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Executive summary

This report provides a strategic roadmap for implementing technological interventions in Jamaica's agricultural sector, with a focus on sustainability and aiding smallholder farmers. It begins by outlining the current state of agriculture in Jamaica, highlighting challenges such as climate vulnerability, low productivity, market access issues, and inadequate post-harvest infrastructure.

The roadmap identifies opportunities for technological solutions including climate-smart practices, post-harvest innovations, better market linkages, value addition through agro-processing, and capacity building for farmers. It emphasizes the importance of stakeholder engagement, involving farmers, government, NGOs, and technology providers to ensure relevant and effective interventions.

Key priority areas for intervention include smart irrigation, pest alerts, climate-smart practices, improved cold storage, digital marketing platforms, mobile banking, and training programs. The document also outlines a framework for selecting appropriate technologies, pilot project implementation, scaling-up strategies, and monitoring and evaluation to ensure ongoing improvement and sustainability.

The roadmap concludes by emphasizing the need for long-term support, market connectivity, financial incentives, and systematic documentation to replicate successful interventions across Jamaica and possibly other regions.

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1 Introduction

This report provides a strategic roadmap for implementing technological interventions in Jamaica's agricultural sector, with a focus on sustainability and aiding smallholder farmers.

The agricultural sector in Jamaica is a vital component of the nation's economy and cultural identity, engaging a significant portion of the population and contributing to food security and rural livelihoods. Despite its importance, Jamaican agriculture faces numerous challenges that hinder its growth and sustainability. Smallholder farmers, who dominate the landscape with average farm sizes of less than five acres, grapple with issues such as climate vulnerability, low productivity, limited access to markets, and inadequate post-harvest infrastructure. These challenges are compounded by the impacts of climate change, which threaten agricultural output through extreme weather events, shifting growing seasons, and increasing pest pressures.

Recognizing the urgency of these challenges, this report provides a strategic roadmap for implementing technological interventions aimed at transforming Jamaica's agricultural sector. The focus is on fostering sustainability and empowering smallholder farmers, who often lack the resources and support needed to innovate and thrive in an increasingly competitive and unpredictable environment. By leveraging technology, the roadmap seeks to enhance productivity, improve market access, and reduce post-harvest losses, ultimately contributing to greater food security and economic resilience.

This report outlines the current state of agriculture in Jamaica, presenting a comprehensive assessment of the agricultural value chain and identifying key challenges and opportunities for technological intervention. It emphasizes the importance of stakeholder engagement, ensuring that the voices of farmers, government agencies, NGOs, and technology providers are integrated into the decision-making process. The roadmap highlights priority areas for intervention, including smart irrigation, pest management systems, improved cold storage solutions, digital marketing platforms, and capacity-building initiatives.

In conclusion, this report aims to serve as a guide for policymakers, practitioners, and stakeholders in the agricultural sector to collaboratively implement effective and sustainable technological solutions.

2 Roadmap for technology interventions

A strategic roadmap for transforming Jamaica's agricultural sector through technology should centre around enhancing productivity, market access, and climate resilience. This involves investing in and promoting access to digital platforms for market information and e-commerce, fostering the adoption of precision agriculture technologies like sensors and data analytics for optimized resource use, and developing climate-smart solutions such as drought-resistant crops and water management systems. Crucially, the roadmap must prioritize farmer training and capacity building to ensure effective adoption and utilization of these technologies, alongside supportive policies and public-private partnerships to facilitate innovation and investment in the sector.

The following sections outline a roadmap for policymakers, practitioners, and stakeholders in the agricultural sector to collaboratively implement effective and sustainable technological solutions.

2.1 Assessment of current state

This section provides an overview of the current state of Jamaica's agricultural value chain, highlighting key challenges and opportunities for technological intervention.

2.1.1 Current state of Jamaica's agricultural value chain

Jamaica's agricultural landscape is primarily shaped by smallholder farmers, with the average farm size being less than five acres. These farmers have traditionally focused on cultivating export crops like bananas, sugar, and coffee, alongside domestic staples such as yams and plantains. However, there's a growing interest in diversifying into non-traditional, high-value crops like herbs, spices, and fruits, as well as a rising trend towards organic farming practices. Despite this potential, Jamaican agriculture faces challenges such as climate change vulnerability, an aging farmer population, land tenure issues, and limited access to finance and technical assistance.

Post-harvest handling and storage present significant bottlenecks in the value chain. Inadequate infrastructure, including a lack of sufficient cold storage and packing facilities, results in high post-harvest losses, estimated to be between 30% to 40%. This loss of produce directly impacts farmers' incomes and undermines food security efforts. Furthermore, limited value-added processing reduces the potential for higher earnings and prevents farmers from fully capitalizing on their harvests.

Marketing and distribution of agricultural products in Jamaica operate through a mix of formal and informal channels. Small farmers, in particular, face challenges accessing larger and more lucrative markets. Price volatility, competition from imported goods, and limited market information further complicate the situation. However, the flourishing tourism sector offers a promising opportunity for farmers to tap into a growing demand for high-quality, locally sourced produce.

This demand aligns with a broader trend among Jamaican consumers who are increasingly seeking out healthy, locally sourced food options. However, the country still heavily relies on imported food, contributing to a substantial food import bill. This highlights a crucial need for strengthening local production and improving the efficiency of the agricultural value chain to enhance food security and economic growth.

2.1.2 Key challenges

Jamaica's agricultural sector faces a multifaceted array of challenges. **Climate change** and **environmental degradation** pose significant threats, with **extreme weather events** such as hurricanes and droughts, coupled with **soil erosion** and increasing **water scarcity**, jeopardizing productivity and the livelihoods of farmers. **Low productivity** and **overall efficiency** within the sector are further compounded by the **limited adoption of modern agricultural practices**, an **aging farming population**, and **land fragmentation**, all of which hinder growth and output.

