, thereby minimizing environmental pollution and health risks associated with pesticide use.

One of the key benefits of IPM is its ability to maintain ecological balance by preserving beneficial insect populations that contribute to natural pest control. Additionally, by reducing pesticide use, IPM helps prevent the development of resistance in pest populations, ensuring long-term effectiveness of pest management strategies. Moreover, IPM contributes to long-term economic sustainability, thus minimizing crop losses, and fostering a balanced ecosystem within agricultural landscapes.

This method aligns with the World Bank's directives on sustainable pest control practices, which advocate for reducing chemical inputs to promote agricultural sustainability and biodiversity conservation.

8. Forecasting and Early Warning Systems

Forecasting and early warning systems utilize advanced meteorological data to provide farmers with precise and timely information about upcoming weather conditions. These systems are crucial in helping farmers proactively manage the risks associated with climate variability. By accessing accurate weather forecasts, farmers can make informed decisions on critical agricultural activities such as when to plant or harvest, which crop varieties to select based on expected weather patterns, and how to manage water resources more efficiently (Moges and Gebregiorgis 2013).

These systems are particularly vital in mitigating the impacts of extreme weather events such as droughts and floods. For example, knowing in advance the likelihood of a drought can prompt farmers to implement water-saving measures or switch to drought-resistant crop varieties. Similarly, forecasts of heavy rainfall can lead farmers to take preventive actions to avoid crop damage and soil erosion. This proactive approach enhances farm resilience and is in line with the

World Bank's strategy to strengthen agricultural planning and response mechanisms in the face of climatic changes.

9. Soil Health Management

Soil health management, fundamental to the sustainability of agricultural systems, is particularly critical in regions experiencing climatic extremes. Preventing land degradation is crucial; it involves combating soil erosion, nutrient depletion, and the loss of ecological integrity. Healthy soils are essential to the success of ecosystems and societies, playing a pivotal role in food and nutritional security, water quality, human health, climate change mitigation and adaptation, and biodiversity preservation.

This practice focuses on maintaining and enhancing the quality of soil through techniques such as the application of organic compost, the integration of biochar, and the adoption of reduced or no-tillage farming practices. These methods serve to increase the organic matter content of the soil, which improves its water retention capabilities, nutrient content, and overall structure.

Healthy soil acts as a buffer against the impacts of extreme weather, such as heavy rains and droughts, by improving water infiltration and reducing runoff. It also provides a robust foundation that supports plant health and growth, which is crucial for maintaining crop yields under varying environmental conditions (Miner et al. 2020). These sustainable soil management practices are aligned with the World Bank's recommendations for building resilient agricultural systems that can adapt to and thrive in the face of changing climatic conditions.

10. Agrivoltaic Farming

The adoption of agrivoltaics (i.e. solar photovoltaic panels in agriculture) (Figure 6), represents a significant shift towards sustainable and energy-efficient farming. Agrivoltaics combine renewable energy and agricultural production on the same area. These systems utilize solar photovoltaic panels to generate electricity, which can power a wide range of agricultural equipment, from irrigation pumps to processing facilities. The integration of solar energy in farming operations drastically reduces the reliance on non-renewable power sources, cutting down greenhouse gas emissions and diminishing the overall environmental impact of agricultural practices.

In addition to environmental benefits, Agrivoltaic Farming offers economic advantages, particularly in remote areas where access to conventional electricity is limited or expensive. By reducing energy costs, solar systems help lower the operational costs of running farm equipment and storage facilities, thus boosting the profitability of farming enterprises (Widmer et al. 2024). This sustainable energy solution aligns with the World Bank's focus on promoting renewable energy sources in agriculture, supporting efforts to create more economically and environmentally sustainable farming systems.



Figure 6. Agrivoltaic farming.⁶

11. Stress-Tolerant Livestock Breeds

In regions affected by harsh climatic conditions, stress-tolerant livestock breeds are invaluable for sustaining productive agricultural systems. Breeds like the Red Maasai sheep (Figure 7), which are adapted to withstand high temperatures and limited water availability, offer a viable solution for maintaining livestock productivity under stressful environmental conditions. These breeds have developed natural resilience to local challenges such as drought and endemic diseases, making them particularly suited for arid and semi-arid regions (Chang'a, Chasama, and Kifaro 2023).

Promoting the use of stress-tolerant breeds enhances the sustainability of livestock management by ensuring that animals can thrive in their local environments without requiring extensive resources. This practice not only improves the welfare of the animals but also aligns with the World Bank's initiatives aimed at sustainable livestock management. By fostering the adoption of these breeds, farmers can secure their livelihoods and contribute to the resilience of the agricultural sector.

⁶ <https://www.chemitek.pt/blog/agrivoltaic-systems>



Figure 7. The Red Maasai sheep slow food presidium.⁷

12. Biogas for Energy

Biogas technology offers a dual-purpose solution for agricultural waste management and energy production. By converting organic waste materials such as livestock manure and crop residues into biogas through anaerobic digestion, these systems produce clean, renewable energy while also generating bio-slurry (digestate), a byproduct that can be used as a nutrient-rich organic fertilizer (Figure 8). This process effectively closes the nutrient cycle on farms, reducing the need for chemical fertilizers and minimizing waste.

Implementing biogas systems supports sustainable energy initiatives as endorsed by the World Bank, helping to reduce overall greenhouse gas emissions and enhance the energy self-sufficiency of farming operations. Additionally, by providing a reliable source of energy and improving soil fertility, biogas technology plays a crucial role in enhancing the sustainability and environmental friendliness of agricultural practices (Keerthana Devi et al. 2022).

⁷ <https://www.ifad.org/pt-BR/web/latest/-/the-maasai-of-kenya-and-the-red-maasai-sheep-slow-food-presidium>

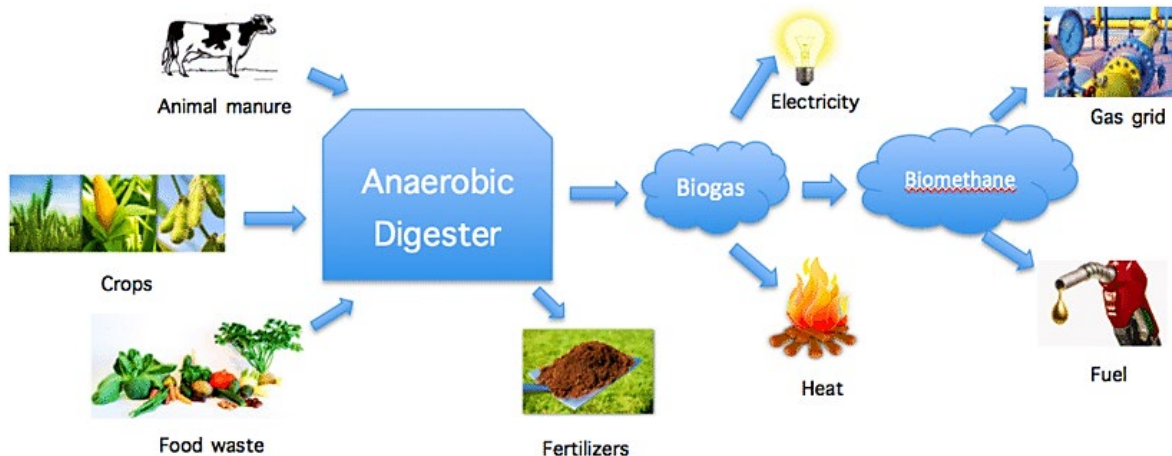


Figure 8. Anaerobic digestion process for biogas production.⁸

13. Index-Based Insurance (IBI) Schemes

Index-based insurance (IBI) schemes offer a modern approach to agricultural insurance by providing payouts based on specific climatic indices, such as rainfall levels, rather than detailed individual loss assessments. This approach greatly simplifies the insurance process, eliminating the need for extensive, costly field evaluations and enabling quicker, more dependable compensation.

These schemes are particularly beneficial in regions vulnerable to climate variability, serving as an essential safety net that allows farmers to manage risks more efficiently. By adhering to the World Bank's recommendations for innovative financial instruments, index-based insurance contributes to stabilizing farmers' incomes and bolstering their confidence to invest in enhancing their agricultural practices. This financial innovation plays a crucial role in increasing the resilience of agricultural operations against climate-related challenges, promoting sustainable growth and stability in the sector.

14. Mobile Technology for Real-time Information

Mobile technology has revolutionized access to critical information for farmers, enabling them to make informed decisions swiftly. Platforms that deliver real-time data on weather conditions, market prices, and best agronomic practices directly to mobile devices empower farmers to respond proactively to environmental and economic challenges. For instance, timely information about an impending frost can prompt farmers to harvest crops early or protect them, thereby minimizing potential losses.

Moreover, access to current market prices helps farmers optimize the timing and scale of their crop sales, enhancing profitability. This immediate flow of information is crucial for adjusting

⁸ https://www.researchgate.net/figure/Anaerobic-digestion-of-lignocellulosic-biomass_fig1_318658837

farming strategies to rapidly changing conditions and market opportunities. The deployment of mobile technology in agriculture aligns with the World Bank's strategies to bolster agricultural resilience and profitability by improving farmers' access to information. Such technological advancements support sustainable farming by facilitating better resource management and market engagement.

