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Digital Agriculture Profile • Grenada

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HIGHLIGHTS

The agricultural sector of Grenada employs 13.8% of the labor force and the total value of agricultural exports is US$13.4 million

Extreme weather, biophysical island characteristics, low-quality standards, and low economies of scale in production are the **primary challenges** facing Grenadine agriculture

Digital infrastructure and usage is well established in Grenada; there are 111 mobile-phone subscriptions for every 100 inhabitants. The primary constraints to digital agricultural solutions are low digital literacy rates of user groups along the value chain and the economies of scale

The most promising technologies for addressing agricultural issues in Grenada include Internet-based information sharing, advanced analytics with SMS / IVR[1] communication technologies for market analysis and advisory services, bar coding for traceability of agricultural, and technologies for land tenure determination

The public sector, nonprofit organizations, private industry, and international community **all have important and distinctive roles to play** in creating sustainable digital agricultural solutions in Grenada

1 Short Message Service / Interactive Voice Response.
2 Gross National Income.
3 Information Communication Technology.

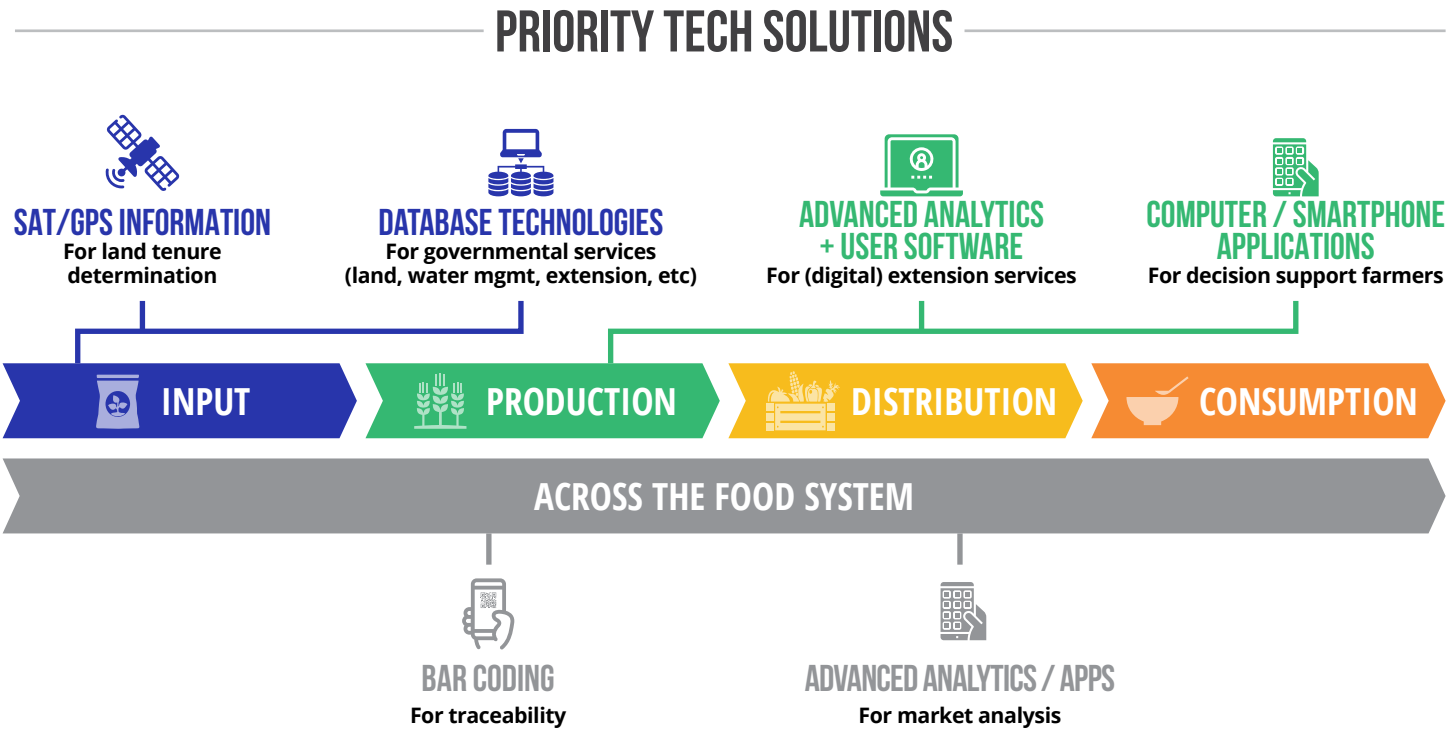
91.4% OF GRENADINES HAVE **ELECTRICITY**