Post-harvest losses present a substantial hurdle, as **inadequate infrastructure** and **inefficient handling practices** lead to significant spoilage and waste, reducing farmer income and undermining food security efforts. Furthermore, small farmers often struggle with **market access** and **value chain coordination**. They face challenges in accessing lucrative markets, coupled with **difficulties in price negotiation** and **limited access to timely market information**, hindering their ability to profit effectively from their labour.

The **lack of value addition** poses another significant challenge. The absence of adequate **processing and packaging facilities** limits the development of value-added products, restricting income potential for farmers and preventing the sector from tapping into higher-value markets. Lastly, **data deficiency** remains a critical concern. The lack of reliable and readily available data on production, prices, and market demand makes it difficult for stakeholders across the value

chain to make well-informed decisions, ultimately hindering planning and growth within Jamaica's agricultural sector.

2.1.3 Opportunities for technological intervention

Technological intervention offers a powerful avenue for transforming Jamaica's agricultural sector. Embracing climate-smart agriculture practices, such as **precision agriculture**, can significantly improve efficiency and sustainability. By **utilizing sensors, drones, and data analytics**, farmers can optimize irrigation, fertilizer use, and pest control, minimizing waste and environmental impact. **Implementing early warning systems**, particularly mobile-based weather alerts and pest/disease forecasting, can empower farmers to take timely action, mitigating potential losses. Furthermore, developing and promoting **climate-resilient crop varieties** that are drought-tolerant, disease-resistant, and high-yielding will be crucial for adapting to the changing climate.

Addressing post-harvest losses requires innovation in post-harvest management. Providing **affordable, solar-powered mobile cooling units** can revolutionize cold storage solutions, particularly for perishable produce, significantly reducing spoilage and waste. Introducing **improved packaging and storage technologies** that extend shelf life and maintain product quality will further enhance the value chain, ensuring that farmers' hard work translates into marketable goods.

Strengthening market linkages and value chain development are vital for farmers to thrive. E-commerce platforms offer a direct link between farmers and consumers, creating new market opportunities and enabling fairer pricing. Developing robust **market information systems** that provide real-time data on market prices, demand, and supply will empower farmers to make informed production and marketing decisions. Additionally, exploring **blockchain technology** can enhance traceability and transparency in the supply chain, potentially opening doors to premium markets seeking ethically sourced products.

Investing in value addition and agro-processing will unlock greater economic potential for farmers. Making affordable, **small-scale processing equipment accessible** will enable them to transform raw produce into value-added products, diversifying income streams and meeting consumer demand for processed goods. Establishing food hubs, shared facilities for processing, packaging, and marketing, will **create economies of scale**, reducing costs and increasing efficiency for small farmers.

Finally, **prioritizing capacity building** and knowledge sharing is essential for successful technological adoption. Utilizing **mobile apps and online platforms** to disseminate information on best practices, market opportunities, and new technologies will empower farmers with crucial knowledge. Implementing **training programs** designed to build practical skills in using new technologies and adopting **climate-smart practices** will equip farmers with the tools needed to thrive in a rapidly evolving agricultural landscape.

2.2 Stakeholder engagement

Developing a successful roadmap for ad hoc technology intervention in Jamaica's agricultural value chain hinges on a participatory and inclusive approach, ensuring that the voices and perspectives of all key stakeholders are heard and integrated. This engagement process should be structured around open dialogue, collaborative workshops, and information-sharing sessions, creating a platform for constructive feedback and co-creation.

Firstly, direct engagement with farmers is vital. Farmers, as the ultimate end-users of these technologies, must be actively involved in identifying the specific challenges they face, their technology needs and preferences, and their capacity for adopting new solutions. This can be achieved through focus group discussions, field visits, and surveys tailored to different farming communities and production systems across the island.

Simultaneously, consultations with government agencies, including the Ministry of Agriculture and Fisheries and the Rural Agricultural Development Authority (RADA), are crucial for aligning the technology roadmap with national policies, regulatory frameworks, and existing agricultural development programs. Collaborating with NGOs already working on the ground in agricultural development can provide valuable insights into community-level needs, existing local knowledge, and potential implementation challenges.

Engaging with technology providers, both local and international, is essential to explore the range of available and emerging technologies suitable for the Jamaican context. This dialogue should focus on affordability, adaptability to local conditions, and the potential for local manufacturing or assembly to ensure long-term sustainability. Finally, convening multi-stakeholder workshops that bring together representatives from all groups – farmers, government, NGOs, technology providers, researchers, and financial institutions – will foster a shared vision, facilitate knowledge exchange, and ensure buy-in from all parties involved. This collaborative approach will be instrumental in developing a technology intervention roadmap that is context-specific, impactful, and sustainable in the long run.

2.3 Priority areas

Specific areas along Jamaica's agricultural value chain where technology intervention can yield the most significant impact, include:

1. Production:

- Implementing sensor-based irrigation systems, drone-based crop monitoring, and data-driven fertilizer application can significantly improve water and nutrient use efficiency, leading to higher yields and reduced environmental impact. This is especially crucial given Jamaica's vulnerability to drought
- Mobile applications providing real-time pest and disease alerts, coupled with image recognition tools for early detection, can enable timely and targeted interventions, minimizing crop losses and reducing reliance on chemical pesticides
- Promoting and supporting the adoption of climate-smart practices, such as drought-tolerant crop varieties, water-harvesting technologies, and shade houses, can enhance resilience to climate change impacts

2. Post-harvest management and value addition:

- Expanding access to affordable, small-scale cold storage solutions, particularly in rural areas, will significantly reduce post-harvest losses of perishable produce, increasing farmer incomes and improving food security
- Introducing and promoting the use of affordable equipment for drying, juicing, preserving, and packaging can empower farmers to add value to their produce, extending shelf life and creating new market opportunities

3. Marketing and market access:

- Connecting farmers directly to consumers and businesses through online platforms can overcome geographical barriers, increase market access, and enable fairer pricing for farmers
- Developing mobile-based systems that provide farmers with up-to-date information on market prices, demand, and supply can improve decision-making regarding planting, harvesting, and sales, maximizing profits and reducing waste