15. Buffer Strips in Riparian Zones

Buffer strips in Riparian zones (Riparian buffers) play a critical role in maintaining ecosystem health within agricultural landscapes. These vegetative barriers, strategically placed along watercourses, serve multiple environmental functions (Figure 9). Specifically, they filter out pollutants such as pesticides and nutrients from agricultural runoff before they enter water bodies, thereby significantly reducing the risk of water pollution and eutrophication. Additionally, they help control soil erosion by stabilizing riverbanks and reducing the velocity of surface runoff (Alemu et al. 2017).

The ecological benefits of Riparian buffers extend beyond water quality protection; they also enhance biodiversity by providing habitat for both aquatic and terrestrial organisms.

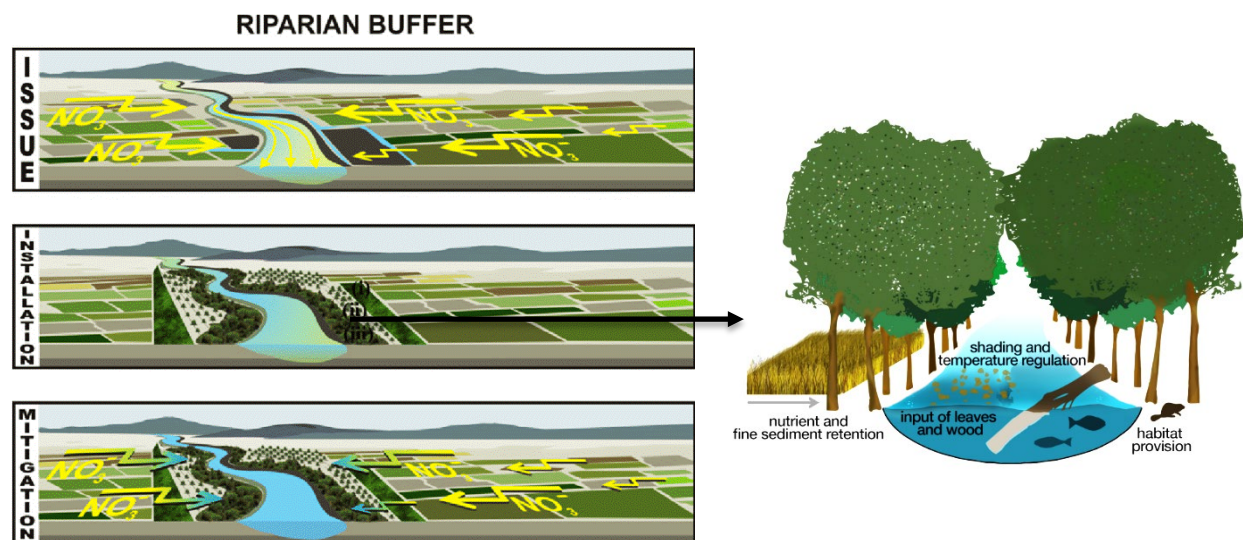


Figure 9. Riparian Buffer installation ^{9,10}.

Establishing these green zones is a practice endorsed by the World Bank as part of sustainable agricultural and environmental management strategies. Such practices not only contribute to the

⁹ https://www.researchgate.net/figure/Riparian-buffer-Issue-Agricultural-N-derived-from-fertilizer-applications-flows-toward_fig7_233770228

¹⁰ <http://www.freshwaterplatform.eu/index.php/oscar-tools.html>

long-term viability of agricultural operations but also support broader environmental conservation efforts.

16. Community Seed Banks

Community seed banks are vital informal institutions for agricultural resilience and biodiversity conservation, locally governed and managed, whose core function is to preserve seeds for local use. By preserving a wide array of seed varieties (as shown in Figure 10), including those that are indigenous or have been specifically bred for local conditions, these banks ensure that farmers have access to seeds that are resilient to local climate challenges, diseases, and pests. This is particularly important in areas prone to climatic stresses where commercially available seeds may not perform well.

These seed banks empower communities by providing them control over their genetic resources and supporting food security by enabling access to seeds that can thrive in local conditions. This practice aligns with the World Bank's initiatives aimed at promoting agricultural diversity and sustainability. By facilitating local adaptation and innovation in farming practices, community seed banks play a crucial role in enhancing food security, preserving local agricultural heritage, and fostering community resilience against environmental and economic fluctuations (De Falcis et al. 2022).



Figure 10. Sharing seed diversity in a Community Seed Bank.¹¹

¹¹ <https://grpi2.wordpress.com/2016/03/31/official-opening-and-handing-over-of-the-gumbu-community-seed-bank-south-africa/>

17. Rotational Grazing

Rotational grazing is a strategic approach to pasture management where livestock is moved between different fields or paddocks, allowing vegetation in previously grazed areas to recover and regrow. This technique not only optimizes the use of pastureland but also improves soil health through natural fertilization from animal waste. Over time, rotational grazing can lead to enhanced soil structure, increased organic matter, and improved water infiltration, significantly reducing erosion and runoff. Additionally, by encouraging deeper root systems and increasing plant density, this method effectively sequesters more carbon in the soil, contributing to climate change mitigation (Jiménez, García, and Aguilar 2024).

The practice supports sustainable livestock management by maintaining high-quality forage over time, which can lead to better livestock health and productivity. Rotational grazing aligns with the World Bank's strategies to improve land use efficiency and environmental sustainability in livestock management, making it an essential practice for ecologically responsible farming.

18. Crop Insurance Programs

Crop insurance programs play a critical role in risk management for agriculture, providing farmers with financial protection against losses due to climate-related events such as droughts, floods, or pest outbreaks. By mitigating the financial risks associated with unpredictable environmental conditions, these insurance schemes encourage farmers to invest in more sustainable practices. They enable farmers to maintain stability in their operations despite climatic uncertainties, thereby supporting consistent agricultural productivity (Colovic and Mrvic-Petrovic 2014).

Such programs are integral to the World Bank's efforts to promote sustainable agricultural development and resilience. By reducing the economic vulnerability of farmers to climate shocks, crop insurance programs secure individual farmer livelihoods and bolster the overall stability of the agricultural sector.

19. Permaculture Design

Permaculture design is a holistic approach to agriculture that emphasizes the creation of sustainable and self-sufficient food systems. It integrates ecological principles and sustainable practices, such as companion planting, water harvesting, and natural pest management, to develop agricultural ecosystems that mimic natural processes. Permaculture designs aim to maximize functional relationships between plant and animal species to create synergistic interactions that support the health and productivity of the entire system.

This approach reduces the need for external inputs such as chemical fertilizers and pesticides, enhances soil fertility, and increases biodiversity within the farming system (Krebs and Bach 2018). By promoting more sustainable land use, permaculture aligns with the World Bank's

strategies for environmental sustainability and supports the development of agricultural systems that are both economically viable and ecologically sound.

20. Vertical Farming

Vertical farming is an innovative agricultural practice that does not require soil and therefore utilizes vertically stacked layers to grow crops in controlled environments, such as greenhouses or specially constructed buildings (Figure 11). This method significantly reduces the land area required for crop production and minimizes water usage through recirculating systems. Vertical farming also reduces the need for pesticides and herbicides due to the controlled environment, which is less prone to pests and diseases.

By bringing production closer to urban consumers, vertical farming minimizes transportation costs and emissions, contributing to reduced food miles and fresher produce in urban markets (Naqvi et al. 2022). Supported by World Bank initiatives that favor sustainable urban development, vertical farming offers a forward-thinking solution to the challenges of urban food security and sustainable agriculture.



Figure 11. Vertical Farming.¹²

¹² <https://www.edengreen.com/blog-collection/how-hydroponics-can-save-our-food-system>

Each of these climate-smart agricultural practices integrates economic, environmental, and social sustainability to enhance the resilience and productivity of Kenya's agricultural sector, as well as to minimize greenhouse emissions. By adopting these practices, Kenya can better adapt to ongoing climatic changes, ensuring food security and economic stability for its growing population. These strategies reflect the strategic directions recommended by the World Bank, aiming to create a sustainable and resilient agricultural future.

4. Agripreneurship practices

In the context of Kenya's dynamic agricultural sector, fostering agripreneurship is crucial for economic development and sustainability. This extensive exploration details 20 agripreneurship practices aligned with the FAO guidelines, which emphasize three critical areas: A. Business and Markets, B. Governance and C. Empowerment, and Knowledge and Technology. Each practice is crafted to address the unique challenges and opportunities within Kenya's agricultural framework, providing a comprehensive approach to enhancing agripreneurial ventures.

A. Business and Markets

1. Mobile Market Platforms

The development of mobile market platforms revolutionizes the agricultural supply chain by creating direct linkages between farmers and end-users, effectively eliminating many of the traditional middlemen who diminish farmers' profits. These e-Marketing platforms are available free of cost, can be accessed from anywhere, and are presented in language that is easily understandable to farmers. They leverage technology to provide real-time data on pricing, demand fluctuations, and consumer preferences. This dynamic flow of information enables farmers to respond swiftly to market changes, adjust production plans accordingly, and optimize their sales strategies to maximize revenue. Moreover, these platforms often incorporate features that enhance visibility and traceability of agricultural products, thereby increasing consumer trust and opening up new market opportunities. The direct connection not only improves profitability for farmers but also ensures that consumers have access to fresh and traceable produce, aligning with the FAO's goals to improve market access and profitability through innovative, market-oriented approaches.