100% MOBILE PHONE PENETRATION FOR SEVERAL YEARS

BETWEEN 2016 AND 2018 MOBILE SUBSCRIPTIONS HAVE INCREASED FROM **37%** TO **56%**

A STANDARD MOBILE-BROADBAND PLAN WITH A DATA ALLOWANCE OF 500 MB PER MONTH COSTS **3.7%** OF THE GNI[2] PER CAPITA

GRENADA RANKS **73RD** WORLDWIDE ON THE ICT[3] DEVELOPMENT INDEX



Introduction

Recent years have brought significant new challenges, as well as important investment opportunities, to agriculture in Grenada. The sector's principal exports remain in high demand. However, Grenadian agriculture lacks the contemporary technologies and decision support tools necessary for sustaining and improving yields. This challenge is exacerbated by climate change; Grenadian farmers are grappling with increasingly volatile weather, more frequent extreme weather events, and accelerated environmental degradation, all of which have recently brought significant long-term damage to entire subsectors of the agricultural economy. Other stakeholders along agricultural value chains, including input providers, distributors, and consumers, also face substantial challenges, including lack of product quality, high input prices, lack of information on best practices, and lack of market information for informed decision making.

One possible solution to address these challenges is digital agriculture. While the concept of digital agriculture is relatively new and still evolving, foundational technologies such as mobile and Internet connectivity are already available to support innovative digital solutions to the biggest challenges faced by the agricultural sector. Furthermore, the pre-dominantly high value nature of the agricultural products being cultivated in Grenada means THAT production is commercially-focused and opens the doors for digital services.

Digital agriculture is the use of new and advanced technologies, integrated into one system, to enable farmers and other stakeholders to improve their products and processes.[4] Integrating digital solutions into agriculture can improve efficiency by decreasing financial and labor costs, by providing information to support management decisions, by increasing product quantity and/or quality, by reducing losses, and/or by ensuring effective and sustainable use of resources. Ultimately, the transition to digital agriculture presents a unique opportunity to spur sustainable economic growth and development by addressing agriculture's biggest challenges.

As part of the initiative on Digital Agriculture Transformation led by the World Bank, this Digital Agriculture Profile for Grenada leverages the expertise of stakeholders to evaluate the current landscape of digital agriculture in the country, including its key players across value chains, the main barriers faced, and the potential to overcome these barriers through the adoption of innovative technologies. In identifying and prioritizing these technologies, we aim to support investors and implementers in maximizing

4 United Nations, "Digital Agriculture."

their impact by focusing on the opportunities of highest potential. Once enabling factors are identified and understood, the mainstreaming of digital agriculture in Grenada can begin in earnest.

National Context

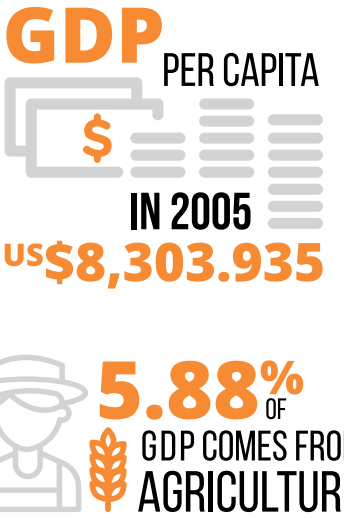
Economic relevance of agriculture

Agriculture has historically played a prominent role in the economies of Caribbean island states. While agriculture continues to contribute to the livelihoods of thousands of citizens in Grenada, tourism started to gain standing as the region became more recognized and travel became more accessible. Today, tourism accounts for 25% of total GDP (US$1.13 billion) and is the cornerstone of the national economic sector.[5] The agricultural sector of Grenada employs 13.8% of the labor force, contributes 5.8% of the Gross Domestic Product, and accounts for to US$13.4 million in export value. The primary threats to agriculture in Grenada are natural disasters such as hurricanes, international competition for trade, and pests and diseases.[6]

Grenada is known as the Spice Island; spices such as nutmeg and mace are the country's principal exports. In general the Grenadian GDP has shown near-constant growth over the last decades. Up to 2004, nutmeg dominated the Grenadine agriculture sector, comprising 80% of total export value[7] and 25% of world production. However, the hurricane seasons of 2004-2005 devastated the Grenadian economy. Hurricane Ivan alone caused damages equivalent to 200% of GDP,[8] destroying huge swaths of the island's nutmeg trees. Replanting alone is a massive task; in addition, the trees require nearly a decade of growth from planting until first harvest.