4. Access to finance:

- Expanding access to mobile banking, micro-loans, and crop insurance through digital platforms can overcome traditional barriers to financial inclusion, enabling farmers to invest in improved technologies and inputs

- Implementing blockchain technology to track produce from farm to market can increase transparency and build trust with consumers, potentially unlocking access to premium markets and price premiums for farmers using sustainable practices

5. Capacity building and knowledge sharing:

- Leveraging mobile phones to deliver timely and targeted information on best practices, weather forecasts, market updates, and new technologies can bridge the information gap for farmers, especially those in remote areas
- Utilizing online platforms to provide interactive training modules, webinars, and peer-to-peer learning opportunities can enhance farmers' skills in using new technologies and adopting climate-smart practices, further amplifying the impact of technological interventions

2.4 Technology selection

Selecting the most appropriate technologies for Jamaica's agricultural value chain requires a considerate and context-specific approach, ensuring that the chosen solutions effectively address the identified challenges while being accessible, affordable, and adaptable to local conditions. The below framework can be used for guiding the selection process:

- 1. Prioritize farmer needs and challenges:** Begin by thoroughly understanding the specific challenges faced by farmers at different points in the value chain. Conduct surveys, focus group discussions, and field visits to gather insights from farmers themselves. What are their most pressing concerns? Where do they experience the most significant losses or bottlenecks? Which technologies do they believe could make the biggest difference in their operations?
- 2. Assess technology suitability:** Evaluate potential technologies based on their suitability for the Jamaican context, considering factors such as:
 - **Climate compatibility:** Is the technology suitable for Jamaica's tropical climate and prone to extreme weather events?
 - **Local infrastructure:** Does the technology require reliable electricity, internet connectivity, or specialized infrastructure that may be lacking in certain areas?
 - **Skill level:** How user-friendly is the technology? Can farmers with varying levels of education and technical skills easily adopt and use it?
 - **Maintenance and support:** Are local technicians available to provide maintenance and repair services? Is ongoing technical support accessible and affordable?
- 3. Focus on affordability and scalability:** Prioritize technologies that are affordable for small-scale farmers, who constitute a significant portion of Jamaica's agricultural sector. Explore options like:
 - **Low-cost, open-source solutions:** Are there open-source technologies or locally manufactured alternatives that offer similar functionality at a lower cost?
 - **Shared ownership models:** Can farmers pool resources to purchase and share equipment, such as mobile cooling units or processing machinery?
 - **Government subsidies and microfinance:** Are there government programs or microfinance initiatives that can help farmers access funding for technology adoption?
- 4. Consider long-term sustainability** by taking into account:
 - **Environmental impact:** Does the technology contribute to a more sustainable and environmentally friendly agricultural system?
 - **Local capacity building:** Does the technology promote local skills development and create job opportunities in areas such as maintenance, repair, or data analysis?
 - **Supply chain resilience:** Does the technology rely heavily on imported components or expertise, or does it strengthen local supply chains and self-reliance?

Choosing the right technology for Jamaican farmers means being mindful of their current resources and needs. For example, while sophisticated drone-based precision agriculture systems offer advanced capabilities, farmers struggling with water scarcity might see more immediate benefits from investing in low-cost soil moisture sensors and drip irrigation systems. These simpler technologies provide targeted irrigation solutions that are both affordable and easier to implement, making them a more practical choice for those with limited resources.

Similarly, when addressing market access challenges, starting with a simple SMS-based market information service that delivers price updates to farmers' basic mobile phones could have a wider and more immediate impact than launching a complex e-commerce platform. This is particularly relevant considering that not all farmers have access to smartphones or reliable internet connectivity. Likewise, piloting a blockchain-based traceability system for a specific high-value export crop like coffee, focusing initially on farmers already meeting specific quality standards, offers a more strategic and manageable approach than attempting to implement such a system across the entire agricultural sector. This targeted approach allows for a more focused implementation, enabling stakeholders to test the technology's feasibility and demonstrate its value before scaling up to other crops or segments of the market.

2.5 Pilot projects

A crucial step in implementing this roadmap is the establishment of pilot projects. These pilot initiatives will serve as real-world testing grounds for the chosen technologies, providing valuable insights into their effectiveness, adaptability, and impact on participating farmers.

These pilot projects should be strategically located in representative agricultural areas across Jamaica, encompassing diverse farming systems and targeting specific challenges identified through stakeholder engagement. For instance, a pilot project focusing on smart irrigation could be implemented in a drought-prone region, while a pilot testing mobile market information services might be rolled out in an area with limited market access. By carefully selecting pilot sites and involving farmers from the outset, these initiatives can generate location-specific data and practical knowledge that will be invaluable for refining and scaling up successful technologies.

Throughout the pilot phase, rigorous monitoring and evaluation are essential. This involves collecting data on key indicators such as crop yields, water usage, input costs, sales prices, and farmer incomes, comparing outcomes between participating farmers and a control group using traditional methods. Regular assessments will help gauge the impact of the technologies on farmers' productivity, profitability, and overall livelihoods, providing evidence-based insights for decision-making. Moreover, these pilot projects will serve as valuable learning opportunities for all stakeholders, enabling technology providers to refine their solutions based on real-world feedback, policymakers to understand potential challenges and opportunities for scaling up, and, most importantly, farmers to gain firsthand experience with new technologies and share their knowledge with their peers.

2.6 Capacity building

A key factor in the successful implementation of any new technology is ensuring the people who will be using it have the knowledge and skills to do so effectively. Therefore, a comprehensive training and capacity building program for farmers and other stakeholders is essential.

These programs should be tailored to the specific technologies being introduced, using a hands-on, participatory approach that builds confidence and encourages adoption. For example, farmers being introduced to precision agriculture tools would need training on how to install, operate, and maintain sensors, interpret data dashboards, and adjust their farming practices based on the insights gathered. Similarly, training on using mobile market information services might include modules on navigating the app or platform, understanding market trends and price

fluctuations, and using the information to make informed decisions about planting and selling their produce.