2. Agri-Input Credit Facilities

Agri-input credit facilities address one of the primary challenges faced by farmers: the availability of capital for upfront agricultural investments. By offering credit for essential inputs like seeds, fertilizers, and farming equipment, these facilities allow farmers to defer payments until after the harvest, significantly reducing the initial financial barrier to entry. This access to necessary resources without immediate financial strain enables farmers to invest in high-quality inputs, which are crucial for improving both yield and crop quality. Enhanced productivity directly translates into higher income and more stable financial conditions for the farmers, which is vital for their economic resilience.

Moreover, these credit facilities are often structured with flexible repayment terms tailored to agricultural cycles, which further eases the financial pressure on farmers and aligns with their

seasonal cash flows. By boosting resource utilization and operational efficiency, these financial solutions foster long-term sustainability within the agricultural sector. This strategic financial support not only helps individual farmers maintain consistent production levels but also contributes to broader economic stability and growth, perfectly embodying the FAO's emphasis on innovative financial mechanisms that enhance the overall sustainability and resilience of the agricultural sector (Ekwere and Edem 2014; Nzomo and Muturi 2014).

3. Value Added Centers

Value Added Centers are pivotal facilities that transform raw agricultural products into processed and refined goods, thereby greatly enhancing their market value and broadening their consumer appeal (Holcomb and Johnson 2007). These centers function by employing various processing techniques such as drying, canning, juicing, and packaging, which not only extend the product's shelf life but also increase its usability and convenience for consumers.

The transition of raw materials, such as fruits transformed into jams or grains processed into flour, adds significant value by improving both the quality and diversity of available agricultural products. This increase in value is crucial as it allows farmers and producers to command higher prices in the market, thus directly boosting their income and economic stability.

Moreover, these centers are instrumental in creating job opportunities in rural areas, involving roles in handling, processing, quality control, and logistics. This employment generation is vital for community development and reduces the rural-urban migration by providing sustainable livelihoods within agricultural regions.

Value Added Centers also play a critical role in reducing post-harvest losses, a major issue in agricultural supply chains, particularly in developing countries. By processing perishable goods promptly and efficiently, these centers help preserve the abundance of harvests that might otherwise be lost to spoilage, thereby ensuring more food makes it to market and contributing to overall food security.

This initiative aligns seamlessly with the FAO's objectives to strengthen the agricultural value chain and enhance local economies. By boosting the development of higher-value products, Value Added Centers encourage a more robust, diversified agricultural sector capable of contributing to sustainable economic growth and development. They also support the move towards more sustainable consumption patterns by providing products that meet the needs of a modern consumer base, further integrating agricultural communities into broader economic systems.

4. Contract Farming Initiatives

Contract farming initiatives are strategic agreements that connect farmers directly with agribusiness firms, retailers, or processors, providing a secure market for their produce. These agreements typically specify the quantity and quality of products required, with pre-agreed pricing

structures, thus providing farmers with a stable, predictable income. This stability is crucial for smallholder farmers who otherwise face volatile markets where prices can fluctuate dramatically due to various external factors. By stabilizing income, these contracts enable farmers to plan better, invest in quality inputs, and adopt new technologies, leading to improvements in product quality and yield.

Furthermore, contract farming often involves technical support from the contracting company, which can include the provision of high-quality seeds, fertilizers, and training on best practices. This support helps ensure that the produce meets the quality standards required by the market, enhancing the overall value chain's efficiency. By linking small-scale farmers directly to markets, contract farming reduces intermediaries, increasing the farmers' share of the final product price (Arouna, Michler, and Lokossou 2021).

In Sub-Saharan Africa, many smallholders have entered contract farming for crops that are primarily grown for commercial purposes such as sugarcane (Machimu 2024).

This approach is fully aligned with the FAO's advocacy for creating sustainable market linkages and business cases that offer mutual benefits. Contract farming not only secures financial benefits for both farmers and companies but also promotes sustainable agricultural practices by encouraging adherence to agreed standards and practices that might include environmentally sustainable methods.

5. Agripreneurship Incubation Programs

Agripreneurship Incubation Programs are critical in fostering the growth and development of new and innovative agricultural enterprises. These programs provide a supportive environment that offers young businesses access to essential resources, including mentorship from experienced professionals, technical training, networking opportunities, and often, crucial financial support in the form of grants or seed capital.

The mentorship component focuses on bridging knowledge gaps that many new agripreneurs might face, covering areas such as market analysis, business strategy development, management practices, and compliance with regulatory requirements. This guidance is invaluable as it helps new businesses avoid common pitfalls and accelerates their journey from concept to market.

Technical training sessions offered as part of incubation programs are tailored to the specific needs of agricultural enterprises, focusing on areas such as innovative farming techniques, sustainable resource management, and the integration of technology in agriculture. These training programs are designed to enhance the technical skills of agripreneurs, enabling them to implement efficient, modern agricultural practices that can lead to higher productivity and sustainability.

Additionally, these incubators facilitate networking by connecting new businesses with potential partners, suppliers, and even customers. They also offer platforms for agripreneurs to engage

with investors and other stakeholders who can provide the capital and support needed to scale their operations (Abdul Raman et al. 2014).

Aligned with the FAO's strategic goals, these incubation programs enhance entrepreneurial skills and foster business development in agriculture. They play a pivotal role in developing the agricultural sector by supporting innovation and entrepreneurship, which are crucial for addressing food security challenges and promoting sustainability in agriculture. Through these programs, agripreneurs are equipped to contribute effectively to their local economies and the global agricultural landscape.

B. Governance and Empowerment

6. Farmer Cooperatives

Farmer cooperatives are essential organizations that unify small-scale farmers, allowing them to pool resources, share risks, and enhance their collective negotiating power with buyers, suppliers, and financial institutions. By joining a cooperative, farmers can achieve economies of scale, thereby reducing the costs of inputs through bulk purchasing and accessing higher-value markets which might otherwise be out of reach for individual smallholders. This collective approach empowers farmers to influence pricing more effectively and secure fairer deals, which can significantly increase their profitability.

Cooperatives also serve as an effective platform for knowledge exchange and innovation dissemination among members. They organize training sessions and workshops that equip farmers with modern agricultural practices and technologies. This communal learning environment fosters a more educated and technologically adept farming community, which is crucial for improving agricultural productivity and sustainability.

Moreover, cooperatives can advocate for farmers' interests, representing their needs and concerns in policy discussions and regulatory frameworks. This collective voice is much stronger and more likely to be heard than those of individual farmers, facilitating more farmer-friendly policies and practices (Grashuis and Ye 2019).

Such cooperatives are in line with the FAO's guidelines that emphasize the importance of coordination platforms and collective action, aiming to strengthen governance structures in rural areas and enhance the overall resilience and economic stability of agricultural communities.

7. Women in Agribusiness Programs

Women in Agribusiness Programs are targeted initiatives designed to empower female entrepreneurs and farmers in the agricultural sector. In sub-Saharan Africa, women contribute significantly to agriculture, accounting for an estimated 40% of the agricultural labor force. Despite their essential role, women often find themselves marginalized from decision-making processes

and have restricted access to productive resources. They are predominantly employed in lower-paying or unpaid roles within the sector (Kadzamira et al. 2024).

These programs recognize the critical role that women play in agriculture and rural economies and aim to address the significant barriers they face, such as limited access to land, capital, training, and markets. By providing women with specialized resources and support, these programs help level the playing field and allow women to fully participate in and benefit from agricultural and business opportunities.

These initiatives often include access to microfinance and credit facilities tailored to women's needs, training in agricultural techniques, business management, and leadership skills. Such comprehensive support not only boosts women's confidence and competence but also their visibility and influence within the agricultural sector.

Furthermore, empowering women in agriculture has been shown to have a multiplier effect, enhancing not only their families' well-being but also contributing to broader community development and poverty reduction. Women typically invest a higher proportion of their earnings in their families and communities compared to men, leading to better health, education, and nutrition outcomes for future generations.

Programs that focus on women's empowerment in agribusiness support the FAO's goals for gender equity and empowerment in rural development. They aim to create more inclusive economic growth by ensuring that women have equal opportunities to contribute to and benefit from the agricultural sector.

8. Youth Agricultural Education and Training

Young people are vital to African agriculture, constituting a significant portion of the region's overall population and, by extension, its agricultural labor force. However, like women, they often find themselves marginalized from decision-making processes and have limited access to productive resources. Additionally, they are typically employed in low-paying or unpaid roles within the sector (Kadzamira et al. 2024).

Youth Agricultural Education and Training programs are pivotal in fostering a new generation of agriculturists who are equipped with the skills and knowledge necessary to drive the future of farming. These programs focus on blending traditional agricultural practices with modern techniques and technologies, such as precision agriculture, sustainable farming practices, and agribusiness management. By exposing young people to innovative agricultural methods and the potential for entrepreneurship within the sector, these programs aim to shift the perception of agriculture from a traditional subsistence activity to a modern, technologically advanced, and profitable career choice.

Moreover, integrating practical training with academic learning helps bridge the gap between theory and practice, providing youth with hands-on experience that prepares them for real-world challenges. These initiatives often include internships, apprenticeships, and mentorship

opportunities with successful agribusinesses, enhancing job readiness and entrepreneurial skills (Mkandawire et al. 2023).