Today, the nutmeg sector is beginning to recover its prior position as the most important national export, and now constitutes 30% of the agricultural GDP.[9] Spice exports as a whole reached a value of nearly US$10 million in 2016.[10] Nevertheless, threats to the nutmeg industry continue, including natural disasters, competition from Asian exporters, and nutmeg wilt disease. The Grenadian government has consequently prioritized nutmeg, along with the cocoa industry, for programs and projects.[11]

Primary imports include chicken (16.2% of value), wheat (10%), milk and cheese (8.5%), and rice (3.1%). The size of this small island state means that food imports are both crucial to national food security and to upholding other economically important sectors, such as tourism.



Agricultural production systems

Grenada is composed of seven (three primary) mountainous, volcanic islands in the Eastern Caribbean. The total land area is 340 km², 23.5% of which is dedicated to agriculture. Although this figure has remained somewhat constant since 2009, there has been an overall decline in agricultural land coverage since the 1970s. In the 1960s, agriculture accounted for 64.7% of total land area. The sharpest decline occurred during the devastating 2004-2005 hurricane season, which reduced agriculture from 35.2% to 20.6% of land area in a matter of months.

British sugarcane plantations dominated the agricultural landscape throughout the mid-nineteenth century, when nutmeg rose in popularity.[12] Primary crops according to production quantity include sugarcane (7,250 tonnes/year), coconut (6285 tonnes/year), bananas (3,177 tonnes/year) and spices (nutmeg, mace and cardamom) (2,589 tonnes/year).

5 Nelson, "Tourism, Agriculture, and Identity: Comparing Grenada and Dominica."

6 Caribbean Climate Smart Agriculture Forum, "Climate Change and Agriculture: Policies, Strategies, and Actions."

7 Akpinar-Elci et al., "Occupational Exposure and Respiratory Health Problems among Nutmeg Production Workers in Grenada, the Caribbean."

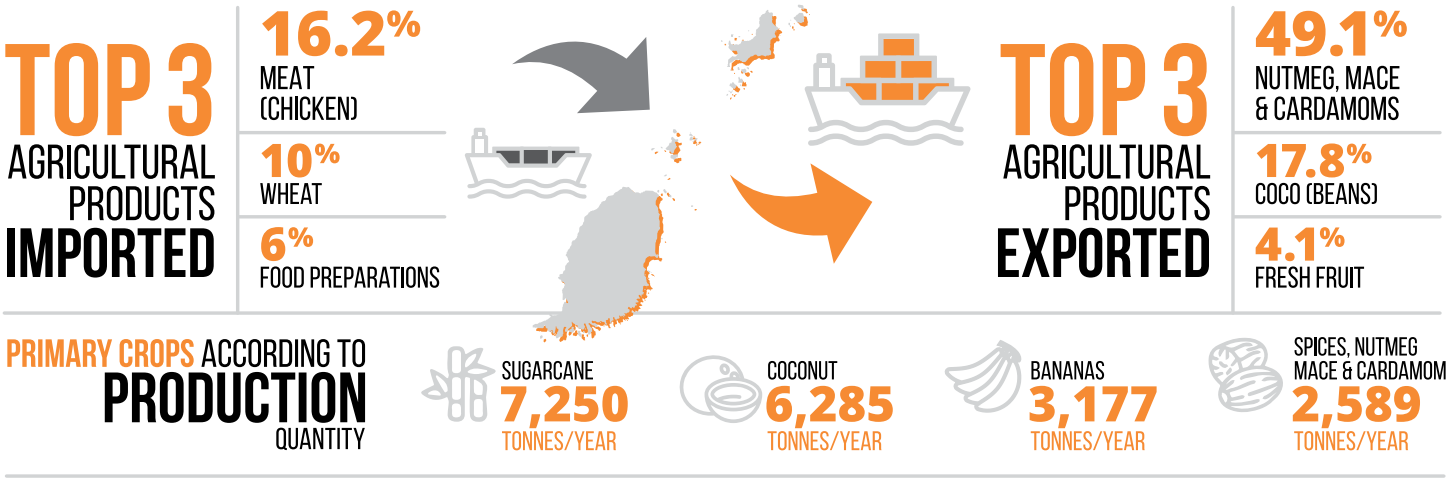
8 Food and Agriculture Organization of the United Nations, "Introduction to Grenada and Its Agriculture Sectors."