Beyond basic technical skills, these programs should also focus on building a broader understanding of the benefits and potential challenges associated with each technology. This might include modules on data privacy and security for those using blockchain-based traceability systems, or training on sustainable water management practices for farmers using smart irrigation technologies.

Importantly, these training programs should not be limited to farmers themselves. Engaging other stakeholders – such as extension officers, agricultural technicians, and even members of farmer cooperatives – will help build a network of local expertise and ensure long-term sustainability.

2.7 Scaling-up

Once the pilot projects have demonstrated the effectiveness and viability of selected technologies, the next critical stage in this roadmap is to scale up these successful interventions, extending their reach to benefit a larger number of farmers in the target areas. This scaling process requires careful planning and a multi-pronged approach to ensure sustainability and impact.

Firstly, it's crucial to leverage the lessons learned during the pilot phase. The data gathered on technological effectiveness, adoption challenges, and farmer feedback will be invaluable in refining implementation strategies, training programs, and even the technologies themselves to better suit the needs of a wider user base. Sharing the success stories and impact data from the pilot projects will also be essential for building confidence and encouraging wider adoption among farmers who may be hesitant to embrace new technologies.

Scaling up also necessitates securing adequate funding and forging strategic partnerships. This might involve engaging with government agencies to advocate for increased investment in agricultural technology, partnering with private sector companies to explore innovative financing models or technology subsidies, and collaborating with NGOs and international development organizations to leverage their expertise and resources. Exploring blended finance models, where public funds are used to de-risk investments and attract private capital, could also be a viable option.

Expanding access to these technologies might involve establishing local distribution networks for affordable equipment, or creating online training platforms that can reach farmers in remote areas. It's crucial to ensure that these technologies remain accessible and affordable as they are scaled up, avoiding the creation of a "digital divide" where only a select few benefit.

2.8 Monitoring and Evaluation (M&E)

Establishing a robust monitoring and evaluation (M&E) framework to track the progress and impact of technology interventions is the next stage in this roadmap. This begins with defining key performance indicators (KPIs) across three levels: output, outcome, and impact. Output KPIs will track direct results of the interventions, such as the number of farmers trained, farms adopting new technologies, investment leveraged, and the functionality of deployed technology. Outcome KPIs will focus on the benefits experienced by participating farmers, including increased yield and productivity, reduced post-harvest losses, improved product quality and safety, better market access, increased sales, and ultimately, higher incomes. Lastly, impact KPIs will assess the broader effects on food security, climate resilience, empowerment of women and youth in agriculture, and the creation of new economic opportunities.

Effective data collection and analysis are crucial for a robust M&E framework. Before implementing any interventions, baseline data on all key indicators must be collected to provide a benchmark for measuring progress. A mix of quantitative and qualitative data collection

methods will provide a comprehensive understanding of the interventions' impact. This includes surveys of participating farmers, focus group discussions with stakeholders, field visits to observe technology adoption, data from technology platforms themselves, and administrative data from relevant partners and government agencies. The collected data will then be analyzed using appropriate statistical techniques to measure the interventions' effectiveness and identify areas for improvement.

To ensure the interventions remain relevant and responsive to the evolving needs of farmers and the agricultural landscape, establishing robust feedback mechanisms is crucial. This involves creating regular communication channels between farmers, technology providers, extension officers, researchers, and policymakers. Farmers should have accessible ways to share their experiences, challenges, and suggestions, utilizing tools like feedback forms, suggestion boxes, dedicated phone lines, online platforms, and interactive farmer field days and workshops. Furthermore, periodic stakeholder consultations will provide a platform to discuss progress, address challenges, and collectively learn from the initiative.

A successful M&E framework must embrace adaptive management and continuous improvement. A dedicated team should regularly review and analyse the collected data to understand what is working, what is not, and why. This iterative approach ensures that the interventions are constantly refined based on data-driven insights. Flexibility and responsiveness are key; the interventions should be adjusted based on the evolving needs of farmers, the dynamic technological landscape, and the shifting market context. Finally, documenting and sharing lessons learned and best practices with all stakeholders is essential to promote wider adoption and scaling of successful technology interventions, amplifying their positive impact.

2.9 Sustainability and long-term planning

A robust sustainability plan must underpin any technology intervention. This plan should focus on building local capacity, connecting farmers to markets, and incentivizing long-term adoption, ensuring technology use becomes self-sustaining beyond the initial project phase.

Farmers need ongoing support to confidently use and maintain new technologies. This requires investment in training programs that go beyond basic usage and cover maintenance, troubleshooting, and data interpretation. Establishing local "technology champions" within farming communities can provide accessible peer-to-peer support, while integrating technology training into existing agricultural extension services ensures widespread reach. Alongside training, a network of local technicians or service providers offering affordable repair and maintenance is key. This can be encouraged through seed funding, micro-loans for entrepreneurs, and partnerships with vocational schools to develop relevant curriculum, ensuring long-term access to technical expertise.

Online marketplaces and mobile platforms can be powerful tools, enabling farmers to advertise their products and connect with buyers directly, increasing profits by reducing reliance on intermediaries. Further, supporting the formation of farmer cooperatives and producer groups allows for collective leverage of technology, improving bargaining power and facilitating entry into higher-value markets.

Finally, to ensure widespread and continued adoption, incentives are key. Financial incentives, such as micro-loans, subsidies, reduced interest rates, and tailored insurance schemes, can offset the costs associated with technology adoption. Equally important is the creation of programs that recognize and reward farmers who successfully adopt technology and demonstrate improvements in their productivity, income, or environmental practices. By promoting public-private partnerships to secure affordable access to technology and prioritizing open-source solutions that can be adapted and maintained locally, the long-term affordability and sustainability of these interventions are further strengthened.