Supporting youth in agriculture is critical not only for replacing an aging farmer population but also for injecting innovation, energy, and new ideas into the agricultural sector. This approach is in direct alignment with the FAO's strategy to promote growth through education and skill integration, ensuring that the agricultural workforce is capable, adaptable, and forward-thinking.

9. Policy Advocacy Groups

Policy Advocacy Groups play a crucial role in shaping a conducive agricultural policy environment. These groups consist of stakeholders from various facets of the agriculture sector, including farmers, agripreneurs, academics, and NGOs. They work collectively to lobby for policies that support sustainable agricultural practices, fair trade, access to markets, and the protection of farmer rights. By advocating for legislation and regulations that reflect the real needs and challenges of the agricultural community, these groups help ensure that policies are not only practical but also beneficial to those directly impacted.

Effective advocacy involves rigorous research to build evidence-based arguments, strategic communication with policymakers, and ongoing engagement with agricultural communities to ensure that their voices are heard. This proactive involvement in policy-making helps to safeguard the interests of agripreneurs and farmers, promoting an environment that fosters growth, sustainability, and innovation within the sector, consistent with the FAO's emphasis on effective governance and supportive policy frameworks (Gen and Wright 2013).

10. Community Leadership Development

Community Leadership Development initiatives are designed to empower individuals within rural and agricultural communities to take on leadership roles. By developing local leaders, these programs aim to foster community-driven management and innovation in agriculture. Leaders are equipped with skills in project management, conflict resolution, resource allocation, and strategic planning, enabling them to effectively guide their communities through development projects and local challenges (Kirk and Shutte 2004).

These leaders act as catalysts for change, driving agricultural innovations and community development projects that can have far-reaching impacts on local food security, economic stability, and sustainability. Training local leaders also promotes a greater sense of ownership and accountability, ensuring that development initiatives are more tailored to the specific needs and circumstances of the community.

Developing strong local leadership is essential for the sustainable management of agricultural and natural resources. It supports the creation of governance structures that are more participatory, inclusive, and effective, directly aligning with FAO guidelines that emphasize local

empowerment and the building of management capabilities within communities. This grassroots approach not only enhances the immediate agricultural outputs and outcomes but also builds a foundation for long-term resilience and growth.

C. Knowledge and Technology

11. Technology Transfer Partnerships

Technology Transfer Partnerships play a vital part in bridging the gap between scientific research and practical agricultural applications. These partnerships typically involve collaborations between research institutions, universities, technology companies, and farming communities. By transferring cutting-edge research and innovations directly to the field, these partnerships enable the practical implementation of scientific breakthroughs, enhancing agricultural productivity and sustainability.

These collaborations often focus on developing and refining technologies that are specifically tailored to local agricultural conditions and challenges, ensuring that innovations are not only technologically advanced but also contextually relevant and user-friendly. Additionally, these partnerships may provide training and support to farmers, helping them to adopt and effectively utilize new technologies.

This direct application of research to everyday farming practices is fundamental to improving crop yields, managing pests and diseases more effectively, and reducing environmental impacts. Aligning with the FAO's strategy, Technology Transfer Partnerships enhance the capacity of the agricultural sector to innovate and adapt, fostering sustainable growth and resilience.

12. Precision Agriculture Technologies

Precision Agriculture Technologies encompass a range of tools and systems designed to make farming more accurate and controlled. Technologies such as GPS guidance, drones, IoT sensors, and computer models are used to monitor and optimize the agricultural processes, from planting to harvesting. These technologies allow for precise mapping of field variability, enabling farmers to apply the exact amount of water, fertilizers, and pesticides needed at different locations across their fields, thereby minimizing waste and enhancing crop yields.

The adoption of these advanced technologies leads to more efficient use of land and water resources, significantly reducing the ecological footprint of farming operations. By optimizing input usage, precision agriculture helps in conserving natural resources and reducing costs, which directly supports the FAO's focus on sustainable technological integration in agriculture. This approach not only boosts productivity and profitability but also contributes to environmental sustainability and the fight against climate change (Vinodhini S. M 2024).

13. Digital Agriculture Strategies

Digital Agriculture Strategies involve the integration of information and communication technology (ICT) into all aspects of agricultural operations and supply chains. These strategies leverage digital tools to enhance data collection and analysis, improve communication and information sharing, and streamline agricultural operations from production to distribution.

By employing technologies such as mobile apps, online platforms, and cloud-based solutions, e-agriculture strategies enhance farmers' access to critical information, including market prices, weather forecasts, and agricultural best practices. This improved access to information helps farmers make informed decisions, better manage risks, and increase their competitiveness in the market.

Furthermore, digital strategies facilitate the connection between farmers and various stakeholders, including buyers, suppliers, and financial institutions, making the agricultural value chain more efficient and transparent. This embodies the FAO's directive to incorporate ICT into agriculture, aiming to enhance operational efficiency, improve access to markets, and strengthen connectivity within the agricultural sector.

By integrating these technologies and strategies, the agricultural sector can achieve significant improvements in efficiency, productivity, and sustainability, directly contributing to the FAO's goals and the broader agenda of transforming agriculture into a more modern, efficient, and sustainable industry.

14. Climate Smart Agricultural Practices

Climate Smart Agricultural Practices encompass a broad range of techniques and strategies designed to increase sustainability, enhance resilience, and reduce the environmental impact of agricultural practices. This training includes methods such as water management techniques to conserve water resources, organic farming to decrease dependency on chemical inputs, crop rotation to improve soil health, and the integration of crop and livestock production systems to maximize resource efficiency (Tabe-Ojong, Kedinga, and Gebrekidan 2024).

By focusing on sustainable practices, this approach addresses the pressing issues of climate change by reducing agricultural carbon footprints and enhancing the capacity of farms to adapt to changing climatic conditions. Training and implementation of these practices are crucial for not only mitigating the effects of climate change but also for ensuring food security in increasingly variable weather conditions. This aligns closely with the FAO's objectives for promoting environmental stewardship and building climate resilience, aiming to transform agricultural systems into sustainable platforms capable of supporting global food demands in a changing world.

15. Online Agribusiness Courses

Online Agribusiness Courses are transforming agricultural education by providing widespread and affordable access to cutting-edge knowledge and best practices. These courses cover a diverse array of subjects from agroecology and sustainable farming practices to agribusiness management and market analytics. By leveraging digital platforms, these courses offer flexible learning opportunities that can reach a broad audience including farmers in remote locations, agricultural professionals, and students globally.

The scalability and accessibility of online learning support the FAO's goal of disseminating agricultural knowledge widely, breaking down traditional barriers to education such as geographic isolation or financial constraints. This democratization of knowledge is essential for empowering farmers and agribusiness professionals to make informed decisions, innovate, and adapt to market and environmental changes efficiently.

16. Agri-Tech Startup Challenges

Agri-Tech Startup Challenges stimulate innovation in the agricultural sector by providing a platform for entrepreneurs to showcase and develop their technological solutions. These challenges often involve tasks that require participants to address specific agricultural issues with innovative approaches, potentially leading to breakthrough technologies in areas like precision farming, sustainable resource management, or supply chain efficiency.

These competitions not only offer financial incentives and exposure but also provide mentorship and support from industry leaders, which can be critical for transforming a nascent idea into a commercial product. Encouraging such innovation aligns perfectly with the FAO's guidelines to foster a culture of innovation and practical problem-solving within agriculture, positioning these challenges as catalysts for advancing agricultural technology and sustainability.

17. Farmers' Access to Real-time Data

Providing farmers with access to real-time data on weather, soil conditions, crop health, and market prices empowers them to make more informed and timely decisions about their agricultural practices. This access is facilitated through advanced technologies like IoT devices, satellite imagery, and mobile apps, which can deliver critical information directly to farmers' smartphones or computers.

This capability enhances a farmer's ability to react swiftly to weather changes, optimize resource use, and improve yield outcomes, which is essential for increasing both productivity and sustainability in farming operations. Real-time data access supports the FAO's initiative for data-driven agriculture by promoting more precise and efficient farming practices, enhancing overall agricultural productivity and sustainability. This strategic use of data not only supports individual

farm management but also contributes to broader goals of food security and economic stability in the agricultural sector.

18. Sustainable Packaging Solutions

Adopting sustainable packaging solutions is essential for minimizing the environmental footprint of the agricultural supply chain. This initiative involves the integration of eco-friendly materials and technologies in packaging agricultural products. By moving away from conventional plastic-based packaging to alternatives made from biodegradable, recycled, or renewable materials, these solutions help reduce waste and pollution. Moreover, sustainable packaging technologies often include innovations that extend the shelf-life of products, such as advanced sealing techniques and atmospherically adaptive materials, which further decrease food waste along the supply chain.

This shift not only meets the growing consumer demand for environmentally responsible products but also aligns with the FAO's advocacy for sustainable practices throughout the agricultural sector. By implementing sustainable packaging, businesses can enhance their brand image and marketability while contributing to global efforts to combat plastic pollution and reduce resource depletion. These practices are crucial for maintaining ecosystem health and ensuring that agricultural practices remain sustainable well into the future.

19. Aquaponics

Aquaponics, combining aquaculture and hydroponics, offers a sustainable agripreneurship opportunity in Kenya. This system utilizes fish waste as a nutrient source for plants, which in return purify the water, creating an efficient symbiotic environment. Ideal for urban and resource-limited areas, aquaponics is water-efficient and produces high-quality protein and vegetables (Okomoda et al. 2023).