9 World Bank, "Data."

10 OEC, "Grenada Export, Import, and Trade Partners."

11 Lewis, "Grenada."

12 OEC, "Grenada Export, Import, and Trade Partners."



People, livelihoods and agriculture

Grenada is home to 107,825 people, 64% of whom live in rural areas. Nearly 97% of people have access to potable water, and 91.4% have electricity. Most (98.9%) of youth are literate, indicating good educational services. Grenada is ranked at 75 in the world on the Human Development Index with a score of 0.772, placing it in the "medium development" category. There are no published poverty statistics. However, as of 2005, 6% of the urban population lived in slums. Grenada is not included in the Gender Inequality Index.[13] Nutritional health is an issue in Grenada, both for malnutrition and obesity. In 2016, in the adult population, 23.5% of women had anaemia, and diabetes prevalence was 13.3% amongst women and 8.8% in men. Additionally, 29% of adult women and 13.3% of adult men suffered from obesity.[14] Of the 4,003 registered commercial farmers in the nation, 78% are male and 22% are female.[15] The average farm size in Grenada is just 0.1 ha for food crops and 0.84 for permanent crops and trees.[16] The majority of producers (80%) in Grenada are small-scale farmers with plots of less than 0.2 ha.

Challenges in the agricultural sector

A number of challenges have slowed overall agricultural development in Grenada, generally leading to low farmer household incomes and minimal innovation. Among these, extreme climate events likely rank first. At least 12 hurricanes or tropical storms have affected Grenada in the last 50 years, with substantial economic losses for the agricultural sector. Estimated damage to agriculture from Hurricane Ivan in 2004 amounts to nearly US$45 million, including tree crops, food crops, livestock, fisheries and agricultural infrastructure. Given that nutmeg trees take at least seven years to become productive and 20 years to reach full productivity, the impacts of both damage and development initiatives take time to become apparent. Grenada has also experienced warming temperatures, fluctuations in rainfall, and higher tropical storm intensity.[17] Vulnerability to these extreme events is exacerbated by the dominance of small-scale family farms. With the exception of high-value spice crops, such small operations are not economically viable when a significant portion of the farm income goes toward regular disaster recovery. Lack of economic viability and high climate risk also means that farmers cannot easily access credit and insurance.

Biophysical factors contribute to low levels of agricultural economic growth. Mountainous topography limits the use of machinery to enhance labor productivity; energy and input import prices are high; freshwater supplies are limited; and pests and diseases are common. The island is also particularly vulnerable due to significant erosion.[18]

Current land tenure regimes in Grenada dissuade producers from making long-term investments to enhance agricultural outputs. The absence of an efficient land registration system impedes titling and ownership. Furthermore, Caribbean Commonwealth policy dictates that intergenerational family land, which accounts for 15% of the country, remained undivided and co-owned by descendants of the original land purchased. While this provides important welfare functions in terms of enabling all co-owners to live on and cultivate the land,

13 United Nations Development Programme, "Gender Inequality Index."

14 Global Nutrition Report 2019, "Grenada Nutrition Profile".

15 Government of Grenada, "Grenada Food and Nutrition Security Situation Analysis."

16 Caribbean Climate Smart Agriculture Forum, "Climate Change and Agriculture: Policies, Strategies, and Actions."

17 Caribbean Climate Smart Agriculture Forum.

18 World Bank, CIAT, and CATIE, "Climate Smart Agriculture in Grenada."

it also prevents ownership of planted crops (meaning others retain the right to harvest them) and use of land as collateral for financing. Squatting on public lands is also commonly practiced. A land development policy was drafted in the late 1980s with the intention of optimizing land use. However, the policy was never implemented due its high cost and low political will.[19]