2.10 Knowledge sharing and replication

As we advance with the various technology interventions along the value chain, it is crucial to systematically document the lessons learned throughout the process. This documentation should capture both the successes and the challenges faced, providing a comprehensive overview of the intervention's impact. Key aspects to document include detailed accounts of the approaches and methods used, such as technology deployment, training sessions, and support mechanisms. It should also identify obstacles encountered during the implementation phase and the innovative solutions developed to overcome these challenges. Additionally, the documentation should provide quantitative and qualitative data illustrating the intervention's effects on productivity, efficiency, and profitability for the farmers involved, as well as insights and feedback from the farmers and other stakeholders, highlighting their experiences and perspectives on the intervention.

Once documented, these lessons should be compiled into comprehensive reports, case studies, and toolkits. These resources can then be shared with a wide range of stakeholders, including local and national agricultural organizations, to inform policy and support frameworks that can facilitate broader adoption of successful interventions. Educational and research institutions can integrate findings into academic curricula and research agendas, fostering ongoing innovation and improvement. International development agencies can use the insights to aid in the design and implementation of similar interventions in other developing regions.

To promote the widespread replication of successful models, it is important to organize workshops and seminars that create platforms for knowledge exchange where stakeholders can discuss findings, share experiences, and explore opportunities for collaboration. Developing training programs for farmers, extension officers, and other key players is also essential to build capacity and ensure that the necessary skills are in place for effective implementation. Establishing policies or programs that incentivize the adoption of proven technologies and practices, such as subsidies, grants, or recognition awards, can further encourage widespread adoption. Additionally, advancing partnerships between public and private sectors, non-governmental organizations, and community groups can leverage resources and expertise for scaling up successful interventions.

By taking a structured approach to documenting and sharing the lessons learned, and actively promoting the replication of effective models, we can ensure that the benefits of these technology interventions extend well beyond the initial group of participating farmers. This will not only enhance agricultural productivity and sustainability in Jamaica but also serve as a valuable blueprint for similar efforts in other regions and sectors.

3 Addressing threats to agricultural production

To address the threats to agricultural production in Jamaica posed by hydrometeorological hazards such as drought, hurricanes, and floods, it is essential to implement a combination of resilient farming practices that can mitigate the impact of these hazards. Key lessons and best practices that can be scaled and replicated in Jamaica include the following: Implementing **water harvesting and storage systems**, such as rainwater harvesting, building ponds, and installing water storage tanks, can help farmers cope with drought conditions and ensure water availability during dry periods. Encouraging the **use of drought-resistant crop varieties** that require less water and are more resilient to water stress, alongside the adoption of climate-smart agricultural practices that focus on water conservation and efficient water use, is crucial. **Mulching**, a practice where organic or inorganic materials are placed on the soil surface to conserve moisture, suppress weeds, and improve soil health, should be promoted to retain soil moisture and reduce water evaporation during dry periods. **Terracing techniques** on sloping land can reduce soil erosion caused by heavy rainfall and flooding, slowing down water runoff, retaining soil moisture, and preventing soil degradation. **Agroforestry practices**, which integrate trees and shrubs into agricultural landscapes, can improve soil structure, enhance water infiltration, provide shade for crops, and increase biodiversity resilience to extreme weather

events. Encouraging **crop rotation and diversification** can reduce the risk of total crop loss from extreme weather events, spreading risk and ensuring food security in the face of climate variability. Promoting **soil conservation techniques** such as contour ploughing, cover cropping, and erosion control measures can prevent soil erosion and nutrient loss during heavy rainfall and flooding events. Establishing community-based **early warning systems** to alert farmers about impending hydrometeorological hazards can help farmers prepare in advance and minimize crop damage. Providing **training and capacity building programs** to educate farmers about climate-smart agricultural practices, sustainable land management, and disaster risk reduction strategies is essential to empower them with the knowledge and skills to adapt to changing climate conditions. Advocating for **policies that support climate-resilient agriculture** and providing incentives for farmers to adopt sustainable farming practices, in collaboration with government agencies, NGOs, and other stakeholders, can create a conducive environment for scaling up resilient farming practices.

3.1 Measures to minimise the impacts of strong winds

To minimize the impacts of strong winds on the agriculture sector in Jamaica, integrating windbreaks and raised beds can be effective strategies. **Establishing windbreaks** by planting **rows of trees and shrubs** along the edges of fields or in strategic locations can shield crops from strong winds, and choosing **wind-resistant species** that can withstand high winds is essential. **Creating living fences** using dense vegetation such as **hedges or bushes** can serve as natural windbreaks, reducing wind speed and protecting crops from wind damage. Encouraging farmers to plant windbreaks around the **perimeter of their fields** can create a barrier that deflects strong winds away from crops. Implementing **raised beds** or mounds for planting crops can **elevate them above ground level**, improve drainage, prevent waterlogging during heavy rains, and reduce the risk of **soil erosion** caused by strong winds. Enhancing **soil structure** by using organic matter such as **compost or mulch** can create raised beds that are more resilient to wind erosion, helping anchor plants and protect them from wind damage. Planting crops **in rows or blocks** can create a more compact planting arrangement that reduces wind exposure and protects crops from damage. Practicing **companion planting** by intercropping wind-sensitive crops with more wind-tolerant species can provide mutual support and protection against strong winds. Implementing **contour farming** techniques can reduce soil erosion and water runoff on sloping terrain, helping slow down the movement of water and prevent soil loss during heavy winds and rainfall. Planting **cover crops** such as grasses or legumes can protect soil from wind erosion, improve soil structure, and enhance water retention in the root zone. Constructing **physical windbreak structures** such as fences, walls, or hedgerows can provide additional protection to crops against strong winds. Using **greenhouses or high tunnels** can shield crops from wind damage and create a controlled environment that offers protection against extreme weather conditions. Establishing **monitoring systems** to track weather patterns and provide **early warnings** about impending strong winds can help farmers take preventive measures and protect their crops in advance.