The aquaponics model is economically viable with low overhead costs post-setup and scalable from small to large operations. Its efficiency in water and fertilizer usage makes it attractive to investors, meeting the increasing demand for organic, sustainably farmed produce. The system not only enhances the value chain by integrating fish and plant farming but also allows entrepreneurs to directly access consumer and retail markets, increasing profitability.

This multidisciplinary approach requires continuous learning and adaptation, fostering innovation and leadership in agricultural technology. Practitioners must stay abreast of advancements such as water filtration and energy-efficient pumps to remain competitive.

Implementing aquaponics in Kenya provides a novel way to address farming challenges, offering economic benefits and alignment with sustainable development goals. It supports a shift towards more sustainable agriculture, in line with FAO's agripreneurship guidelines.

20. Blockchain for Traceability

Blockchain technology offers a transformative approach to enhancing traceability in the agricultural supply chain. By enabling a secure, transparent, and immutable record of all transactions associated with a product, blockchain technology increases the transparency of the agricultural supply chain from farm to table. This level of traceability is crucial for ensuring food safety, as it allows for rapid response in the event of a food contamination issue and helps verify claims made about organic or sustainably sourced products (Gozali et al. 2024).

Furthermore, blockchain can play a significant role in enhancing the fairness of the supply chain by providing undeniable proof of the origin and journey of agricultural products, which can help ensure that farmers are fairly compensated for their produce. This increased transparency and security align with the FAO's objectives for secure, sustainable, and equitable food systems. By adopting blockchain technology, the agricultural sector can move towards a more transparent, efficient, and trustworthy system that enhances consumer confidence and supports sustainable growth.

By embracing these comprehensive agripreneurship practices, Kenya is set to significantly strengthen its agricultural sector. Each practice not only complies with but also actively contributes to the FAO's strategic guidelines, focusing on establishing a sustainable, profitable, and equitable agricultural environment. Through the implementation of these initiatives, stakeholders in Kenya's agricultural sector can build a resilient and inclusive economy, better equipped to handle future challenges and capitalize on emerging opportunities. This proactive approach to adopting modern agribusiness practices ensures that Kenya not only meets its national food security and economic stability goals but also enhances its standing in the global agricultural landscape.

5. Conclusions

The extensive research and analysis detailed in this report illuminate a path forward for Kenya's agricultural sector amidst climatic adversities and socio-economic complexities. The investigation of 20 climate-smart agricultural practices and the exploration of agripreneurship strategies reveal a landscape brimming with potential for innovation, resilience, and sustainability.

Kenya stands at a crossroads where embracing these transformative practices is not merely an option but a necessity for ensuring the future viability of its agriculture. The dual approach of integrating Climate-Smart Agriculture (CSA) and fostering agripreneurship creates a synergistic effect, enhancing the sector's resilience while promoting economic growth and sustainability. Through meticulous research, this report has highlighted practices that uniquely suit Kenya's diverse ecological and socio-economic conditions, providing a roadmap for stakeholders to follow.

Furthermore, the recommendations offered are aimed at catalyzing action among all stakeholders, including government bodies, NGOs, and the private sector, to adopt and scale these innovative practices. This strategic alignment is designed to fortify Kenya's agricultural sector against the impending threats of climate variability and to exploit the full potential of modern technologies and sustainable methodologies.

In conclusion, this report not only presents a vision for a transformed Kenyan agricultural landscape but also lays down actionable strategies that can steer the country towards greater economic stability and improved national food security. The successful implementation of these strategies promises not only to mitigate the impacts of environmental challenges but also to elevate Kenya to new heights of agricultural productivity and sustainability. It is imperative that all stakeholders collaborate and commit to the recommendations put forth to ensure a prosperous and resilient agricultural future for Kenya.

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AGRICULTURAL BEST PRACTICES REPORTS

Somalia report

Table of Contents

1. Introduction.....	3
2. Objectives.....	3
3. Somalia's Climatic Zones.....	4
4. Agricultural Practices in Somalia.....	4
5. Socio-Economic Role of Agriculture in Somalia.....	5
6. Climate-Smart Agricultural (CSA)	6
7. Agripreneurship practices.....	13
8. Conclusions.....	20
9. Bibliography.....	21

Introduction

Somalia's agricultural sector faces challenges such as poor infrastructure, environmental degradation and climate change, affecting agricultural production and food security. To overcome these obstacles and harness the potential of the agricultural sector, it is crucial to adopt climate-smart and innovative agricultural practices. These modern practices could help increase productivity, diversify income sources and promote sustainability in Somali agriculture. Next, we will explore climate smart practices that could support the sustainable development of the agricultural sector and its contribution to economic growth and the well-being of rural communities in the country.

Somalia's agricultural sector plays a vital role in the country's economy, employing over two-thirds of the workforce and contributing over 60% to national productivity. However, challenges such as limited access to quality inputs, inadequate irrigation infrastructure, land tenure issues and the impact of climate change affect the agricultural sector. More than half of Somalia's population lives in rural areas, with a significant portion earning their living from nomadic pastoralism and agriculture. The fisheries sub-sector also has untapped potential due to piracy in coastal areas. To address these challenges and capitalize on growth opportunities, it is crucial to strengthen flood control and irrigation infrastructure, improve seed quality and pest management practices, clarify land tenure issues, and support growth fisheries sub-sector through sustainable management and capacity building for fishermen. By investing in infrastructure such as cold chains, processing facilities and transport links, the agricultural sector can become more efficient and competitive. By implementing training programs, certification, mentoring, public-private partnerships, diversified financing, corporate social responsibility, agricultural tourism, research and innovation, as well as regional cooperation, Somalia can rebuild a resilient and sustainable agricultural sector, contributing to economic development, reducing poverty and improving food security in the country.

Objectives

Proposed objectives for the development of Somalia's agricultural sector include increasing agricultural productivity by promoting climate-smart agricultural practices, improving irrigation systems and efficient management of water resources. It is also aimed at developing the infrastructure for storing and processing agricultural products, creating training and certification programs for agricultural entrepreneurs in international standards, implementing mentoring and coaching programs, promoting the diversification of funding sources, supporting research and innovation, promoting tourism agricultural and agritourism, the implementation of corporate social responsibility programs, the creation of training centers and agricultural incubators, as well as the promotion of regional cooperation and the exchange of agricultural goods and services between states. These objectives are intended to help rebuild a resilient and sustainable agricultural sector in Somalia, supporting economic development, poverty reduction and improving food security in the country.

Somalia's Climatic Zones

In Somalia, the climate varies from arid and semi-arid in the northern and western regions to humid tropical in the southwest of the country. Here is a brief description of the climate characteristics of different regions in Somalia:

Northern and northeastern regions: These areas are characterized by an arid and semi-arid climate with little vegetation and low rainfall. Temperatures can be extremely hot and drought is a common problem. Regions such as Somaliland and Puntland are found here.

Central and Southeast Region: In these regions, the climate is predominantly arid and semi-arid, but there are some areas with a more humid climate due to the influence of monsoons. Drought is still a major problem and rainfall is patchy. The cities of Mogadishu and Baidoa are located here.

Southwest and South: These areas benefit from a humid tropical climate with regular rainfall and a well-defined monsoon season. Rainfall is heaviest during the monsoon season, which usually lasts between April and October. Temperatures are more moderate compared to the northern and eastern regions of the country.

Somalia's climate is influenced by factors such as geographical position, topography of the land and the influence of monsoons. Rainfall is variable and uneven in time and space, making drought a recurring problem in many areas of the country. Water and natural resource management is a major challenge in Somalia due to the arid and semi-arid climate and ongoing climate change

Agricultural Practices in Somalia

Agriculture in Somalia is heavily influenced by the country's arid and semi-arid climate, but remains one of the main pillars of the economy and livelihood of many Somalis. Traditional agricultural practices such as pastoralism and subsistence farming are widespread throughout the country. Staple crops include hops, millet and drought-resistant vegetables. In more fertile regions such as southern and central Somalia, oasis agriculture and traditional irrigation systems support the intensive cultivation of rice, fruits and vegetables. However, frequent drought and political instability pose major threats to agriculture. Somalia often relies on foreign aid to meet its food needs, and sustainable agricultural development could play a crucial role in combating poverty and food insecurity in the country.

Socio-Economic Role of Agriculture in Somalia

The socio-economic role of agriculture in Somalia is essential to the development and stability of the country. Agriculture is the main source of livelihood for many Somalis and is a vital activity for rural and semi-rural communities. It generates jobs and contributes to the reduction of unemployment, having a significant impact on the gross domestic product through the production and marketing of agricultural products. Agricultural exports such as bananas are important for generating foreign trade income. Agriculture contributes to the stability of communities and ensuring the food security of the population, having a crucial role in adapting to climate change and protecting natural resources. Overall, the promotion and development of the agricultural sector could bring significant benefits to the economy and quality of life in Somalia.

Agriculture in Somalia is essential to the survival and well-being of many communities, providing food, jobs and a stable economic foundation. In a country where resources are often limited, agriculture plays a vital role in ensuring food security and livelihoods of the population. It is also a central component of Somali culture and identity, with many agricultural practices reflecting ancient traditions and cultural values passed down from generation to generation.