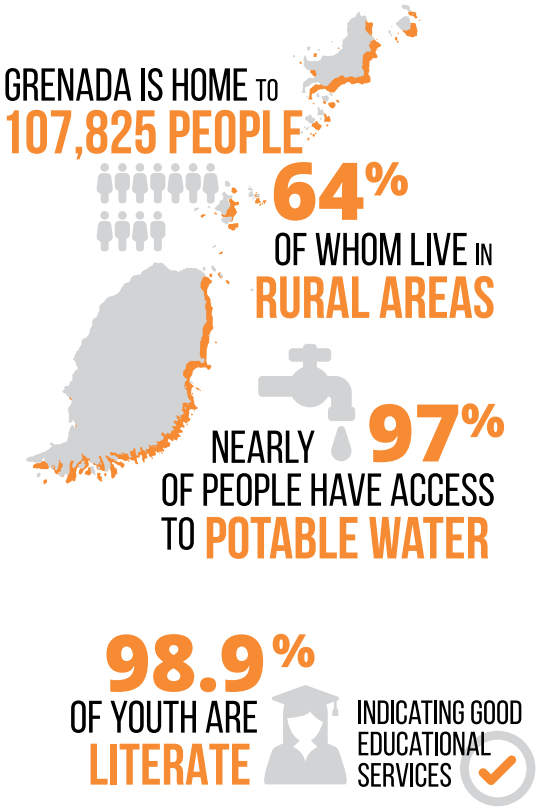
Socio-economic issues also come into play. Domestic markets are quite small and limited by the size of the island. Low quality standards and relatively high production costs limit international market access. Fragmented and informal land tenancy has led to significant areas of arable land being underused or neglected entirely. Youth are generally disengaged from agriculture, leading to an aging and decreasing population of producers. The relatively low capacity of agricultural stakeholders in terms of quality control, business management, marketing, use of climate information, and farm innovation, limit the sector's ability to develop sustainable solutions to twhe challenges it faces.

Current landscape of digital tools and policies

Digital infrastructure, availability and access

Grenada has shown drastic improvements in recent years both in terms of digital infrastructure and digital adoption rates. The 2017 ICT[20] Development Index scores Grenada at 5.8, up from 2016 both in terms of raw score (5.39) and overall global rank.[21] GSMA[22] classifies Grenada as a fast-growering market in the Caribbean, with three network operators and 126,600 mobile connections, 89% of which are prepaid.

The Telecommunication Infrastructure Index scored Grenada at 0.40 in 2016 and at 0.47 in 2018. In both years, Grenada outranked the world and regional averages. From 2016 to 2018, the Internet penetration increased from 37% to 56% and wireless penetration skyrocketed from 1% to 33%. During that same time, broadband penetration increased slightly, from 17.9% to 19.4%, with an Internet speed of 5086 KBps[23] in 2017 and a monthly cost of US$44 USD.[24] Telephone penetration decreased slightly, from 27% to 25%.



19 FAO, "Grenada."

20 Information Communication Technology.

21 International Telecommunication Union, "Global ICT Development Index."

22 Groupe Spécial Mobile Association, also known as Global System for Mobile Communications.

23 Kilobytes per second.

24 ICT Pulse, "Snapshot."

Mobile phone penetration is over 100% of the population (indicating multiple subscriptions per person), but decreased from 126% to 111%; this suggests improved mobile subscription costs and/or coverage, thus disincentivizing the ownership of multiple numbers in order to facilitate contacting individuals on other networks. A mobile-broadband plans with a data allowance of 500 MB[25] per month 2017 costs approximately 3.6% of the GNI[26] per capita.[27] Grenada is not included in the Global Connectivity Index.[28]

Grenada scores 0.59 on the global Index for E-government,a composite measure of provision of online services, telecommunication connectivity and human capacity. This is higher than the world average of 5.5, and ranks Grenada as 89th globally.