3.2 Integrated water resources management (IWRM)

Integrated water resources management (IWRM) is crucial for **sustainable water use** in Jamaica, especially in agriculture. Lessons pertaining to IWRM, including **water capture, storage, and management solutions** such as **rainwater harvesting** and **low-cost water conservation techniques**, can help address **water scarcity** and improve **water resilience**. Implementing **rooftop rainwater harvesting systems** can capture rainwater runoff from buildings for various uses such as irrigation, livestock watering, and household chores. Using **storage tanks** to store harvested rainwater for future use during dry periods is essential, with proper maintenance of storage facilities to ensure water quality and availability. Promoting the use of **drip irrigation systems** that deliver water directly to plant roots can minimize water wastage and maximize efficiency in crop production. Encouraging farmers to use **mulching techniques** to retain soil moisture, suppress weed growth, and reduce water evaporation from the soil surface is also

beneficial. Utilizing low-cost **soil moisture monitoring devices** to assess soil moisture levels and optimize irrigation scheduling can help avoid water waste. **Community engagement** in water management decisions and conservation efforts is key to ensure sustainable use of water resources. Establishing **water user associations** or committees to coordinate water distribution, monitor water quality, and promote water conservation practices among farmers and other stakeholders can enhance community-based water management. Encouraging the reuse of **greywater** from household activities such as bathing and washing for non-potable purposes like irrigation or cleaning can further conserve water. Implementing low-cost **wastewater treatment technologies** to recycle treated wastewater for agricultural or industrial purposes reduces freshwater demand. **Watershed management** through ecosystem-based approaches such as reforestation, soil conservation, and wetland restoration can protect watersheds, enhance water quality, and regulate water flow. Preserving **natural ecosystems** such as wetlands, forests, and mangroves plays a vital role in regulating water resources, reducing erosion, and improving water quality. Developing and enforcing **water management policies**, regulations, and incentives to promote sustainable water use, protect water resources, and ensure equitable access for all stakeholders is crucial. Integrating **water resources management** into broader development planning processes can foster coordination among sectors and stakeholders for effective water governance.

3.3 Pre and post-harvest best practices

Implementing pre and post-harvest best practices is crucial for improving the quality, shelf life, and market value of agricultural products in Jamaica. These practices can significantly enhance the productivity and profitability of selected value chains and crop subsectors in the region.

Pre-harvest best practices focus on optimizing the conditions for crop growth. Effective soil management is fundamental; it involves conducting soil testing to determine nutrient levels and pH, followed by the application of appropriate fertilizers to optimize crop growth. Soil conservation practices such as cover cropping, mulching, and contour ploughing are also essential to prevent erosion and maintain soil health. Efficient water management through the implementation of irrigation systems ensures crops receive adequate water without wastage, and monitoring soil moisture levels helps adjust irrigation schedules to avoid under or over-watering. Selecting crop varieties suitable for local growing conditions and market demand, along with practicing crop rotation, can improve soil fertility, control pests and diseases, and reduce weed pressure. Integrated Pest Management (IPM) is another critical practice, combining cultural, biological, and chemical control methods to manage pests and diseases, with an emphasis on biopesticides and organic methods to minimize chemical residues. Lastly, harvest planning involves harvesting crops at the appropriate stage of maturity and training farm workers on proper techniques to minimize damage during harvest.

Post-harvest best practices are equally important to maintain the quality of the produce after it has been harvested. Proper harvest handling is essential to avoid bruising, cuts, and other physical damage, using appropriate tools and equipment to minimize post-harvest losses. Cleaning and sanitizing harvesting tools, containers, and processing equipment prevent contamination and spoilage, while washing harvested produce using safe and suitable methods removes dirt, debris, and pathogens. Rapid cooling of harvested produce to the optimal storage temperature extends shelf life and maintains quality, and storing crops in well-ventilated, clean, and pest-proof facilities helps prevent spoilage and maintain freshness. Appropriate packaging and labelling protect the produce during transportation and storage, with labels providing necessary product information such as the name of the crop, origin, date of harvest, and handling instructions. Maintaining cold chain integrity during transportation ensures the quality and freshness of perishable crops, and collaborating with reliable transportation partners guarantees timely delivery to markets or processing facilities.

By adhering to these pre and post-harvest best practices, Jamaican farmers can significantly enhance the quality and marketability of their agricultural products.

3.4 Gluts and marketing delays

Jamaica, like many island nations heavily reliant on agriculture, faces a unique set of challenges when it comes to getting produce to market efficiently. One of the primary issues is the occurrence of gluts (i.e. excess produce), which are often driven by the seasonality and weather patterns in the region. Jamaica's tropical climate, characterized by distinct wet and dry seasons, frequently leads to the simultaneous harvesting of specific crops. This concentration results in oversupply, causing prices to crash. Additionally, extreme weather events such as hurricanes can devastate harvests, further disrupting supply chains. Another contributing factor is the lack of diversification in the agricultural sector, with a heavy reliance on a few key export crops like bananas, sugar, and coffee. This over-reliance makes the market vulnerable to price fluctuations and increases the risk of gluts if demand for these specific products drops. Moreover, insufficient cold storage facilities and agro-processing capacity mean that excess produce often goes to waste, as farmers lack the means to preserve it or transform it into value-added products.

Marketing and distribution of agricultural produce also present significant challenges. A large portion of Jamaica's produce is sold through informal market systems, making it difficult to track supply and demand accurately. This exacerbates gluts and leads to inconsistent pricing. Small-scale farmers, in particular, struggle to access larger markets, both domestically and internationally. Factors such as high transportation costs, stringent quality standards, and competition hinder their ability to reach these markets. Additionally, inadequate infrastructure, including poor road conditions in rural areas and limited access to reliable transportation options, creates bottlenecks and delays in getting produce to markets. These logistical issues increase spoilage and reduce profits for farmers.