Despite limited natural resources and difficult climatic conditions, such as frequent drought and erratic rains, many Somali farmers maintain their traditions and rely on traditional farming techniques to feed their families and earn a living. However, there is an increased need to modernize and improve agricultural practices to increase productivity, reduce vulnerability to climate change and boost economic development across the country.

In addition, agriculture can play an important role in promoting peace and reconciliation in Somalia by providing opportunities for collaboration and dialogue between different communities and ethnic groups. By investing in agricultural infrastructure, training and access to markets, Somalia could harness its agricultural resources for the benefit of all its citizens and help stabilize and rebuild the country after decades of conflict and instability.

Climate-Smart Agricultural (CSA) Practices

1. Irrigation System

Strengthening flood control and irrigation infrastructure in Somalia is crucial for effective water resource management and increasing crop yields. This initiative can significantly contribute to increasing food security and economic stability in the country. By building and upgrading irrigation and flood prevention systems, access to water to irrigate crops during droughts and prevent flood damage can be ensured. Thus, Somalia can benefit from a more productive and sustainable agriculture, contributing to improving the living conditions of the population

- Increased productivity: Through rational irrigation, favorable conditions are created for the growth and development of plants, ensuring better and stable harvests of agricultural crops, independent of the amount of atmospheric precipitation. Rivers, lakes, groundwater and other natural water sources can be used as irrigation water sources.
- Increased resilience: Using irrigation systems, the water will only be directed to the ground where the plants are located. This way the body of the plants will not be watered and neither will the soil between the plants. Therefore, pests, diseases and weeds will not spread so easily. From this point of view, you will also achieve an economy in terms of chemicals for the treatment of crops.
- Reduced emissions: Using irrigation canals to reduce emissions is an innovative and sustainable approach to managing water resources and environmental impacts in Somalia. By implementing efficient irrigation and water management technologies, the amount of water lost through evaporation or runoff can be reduced, resulting in a more efficient use of water resources and a reduction in the need for water pumping. This can lead to a reduction in the energy consumption associated with irrigation, which often involves the use of fossil fuels and, by implication, greenhouse gas emissions. Therefore, using irrigation canals to manage water sustainably can help reduce environmental impacts and combat climate change in Somalia.

2. Rainwater Harvesting and Storage

Use techniques like roof water harvesting and small-scale dams to capture rainwater for irrigation. Rainwater harvesting and storage technologies offer practical solutions to enhance water availability for irrigation and agricultural activities in water-stressed regions like Kenya

and Somalia. By promoting these techniques through education, capacity building, and policy support, governments, NGOs, and local communities can improve water security, food production, and livelihoods while building resilience to climate variability and droughts. Collaboration and investment in rainwater harvesting infrastructure are essential for sustainable water management and agricultural development in dryland areas.

3. Improving seed quality and pest management practices is a crucial step in boosting productivity in Somali agriculture. By promoting the use of high-quality seeds and modern pest management technologies, farmers can achieve higher and higher-quality yields. High-quality seeds have the potential to increase crop yields and enhance plant resistance to adverse conditions such as drought or disease. At the same time, effective pest management practices can reduce crop losses due to pest invasions and minimize the use of pesticides harmful to the environment and human health. Ultimately, these efforts can contribute to the development of a more sustainable and resilient agriculture in Somalia that ensures food security and economic prosperity for farming communities.

4. Pest control using pheromone traps

- Increased productivity: The use of pheromone traps in agriculture increases productivity by attracting and selectively capturing pests, effectively monitoring the evolution of their populations in real time and, consequently, by adopting precise and targeted measures in their management, thus reducing the need for extensive use of pesticides and minimizing the negative impact on the environment and human health.
- Increased resilience: It reduces the negative impact on ecosystems and reduces the risk of soil and water contamination. Using these signals, traps attract insects to an environment where they can be collected and removed without using toxic pesticides. The use of pheromone traps eliminates the need to use chemical pesticides dangerous to the environment and human health.
- Reduced emissions: Pheromone traps provide specific protection, do not pollute the environment and allow precise monitoring of pest populations, unlike chemical pesticides that can have adverse effects on human health and the environment.

5. Seed certification

The development and implementation of seed certification programs in Somalia is a crucial initiative to ensure compliance with international standards and to increase farmers confidence in the quality of the seeds they purchase. These programs could include:

- Create an appropriate legal and institutional framework for seed regulation and certification, with the involvement of relevant government authorities and relevant agricultural organisations.
- Development of clear criteria and standards for seed quality and identity, including physical, genetic and phytosanitary parameters.
- Implementation of an assessment and accreditation system for seed producers and processors, which includes periodic inspections and laboratory tests to verify compliance with established standards.
- Establishing a mechanism to issue certificates of conformity for seeds that meet the established standards and are considered suitable for marketing.
- Promote awareness and education of farmers on the benefits of using certified seeds and the importance of purchasing them from authorized and certified sources.
- Establishing a central database for tracking and monitoring certified seeds, including information on producers, processors, distributors and end users

6. Crop rotation

Is an agricultural practice in which different types of crops are grown on the same area of land in successive cycles or seasons. This practice offers numerous benefits to the soil, plants and the entire agricultural ecosystem. Crop rotation is essential for maintaining the nutritional balance of the soil, reducing the incidence of disease and weed infestation, efficient use of water resources, improving soil structure and diversifying agricultural production. This practice helps to protect long-term soil fertility, reduce the use of pesticides and herbicides, prevent soil erosion and increase biodiversity in and around agricultural land, having a positive impact on food security and local ecosystems.

7. Protection Curtains

Forest Protection Curtains are structured in agriculture to provide a number of benefits. They can protect crops against strong winds, extreme temperatures and excessive solar radiation. They can also reduce losses from pests and create a more stable environment for plant growth. By controlling these environmental factors, protective curtains can ensure crop yield, crop quality, and contribute to more efficient resource management in agriculture.

- Increased productivity: The main function of the protective curtains is to modify some excessive climatic factors and bring them as far as possible to normal, bearable parameters, both inside the curtain and especially in the neighboring fields, including: reducing the thermal amplitudes in the air and soil, modification (decrease) of wind speed, with its beneficial effects on the environment and plants (decrease in evapotranspiration, prevention of soil and snow scattering, stop uprooting of crops,

reduction of surface runoff, etc.), improvement of the aerohydric and pedohydric regime. In this way, curtains contribute to increasing agricultural production

- Increased resilience: In irrigated lands, protective curtains reduce water losses by evaporation from lakes, canals and from the surface of the soil and plants by about 30%. Through the changes made to the local climate, protective curtains create favorable conditions for agricultural crops in the space under their influence, helping to increase harvests by 10-20% in normal years and those with less abundant rain, and by 30-100% in dry or very dry
- Reduced emissions: Protective curtains create favorable conditions for the development of a large number of animals or useful insects and birds for agriculture. Moreover provide wood and other forest products that are missing in area

8. Land Tenure Clarity

Clarifying land tenure rights and promoting sustainable land use practices is an essential process to address land tenure issues in Somalia. This can be achieved by developing and implementing a clear legal and institutional framework that facilitates the registration and documentation of land ownership, thus ensuring the protection of property rights and preventing conflicts. In addition, promoting sustainable land use practices such as conservation agriculture and natural resource management can help preserve the environment and ensure the efficient use of agricultural land for future generations.

Supporting the growth of the fisheries sub-sector through sustainable management and capacity building for fishers are two key components to promoting a sustainable and prosperous fisheries industry in Somalia

9. Fish Farming and Aquaculture:

Sustainable aquaculture practices can contribute significantly to livelihoods, food security, and economic development while minimizing negative environmental impacts. By adopting holistic approaches that integrate ecological, social, and economic considerations, fish farming and aquaculture can play a crucial role in sustainable food production and income diversification for coastal and inland communities alike. Ongoing support, capacity building, and knowledge sharing are essential to promote widespread adoption of sustainable aquaculture practices and ensure long-term success in the sector.

In an aquaponic system, the waste generated by the fish, such as excretions and food scraps, is used as nutrients for the plants. These wastes are converted into nutrients by bacteria in the aquatic environment, and plants use these nutrients to grow. At the same time, plants

help purify the water by absorbing nutrients and filtering out impurities, which creates a healthier environment for fish.

This integrated system offers several advantages, such as efficient use of resources, reduced chemical and water use, increased agricultural production per unit area, and improved aquatic environment quality. Thus, aquaponics is a sustainable and ecological method of food production.

10. Hydroponic Systems

Is a method of growing plants without the use of traditional soil. Plants are grown in water and essential nutrients are delivered directly to the roots. This system allows for rapid plant growth, efficient use of resources and precise control of the growing environment.

- Increased productivity: productivity increase by 30%, due to the higher density of plants on a smaller surface and the fact that plant roots, having all the necessary water and nutrients at their disposal, will no longer focus on their procurement, but on growing the part aerial and fruiting
- Increased resilience: Crops are not influenced by weather conditions and can be cultivated in several cycles all year round, even in areas without arable land, arid etc. hydroponic cultures save a large amount of water used in traditional cultures through irrigation and various foliar applications. Moreover, water losses through evaporation and drainage are avoided, the used solutions being recirculated and reused for a longer time.
- Reduced emissions: No excess soil or fertilizer waste is generated, and pest control is often pesticide-free, reducing chemical waste.