Institutions and policies for digital agriculture

The primary national institution for all agricultural matters in Grenada is the Ministry of Agriculture, Lands, Forestry, Fisheries, and the Environment (MAG). Within MAG, responsibility for agriculture is shared among the Land Use, Extension, Farm Machinery and Mechanization, and Veterinary & Livestock divisions. There is a significant focus on climate change and climate-smart agriculture within MAG. The National Agricultural Plan aims to build sustainable food systems that align with regional and international policies, and support food security, economic growth, and robust export.[29] Digital solutions to enable these goals are beginning to surface. This plan specifically aims to increase the use of digital solutions, in particular social media, for export marketing, and to develop digital production cost models to strategically address the establishment of new fruit tree and root crops. However, it stops short of outlining a National Digital Agriculture Strategy. Nevertheless, some policies have already been put in place to begin to address this,[30] in particular in regard to drone usage - the Market Access and Rural Enterprise Development Program,[31] operated jointly by MAG and the Ministry of Works.

Support for production and marketing is provided by state-run purchasing agencies: the Marketing and National

GSMA CLASSIFIES GRENADA AS A FAST-GROWING MARKET IN THE CARIBBEAN WITH 3 NETWORK OPERATORS AND 126,600 MOBILE CONNECTIONS, 89% OF WHICH ARE PREPAID

THE TELECOMMUNICATION INFRASTRUCTURE INDEX SCORED GRENADA AT ✓

0.40 2016 & 0.47 2018

GRENADA OUTRANKED THE WORLD AND REGIONAL AVERAGES

PENETRATION RATE	2016	2018
INTERNET	37%	56%
WIRELESS	1%	33%
BROADBAND	18%	19.4%

IN 2017, A MONTHLY MOBILE PLAN WITH 500 MB COST APPROXIMATELY 3.6% OF THE GROSS NATIONAL INCOME (GNI) PER CAPITA

GRENADA SCORES 0.59 ON THE GLOBAL INDEX FOR E-GOVERNMENT HIGHER THAN WORLD AVERAGE OF 5.5 AND RANKS GRENADA AT 89th GLOBALLY

25 Megabytes.

26 Gross National Income.

27 ITU, "ICT-prices 2017".

28 Huawei, "Global Connectivity Index 2018."

29 Fitzroy, "Grenada National Agricultural Plan 2015-2030."

30 Center for International Agricultural Research, Grenada digital agriculture stakeholder workshop.

31 Latin America and Caribbean Division, "Market Access and Rural Enterprise Programme (MAREP)."

Importing Board (MNIB), the Grenada Cocoa Association (GCA), and the Grenada Cooperative Nutmeg Association (GCNA). Grenada's business community, including agriculture and agro-processing, is represented by the Grenada Chamber of Industry and Commerce (GCIC).

The nonprofit sector also includes many local and national agricultural producers' associations that focus on production and livelihoods, including the Grenada Network of Rural Women Producers (GRENROP). The nongovernmental Caribbean Agricultural Research and Development Institute (CARDI) in Grenada researches productivity innovation in the fruit, vegetable, and livestock sectors. CARDI's 2018-2022 strategy plan includes integrating traditional and new digital tools across all areas of operations. Additionally, they aim to invest in the institute's digital infrastructure and human capacity.[32]

There are a number of regional Caribbean organizations that coordinate policy and facilitate participation in global initiatives, particularly in terms of climate change. There are some examples of digital agriculture initiatives in other parts of the Caribbean;[33] however, no plans for international exchange of digital agriculture best practices or programs have been published to date.

End user diversity and demand

Digital agriculture end users can be grouped into four hubs: input, production, distribution and consumption. Each hub has unique resources and needs in terms of digital agriculture innovations, and each hub faces unique challenges for which digital agriculture could offer solutions.[34] The hubs are not mutually exclusive, as any given individual may function within multiple end user hubs. This section describes users within the four hubs, and their demand for digital agriculture technologies within each of the food system hubs.

The **Input** hub relates to the provision of agricultural inputs for crop and livestock production. Such inputs include seeds, feeds, agrochemicals, machinery, and finance. In Grenada, the input hub is primarily composed of local retailers of imported products. End users in this hub seek decision support tools for optimized input identification and selection, as well as improved product monitoring and traceability.

The **Production** hub is dominated by small-scale family farms with limited economic viability that are primarily oriented towards self-consumption and local markets, with the exception of the spice section and cocoa growers who focus on international markets. Despite generally low digital literacy rates, there is demand for digital agriculture solutions from Production hub end users. Advisory services, weather and vegetation dynamics monitoring, increased financial services access, and improved product traceability would all assist farmers in augmenting productivity and gaining access to international commodity markets.