Market intelligence can play a key role in addressing these challenges. Effective data collection and analysis are essential for gathering real-time information on market demand, prices, and supply levels. This data can help farmers make informed decisions about what to plant, when to harvest, and how to price their products. Improved market information systems are also crucial, as they establish platforms to share this valuable market information widely and effectively with farmers, traders, and policymakers. Adopting stronger value chain coordination is key, and involves creating stronger linkages between farmers, processors, exporters, and retailers to reduce information asymmetry and improve coordination throughout the supply chain.

3.5 Benefits of agroecological practices and agro-silvo-pastoral systems

Adopting agroecological practices and agro-silvo-pastoral systems¹ can significantly increase resilience to hurricanes and tropical cyclones. Diversified production, which integrates a mix of crops including wind-resistant varieties, reduces the risk of total crop loss from a single extreme weather event. Improved drainage and water management techniques, such as contour farming, terracing, and the use of cover crops, enhance soil structure, reduce runoff, and minimize waterlogging and flooding. Windbreaks and shelterbelts, created by strategically planted trees, act as barriers that reduce wind speed and protect crops from damage. Moreover, agroecological practices promote stronger root systems through healthy soil with increased organic matter, making plants better equipped to withstand heavy rains and winds.

These practices also offer substantial environmental benefits. They enhance soil health by improving soil fertility, structure, and water retention through reduced tillage, cover cropping, and the incorporation of organic matter. Biodiversity is promoted by maintaining a diverse mix of crops, trees, and livestock, which supports beneficial insects, pollinators, and wildlife, creating a more resilient ecosystem. Water conservation is improved as healthy soils reduce runoff and enhance water infiltration, thereby reducing the need for irrigation. Additionally, carbon

¹ Agro-silvo-pastoral system is a sustainable land use practice that combines livestock production with agriculture and forestry.

sequestration is increased as trees and healthy soils act as carbon sinks, helping to mitigate climate change.

From an economic perspective, agroecological practices reduce input costs by relying on natural inputs like compost and manure, which decrease the need for expensive chemical fertilizers and pesticides. These systems also create diversified income streams by integrating crops, livestock, and potentially timber production, reducing reliance on a single product. Furthermore, the growing demand for sustainably produced food can open up new market opportunities, increasing market access for farmers.

Focusing on small farmers

It is crucial that this initiative prioritizes the needs of small farmers, who are often the most vulnerable to climate change impacts. This can be achieved by providing training and capacity building to equip farmers with the knowledge and skills necessary to implement these practices effectively. Financial assistance in the form of subsidies, grants, or microloans can support the transition to agroecological systems. Additionally, facilitating connections between small-scale farmers using sustainable practices and buyers seeking these products can enhance access to markets.

Embracing agroecological practices and agro-silvo-pastoral systems, not only benefits farmers by improving their livelihoods and reducing vulnerability to climate change but also enhances environmental health and contributes to the economy.

3.6 Technological interventions

While agroecological practices provide a strong foundation for sustainable agriculture in Jamaica, incorporating appropriate technology can further enhance resilience, productivity, and market access. Technological interventions can play a vital role in addressing specific challenges and improving overall agricultural efficiency.

Smart irrigation systems

Addressing water scarcity is a critical issue in Jamaica, particularly during the dry season. Smart irrigation systems, which utilize sensors and data analysis, can optimize water use by delivering the precise amount needed by crops at the right time. This approach conserves water, reduces costs, and improves yields. Additionally, in coastal areas where saltwater intrusion can be problematic, smart irrigation combined with soil sensors can monitor and manage salinity levels, preventing crop damage.

Protected agricultural systems (greenhouses and hydroponics)

Greenhouses offer climate control, protecting crops from extreme weather events such as hurricanes, intense rainfall, and excessive heat. This controlled environment allows for year-round production and higher-quality yields. Hydroponic systems, which grow plants in nutrient-rich water solutions instead of soil, significantly reduce water consumption compared to traditional farming methods. These enclosed systems also aid in pest and disease management, minimizing the need for chemical pesticides.

Low-cost rainwater harvesting infrastructure

Water security is crucial in water-scarce regions like Jamaica. Implementing simple, low-cost rainwater harvesting systems, such as rooftop collection, can provide a reliable source of irrigation during dry spells. This infrastructure ensures that farmers have access to a sustainable water supply, enhancing their resilience to drought conditions.

Improved storage facilities

Reducing postharvest losses is essential for increasing farmers' incomes and reducing waste. A significant portion of produce in Jamaica is lost after harvest due to inadequate storage and transportation. Investing in improved storage facilities, including cold storage, can extend the

shelf life of perishable crops. This enables farmers to better time their market entry, allowing them to sell when prices are more favourable and avoid market gluts.

Drone technology

The Agriculture and Fisheries Ministry in Jamaica is investing in drone technology to revolutionize farming with a focus on efficiency and sustainability. Through the Rural Agricultural Development Authority (RADA), the Ministry has acquired two Agri-Spray Drones aimed at aiding farmers in crop irrigation, aligning with the 'Grow Smart, Eat Smart' initiative. During a recent demonstration at an onion farm in St. Thomas, the drones showcased their capability to precisely address farming issues using multi-spectral cameras, which detect plant health problems more accurately than the human eye. The drones can spray one acre in 20 minutes, significantly reducing labour and chemical waste. RADA encourages its 257,000 registered farmers to form groups and request drone services via a mobile app or extension officers, promoting the adoption of this advanced technology to enhance farming practices.

Key considerations

To ensure the successful adoption of these technologies, affordability and accessibility are paramount. Technologies must be affordable and accessible to small-scale farmers, potentially through government subsidies, microfinance programs, or collaborative ownership models. Additionally, farmers will need training and support to effectively use and maintain new technologies. Integrating renewable energy sources, such as solar power, into these technologies can further reduce costs and environmental impact.

4 Access to finance for technology adoption

Access to finance is a pivotal enabler for the successful adoption of technological interventions in Jamaica's agricultural sector. While the roadmap outlines a range of promising technologies, many of these require upfront investment that is often beyond the reach of smallholder farmers, who make up the majority of Jamaica's agricultural workforce.