11. The livestock sector

In Somalia is a vital part of the country's economy, having a significant impact on the livelihoods and incomes of many rural communities. To develop the livestock sector in Somalia, the following strategies can be considered:

Promoting the use of animal breeds adapted to local conditions and with high genetic potential for milk, meat or wool production can increase the productivity and efficiency of animal husbandry. Ensuring access to quality feed and appropriate feeding techniques can improve animal health and performance, contributing to increased yields in milk, meat and egg production. The construction of suitable housing, abbreviated systems and sanitary facilities for animals can improve the living conditions and health of the animals, leading to increased performance and reduced losses. Providing access to quality veterinary services and animal care can help prevent and control disease, manage reproduction and increase overall animal health. The creation and strengthening of agricultural cooperatives and livestock farmers' associations can facilitate the exchange of information, resources and technologies among farmers, contributing to improved livestock practices and access to better markets. By implementing these strategies, Somalia can boost the development of the livestock sector,

creating opportunities for increased incomes, job creation and improved food security in rural communities

12. Livestock sector

Using sustainable livestock production systems, such as rotational grazing and efficient animal waste management, to reduce greenhouse gas emissions and improve the resilience of the livestock sector

The use of rotational grazing and effective management of animal waste contribute to increased productivity by giving animals access to fresh and varied pastures, improving feed quality and stimulating milk or meat production.

Implementing these sustainable practices increases farm resilience by reducing reliance on costly inputs and maximizing the use of available resources, making them better able to cope with climate change and market fluctuations.

Reducing greenhouse gas emissions is a direct result of using these sustainable systems, as efficient animal waste management and rotational grazing help conserve natural resources and reduce the use of chemical inputs, which can generate greenhouse gas emissions.

13. Smart Farming

- Increased productivity: The use of drones in agriculture can offer numerous benefits, such as better understanding of crop and soil conditions, better planning and use of fertilizers and pesticides, and better monitoring of weeds and pests. These can lead to a better management of crops and to an increase in productivity and profitability in the agricultural industry.
- Increased resilience: Drones can be used for a variety of applications in agriculture, such as land mapping, water stress analysis, weed detection, pest analysis and nutritional stress analysis. They can be equipped with special sensors to collect data such as NDVI (differential normalized vegetation index) and thermography, which allow the analysis of crop and soil health
- Reduced emissions: Help protect the environment and fight climate change. By reducing the use of chemicals through data-driven targeted treatments and by reducing the need for tractors for this purpose, drones can help reduce pollution, help the environment and help fight climate change.

14. Mulching for Agricultural Productivity

Mulching involves covering the soil with organic or inorganic materials such as straw, leaves, plant debris, gravel or plastic sheeting. This agricultural technique brings multiple benefits to soil and crops:

Mulching increases agricultural productivity by retaining moisture, controlling weeds, maintaining soil temperature, improving soil structure and protecting against erosion.

Mulching increases plant resilience by protecting roots from temperature fluctuations, reducing water stress by retaining moisture, and preventing competition with weeds for resources.

Mulching reduces greenhouse gas emissions by reducing the need for frequent irrigation, reducing the use of chemical herbicides, and improving soil carbon storage by decomposing organic matter.

15. Implementing grassland and rangeland management practices

Significantly contribute to increased productivity, resilience and carbon reduction in the Somali agricultural sector. By adopting techniques such as rotational grazing and using managed grazing methods, farmers can improve soil quality and vegetation health, thereby increasing soil carbon storage capacity. Also, proper grassland management can help reduce greenhouse gas emissions by optimizing the carbon cycle in agricultural ecosystems and minimizing the use of agricultural inputs such as chemical fertilizers. In addition, grassland management practices can increase farm resilience to climate change by improving soil water retention and protecting against erosion. Therefore, the implementation of these practices can contribute to increasing the sustainability and performance of the agricultural sector in Somalia, providing significant benefits in terms of agricultural production, the environment and reducing the impact of climate change.

Agripreneurship practices

Agripreneurship practices in Somalia represent innovative and entrepreneurial initiatives in the agricultural sector aimed at economic growth and sustainable development. These practices involve agricultural entrepreneurs using their creativity and resources to develop profitable and sustainable agricultural businesses. They include adopting modern technologies, diversifying crops, implementing ecological agricultural practices and promoting access to markets for local agricultural products. Agripreneurship practices contribute to creating jobs, reducing rural poverty and improving food security in Somalia, thus strengthening the resilience of communities and stimulating the country's economic development.

1. Innovation and Sustainability in Livestock Agriculture

Developing a solid business case for growing and processing livestock products to increase added value involves detailed analysis of the market and consumer segments, product differentiation by offering a unique value proposition based on quality, sustainability and innovation, rigorous quality assurance and food safety at all stages of the process, the development of an effective distribution network to ensure access to relevant markets and the active promotion of products through adapted marketing strategies and appropriate communication and sales channels.

2. Fish Farm

Organizing a fish farm in aquaculture systems brings numerous social, economic and ecological benefits. This initiative contributes to the conservation of natural resources by reducing pressure on wild fish stocks and maintaining the biodiversity of marine ecosystems. It also stimulates economic growth in local communities by creating jobs and generating income from production and marketing. Aquatic farms provide a constant supply of nutritious food, contributing to food security and improving population nutrition. By using sustainable aquaculture techniques, product quality and safety can be controlled, reducing the negative impact on marine ecosystems and promoting the conservation of natural habitats. This activity diversifies the local economy and can be less vulnerable to climate change, contributing to the adaptability of local communities. In addition, it promotes innovation and research in agricultural technologies, improving the efficiency and sustainability of the aquaculture sector.

3. Online Platform

Creating coordination platforms between farmers, processors and distributors is critical to improving collaboration and efficiency in the agricultural supply chain. These platforms facilitate the exchange of information and cooperation between different actors in the agricultural industry, strengthening partnership relations and improving resource management. Through these platforms, farmers can communicate more effectively with processors and distributors so that agricultural production better aligns with market demand. The platforms also offer the ability to monitor and manage the supply chain in real time, reducing the risks of imbalance between supply and demand. By improving communication and collaboration between all actors involved, the production process can be optimized, reducing costs and time needed to bring agricultural products to market. Thus, the creation of these coordination platforms brings significant benefits to the entire agricultural industry, strengthening partnership relations and contributing to the sustainable growth of the sector.

4. Training programs for farmers

The development and implementation of training programs for farmers is an essential pillar in supporting the growth and prosperity of the Somali agricultural sector. These programs provide farmers with access to current agricultural knowledge and practices and train them in the use of modern technologies and sustainable farming methods. Through these programs, farmers can improve their skills in crop management, resource management, and decision-making regarding specific farming techniques, such as efficient irrigation, pest control, or the use of organic fertilizers. These programs also provide training opportunities in related areas such as business management, marketing and accessing financial resources, helping farmers develop their entrepreneurial skills and maximize their potential for success in the ever-changing agricultural environment. Ultimately, the development and implementation of these training programs contribute to improving the performance and resilience of farmers and fostering sustainable growth and inclusiveness in Somalia's agricultural sector.

5. Lobbying and advocacy

To promote the interests of the Somali agricultural sector at governmental and international levels is an essential strategy to strengthen the position of this sector and to obtain the necessary support from international authorities and organizations. Through lobbying, representatives of the agricultural sector can influence decision-making processes and government policies in the direction favorable to the agricultural industry. This includes lobbying for the allocation of financial resources and support for agricultural programs, the

implementation of legislation to protect farmers' interests, and the promotion of a business environment conducive to sustainable agricultural development.

In terms of international advocacy, it aims to promote the interests of the Somali agricultural sector in international organizations and international trade negotiations. This involves engaging in discussions on international trade and access to foreign markets, promoting foreign investment in Somali agriculture, and drawing attention to specific needs and challenges facing Somali farmers globally, such as climate change or food security.

Through lobbying and advocacy, the Somali agricultural sector can obtain the political and financial support needed to develop its capacities and improve its competitiveness in the domestic and international markets. These efforts also contribute to strengthening Somalia's diplomatic and commercial relations with other states and international organizations, strengthening the country's position in the global agricultural landscape and contributing to the sustainable development of the national economy

6. Diversification of agricultural products

Is a vital strategy to meet market demands and boost income growth in the Somali agricultural sector. This approach involves growing and producing a diverse range of agricultural products, tailored to different consumer needs and preferences. By diversifying, farmers can expand their product portfolio and reduce their reliance on a single type of crop or agricultural product, thereby increasing their resilience to market changes and risks associated with weather conditions or price fluctuations.

This diversification may include expanding the production of agricultural products with high added value, such as specialty crops, organic products or processed foods. New market opportunities for existing agricultural products can also be explored or partnerships can be developed with other sectors, such as tourism or the food industry, to make the most of available agricultural resources.

By diversifying the portfolio of agricultural products, Somali farmers can increase their income and increase their competitiveness in the market, meeting the ever-changing demands and preferences of consumers. This strategy contributes to the sustainable development of the Somali agricultural sector, increasing economic stability and improving the living standards of farming communities.

7. Creating strategic partnerships

With local and international economic agents is an essential strategy for expanding distribution networks in the Somali agricultural sector. These partnerships facilitate access to new markets and distribution channels, thereby helping to increase sales and income for farmers and agricultural producers.