4.1 Financing mechanisms

To ensure equitable access and widespread adoption, the following financing mechanisms should be considered:

1. Microfinance and agricultural credit schemes

Tailored microfinance products, including low-interest loans and flexible repayment terms, can help small farmers invest in technologies such as smart irrigation systems, cold storage units, or mobile-based market platforms. These schemes should be designed with seasonal income patterns in mind and supported by financial literacy training.

2. Government subsidies and incentive programs

Public sector support is essential to reduce the cost burden of technology adoption. This could include:

- **Subsidies** for purchasing approved technologies
- **Tax incentives** for aggrotech investments
- **Matching grants** for farmer cooperatives or community-based technology hubs

3. Blended finance and public-private partnerships

Blended finance models, which combine public funds with private investment, can de-risk agricultural technology projects and attract capital. For example, donor funding could be used to guarantee loans or provide first-loss capital, encouraging banks and aggrotech companies to engage with smallholder farmers.

4. Digital financial services

Expanding access to mobile banking and digital wallets can facilitate easier transactions, savings, and access to credit. Integrating these services with agricultural platforms can streamline payments for inputs, services, and produce sales.

5. Crop insurance and risk mitigation tools

Affordable crop insurance schemes can protect farmers from climate-related losses, making them more creditworthy and willing to invest in new technologies. Bundling insurance with loans or technology packages can further enhance uptake.

6. Group financing and cooperative models

Encouraging farmers to form cooperatives or technology user groups can enable collective bargaining for better loan terms, shared ownership of expensive equipment, and pooled resources for maintenance and training.

7. Financial literacy and advisory services

Building farmers' capacity to manage credit, assess investment risks, and understand return on investment is essential. Extension services and NGOs can play a key role in delivering these trainings.

4.2 Additional considerations for strengthening financial access

In addition to direct financing mechanisms, several broader strategies can help strengthen financial access for smallholder farmers in Jamaica. Financial institutions such as commercial banks, credit unions, and agribusinesses can play a pivotal role by developing tailored products like input financing tied to contract farming, equipment leasing schemes, and weather-indexed insurance. These institutions can also partner with farmer cooperatives to reduce transaction costs and improve loan performance, making credit more accessible and manageable.

Development banks and multilateral agencies—including the Caribbean Development Bank (CDB), the Inter-American Development Bank (IDB), and the Food and Agriculture Organization (FAO)—can provide catalytic support by funding pilot financing schemes, offering technical assistance to local financial institutions, and supporting policy reforms that improve credit access. Their involvement can help scale successful models and ensure long-term sustainability.

Government policy is another key lever for expanding access to finance. Establishing a national credit guarantee scheme can reduce the risk for lenders, while creating a dedicated agrotech fund can support innovation and adoption. Streamlining land titling and collateral systems will also help farmers qualify for loans, particularly those operating on informal or communal land.

Ensuring gender-responsive financing is essential, as women farmers often face greater barriers to accessing credit. This can be addressed by designing gender-sensitive loan products, supporting women-led cooperatives, and ensuring that financial literacy and training programs are inclusive and accessible to all.

Finally, robust monitoring and evaluation of financial inclusion efforts is necessary to ensure equity and effectiveness. Tracking the uptake of financial products by farmer type—such as size, gender, and region—alongside monitoring repayment rates and technology adoption outcomes, will provide valuable insights for refining and scaling financing strategies. These data-driven approaches will help ensure that financial models are responsive to the diverse needs of Jamaica's farming communities.

5 Conclusion

The strategic roadmap outlined in this report presents a comprehensive framework for implementing technological interventions in Jamaica's agricultural sector, emphasizing sustainability and the empowerment of smallholder farmers. The challenges faced by Jamaican agriculture—ranging from climate vulnerability and low productivity to inadequate post-harvest infrastructure and market access—require innovative solutions that leverage both technological advancements and agroecological practices.

By focusing on key areas such as smart irrigation, pest alerts, improved cold storage, digital marketing platforms, and capacity building, this roadmap lays the groundwork for enhancing the resilience and productivity of the agricultural value chain. The integration of these technological interventions has the potential to significantly reduce post-harvest losses, improve crop quality, and increase farmers' incomes, thereby contributing to food security and economic growth in Jamaica.

A critical enabler of this transformation is access to finance. Many of the recommended technologies require upfront investment, which can be a significant barrier for smallholder farmers. The roadmap therefore emphasizes the importance of developing inclusive and innovative financing mechanisms—ranging from microfinance and digital financial services to blended finance models, government subsidies, and cooperative-based approaches. Strengthening the role of financial institutions, development banks, and policy frameworks will be essential to ensure that farmers can access the capital they need to adopt and sustain new technologies. Gender-responsive financing and robust monitoring of financial inclusion will further ensure that these benefits are equitably distributed.

Moreover, stakeholder engagement is crucial to the success of these interventions. By fostering collaboration among farmers, government agencies, NGOs, technology providers, and other key players, the roadmap ensures that solutions are context-specific and tailored to the unique needs of local communities. This participatory approach not only builds trust but also encourages shared ownership of initiatives, facilitating a smoother transition to new technologies.

The proposed pilot projects and scaling-up strategies are essential steps toward demonstrating the feasibility and effectiveness of these interventions. Rigorous monitoring and evaluation will provide valuable insights for continual improvement and adaptation, ensuring that the technologies remain relevant and beneficial to farmers over time.

Ultimately, the success of this roadmap hinges on a commitment to long-term support, financial incentives, and systematic documentation of lessons learned. By replicating successful interventions across Jamaica and potentially in other regions, a model for sustainable agricultural development can be created, that empowers smallholder farmers, enhances food security, and fosters economic resilience.

In conclusion, by embracing a holistic and inclusive approach to technological interventions—grounded in innovation, collaboration, and financial accessibility—Jamaica has the opportunity to transform its agricultural landscape, making it more sustainable, productive, and capable of withstanding the challenges posed by climate change and market dynamics.

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