At the local level, collaboration with economic agents such as local traders, food processors and food distribution chains can help introduce Somali agricultural products to local and

regional markets. Through these partnerships, farmers can benefit from access to transport and storage infrastructure, marketing and sales expertise, as well as promotion and branding opportunities in the local market.

Internationally, partnering with importers, distributors and retailers in other countries can open up new export opportunities for Somali agricultural products. This may involve establishing sustainable business relationships, meeting the quality and food safety requirements of foreign markets, and obtaining the necessary certifications for export. Also, international partnerships can facilitate access to innovative technologies and business practices to support the increased competitiveness of Somali agricultural products in the global market.

By creating these strategic partnerships, the Somali agricultural sector can strengthen its position in the domestic and international markets, expand its distribution networks and maximize its potential for growth and development. Thus, collaboration between local and international economic agents becomes crucial for stimulating progress in the Somali agricultural sector.

8. Digital technologies

The use of digital technologies in the Somali agricultural sector can open up new opportunities by accessing e-commerce platforms and expanding the reach to new market segments. This modern approach allows farmers and agricultural producers to promote their products and interact directly with consumers, cutting out traditional middlemen and connecting them directly with potential customers.

Through e-commerce platforms such as dedicated websites, mobile applications or online sales platforms, farmers can display their products on the global market, set competitive prices and manage their inventory efficiently. This allows them to reach new market segments, including urban consumers or customers from other regions or countries, who may be inaccessible through traditional distribution channels.

9. Weather monitoring systems

The implementation of crop and weather monitoring systems is a vital initiative to optimize agricultural production in Somalia. These systems allow farmers to monitor crop condition in real time and obtain accurate information on weather parameters such as temperature, humidity and rainfall. With this data, farmers can make informed decisions about crop management, including when to irrigate, fertilize or harvest. Monitoring systems also help identify and manage risks associated with climate change, such as drought or flooding, helping to reduce agricultural losses and increase the resilience of the agricultural sector. Additionally, through the use of digital technologies, these systems can be accessed remotely, allowing farmers to monitor and manage their crops even when they are not physically present in the field. Therefore, the implementation of crop and weather monitoring systems

is an essential investment to improve the efficiency and sustainability of agriculture in Somalia.

10. Agricultural cooperatives

The development of agricultural cooperatives in Somalia can play a crucial role in strengthening farmers' bargaining power in the market and facilitating their access to financial resources. By joining a cooperative, Somali farmers can purchase agricultural inputs such as seeds and fertilizers at better prices thanks to bulk purchases. The cooperative can also facilitate access to larger and more diverse markets, both locally and internationally, enabling farmers to obtain better prices for their produce and negotiate more favorable terms for sale.

In addition to commercial advantages, the cooperative can provide its members with access to essential financial services, such as credit and financing, which are often difficult to obtain for individual farmers. This access to finance can support investments in agricultural infrastructure, modern technologies and sustainable practices, helping to increase farm productivity and resilience. In addition, cooperatives can provide technical support and training, helping farmers improve their knowledge and skills.

Overall, the development of agricultural cooperatives in Somalia can transform the agricultural sector, providing farmers with more economic opportunities, improving food security and contributing to the sustainable economic development of rural communities.

11. Marketing and branding

Implementing marketing and branding programs for Somali agricultural products can bring many benefits to farmers and the local economy. These programs can help increase the visibility of products in local and international markets, promoting the unique quality and distinctive characteristics of Somali agriculture. By creating a strong and recognizable brand, agricultural products can attract new market segments and consumers who appreciate the origin and traditional production methods.

Marketing programs could include promotion strategies through various media channels, organizing agricultural fairs and exhibitions, and using digital and e-commerce platforms to reach a wider audience. Branding, on the other hand, could involve developing attractive packaging, certifying organic or ecological products, and creating an authentic story that highlights local traditions and the sustainability of Somali agricultural practices.

These initiatives will not only help increase sales and fetch better prices for agricultural products, but will also help improve the image and reputation of the Somali agricultural sector on the global stage. In addition, effective marketing and branding can attract investors and business partners, thereby stimulating economic development and sustainable growth of Somalia's farming communities.

12. Fairs and exhibitions

Organizing agricultural fairs and exhibitions can play an essential role in connecting Somali farmers with potential buyers and business partners, contributing significantly to the development of the agricultural sector. These events provide an ideal platform for farmers to showcase their products, demonstrate their quality and uniqueness, and interact directly with a wide audience, including distributors, retailers, and investors.

By participating in fairs and exhibitions, farmers have the opportunity to learn about market trends and consumer demands, which allows them to adjust their practices and diversify their products to better meet demand. These events also facilitate the exchange of knowledge and innovation, showcasing new technologies, equipment and agricultural methods that can be adopted to improve productivity and sustainability.

For buyers and business partners, agricultural fairs and exhibitions are an opportunity to discover new products, establish direct relationships with producers and negotiate contracts and collaborations. This direct contact can build trust and create long-lasting partnerships that benefit both farmers, distributors and end consumers

13. Infrastructure development

The implementation of infrastructure development projects for the storage and processing of agricultural products in Somalia can have a significant impact on the quality and sustainability of these products in the long term. These projects could include building modern warehouses, silos and processing facilities that meet food safety and energy efficiency standards.

First, the development of storage infrastructure would enable farmers to store produce in optimal conditions, reducing post-harvest losses caused by factors such as spoilage, pest infestation and adverse weather conditions. Adequate warehouses would maintain the quality of the produce, extending the period during which it can be marketed, which would enable farmers to sell at times when prices are more advantageous.

Second, processing facilities would enable the transformation of raw agricultural products into value-added products such as juices, canned goods, flours and other processed products. This would not only increase farmers' incomes by fully exploiting their resources, but would also create additional jobs in rural communities, contributing to local economic development.

In addition, adequate storage and processing infrastructure would support compliance with international food safety and quality standards, facilitating the access of Somali products to international markets. This would encourage exports and increase the competitiveness of Somali agricultural products in the global market.

14. Mentoring and coaching programs

Implementing mentoring and coaching programs for agricultural entrepreneurs in Somalia can play a critical role in developing leadership and business management skills, with multiple benefits for the agricultural sector. These programs would bring entrepreneurs in touch with experienced experts and mentors who could provide guidance, practical advice and ongoing support. Through mentoring, entrepreneurs would learn directly from successful professionals about effective business strategies, resource management, marketing, financing and strategic planning, and mentors could help them identify market opportunities and navigate specific challenges. Coaching programs would focus on developing the personal and professional skills of entrepreneurs, including improving leadership, decision-making, problem-solving and effective communication skills, as well as team management and creating a positive organizational culture. Participants would receive ongoing support and be encouraged to develop collaborative networks and share experiences and resources, leading to the formation of a community of practice focused on learning and innovation.

15. Agricultural tourism

Promoting agricultural tourism and agritourism in Somalia can bring significant benefits to both farmers and the local economy by diversifying incomes and increasing awareness of local products. This initiative could include the development of tourism programs that offer visitors authentic farm experiences, including guided tours, tastings of local products, participation in agricultural activities and accommodation in traditional farms.

By attracting tourists, farmers could generate additional income from visitor fees, direct sales of agricultural products, and related services such as accommodation and meals. This additional income could be reinvested in improving farm infrastructure, purchasing modern equipment and adopting more sustainable farming practices.

Agritourism would also increase awareness and appreciation of local produce. Visitors would have the opportunity to learn about traditional farming methods, the specifics and benefits of local produce, and establish a personal connection with farmers. This experience could increase demand for local products, both nationally and internationally, as tourists become ambassadors for the quality and authenticity of Somali products.

In addition, agritourism can contribute to the development of rural communities, creating jobs and stimulating the local economy. For example, tourism activities might require local guides, accommodation and catering staff, and artisans to sell souvenirs, all contributing to increased incomes and improved living standards in rural areas.

CONCLUSION

The implementation of climate-smart agricultural practices and innovative entrepreneurial practices in Somalia's agricultural sector could represent a significant opportunity for sustainable agricultural development in the country. By adopting a mix of modern technologies, efficient management of natural resources and diversification of agricultural activities, Somalia could strengthen its agricultural sector, support economic growth and help reduce poverty and improve food security.

By increasing agricultural productivity, diversifying sources of income, increasing the added value of agricultural products, promoting sustainability and stimulating innovation and competitiveness, smart agricultural practices could bring significant benefits to rural communities in Somalia. Also, these practices could contribute to the conservation of the environment and the adaptation of the agricultural sector to climate and market changes.

Therefore, strengthening agricultural development in Somalia through the implementation of climate smart practices could represent an important step towards building a resilient and sustainable agricultural sector that will bring long-term benefits to rural communities and contribute to the country's overall economic growth.

Agripreneurship practices implemented in Somalia's agriculture are crucial for boosting economic growth and sustainable development in the country. These entrepreneurial initiatives have a significant impact on rural communities, helping to create jobs, reduce poverty and improve food security. By adopting modern technologies, diversifying crops and promoting market access, Somali agricultural entrepreneurs can achieve positive long-term results in terms of the sustainability and resilience of the agricultural sector. In conclusion, agricultural entrepreneurship practices are an important driver of socio-economic development in Somalia, helping to build a solid foundation for a more prosperous and sustainable future.

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