The **Distribution** hub consists of all actors in the value chain between farmers and the consumer, such as traders, transporters, and processors. Food distribution in Grenada focuses on imports from the USA, primarily for hotels and resorts in the tourism sector. A distribution network for the export of raw nutmeg, bananas, cocoa, fruits, and vegetables is also well established. The processing and manufacturing industry consists of 265 small - and 9 medium - sized processors,[35] but the expensive value-added products, such as nutmeg oil and oleoresins, are all manufactured outside Grenada. Significant barriers for this hub include poor market access, low mechanization, and poor monitoring and traceability systems.

The **Consumption** hub has two major categories of food consumers: tourists who consume primarily from hotels, resorts, and restaurants, and Grenadians who consume directly from farms or from local grocery stores. In both cases, product monitoring and traceability offers important opportunities for consumers to make informed decisions in terms of the quality, origin, and environmental impact of their food purchases. This also enables producers of higher quality products to promote and market them as such.

Digital agricultural services and applications available

Digital agricultural solutions often develop organically as a result of large, diverse populations spread across challenging geography. Countries with sizeable land areas, poor road networks, or treacherous mountains are the first to turn to digital communications. This is not the case in Grenada, where the tiny population is limited to a very small land area. Similarly, the relatively small sized farms do not drive farmers to directly seek digital solutions when innovating their systems. As such, the market for digital agricultural solutions in Grenada remains nascent.

32 Clarke et al., "Building a Productive and Resilient Regional Agriculture Sector."

33 CARICOM Today, "Marrying Tourism and Digital Agriculture to Benefit Female Farmers in Saint Lucia."

34 The users in these groups, along with the key challenges these users face and the prioritized digital solutions to overcome these challenges, were identified through a consultation process and a workshop with the key experts in the (digital) agricultural sector in Grenada.

35 Caribbean Climate Smart Agriculture Forum, "Climate Change and Agriculture: Policies, Strategies, and Actions."

The digital solutions that have come about offer evidence of how effective digital solutions could be in Grenada.

There are no targeted digital agriculture services or projects currently in place in Grenada. Nevertheless, there has been some work done on data analysis, media, and knowledge sharing. For example, farmers already receive extreme weather event alerts through television and radio. Government-run television programs and media channels promote good agricultural practices. And most recently, The Online Agricultural Network is among the first Internet-based agricultural programs to have been piloted[36].

These initiatives are excellent foundations for tailored digital solutions, and an example of the sorts of novel forms of connectivity that could be established along the food systems to support each end user-hub.

Challenges for digital agriculture

Although the majority of the country is connected to mobile or broadband Internet service, only a minority of professionals in the country are prepared to proficiently use and maintain back end service operations such as data management, machine learning, and GIS.[37] As was evident from the workshop and consultations many farmers are connected to the internet and have smartphones, but actual usage of features beyond SMS[38] is low, especially among small-scale producers and low-income consumers. Digital entrepreneurship in the agricultural sector is not currently incentivized, in part because the digital workforce is quite small.

Given that most farming is at a very small scale, Grenadian farmers reported that they generally do not keep track of data, and when they do, it is not done digitally. This proves to be a challenge for basic analyses and advanced analytics that could inform farmer credit profiles, insurance risk assessments, and other necessary steps toward providing crucial services.

The cost of technology remains out of reach for many stakeholders, particularly those in the production hub. This is particularly challenging for Grenadians because both the very small average farm size and the tiny national population prevent economies of scale from making technology an affordable investment.

36 "The Agricultural Network."

37 Geographic Information Systems.

38 Short Message Service.

Enabling Digital Agriculture

An important first step in leveraging digital agriculture to solve real-world problems is identifying the most promising technologies across multiple end user-barriers.[39] This process will enable investors and implementers to focus their efforts on areas of highest impact. Once enabling factors are identified and understood, the mainstreaming of digital agriculture in Grenada could become a reality.

Prioritized technologies and their impact potential[40]

Cross-cutting constraints include low traceability of agricultural products and a lack of decision support tools across the value chain. The most promising technologies to address these constraints include bar coding, advanced market analytics, and platforms for peer-to-peer knowledge sharing. Bar coding is most appropriate in the short to medium term for large commercial farmers; such technologies have very limited applicability and feasibility for smallholders. Market analytics and peer-to-peer knowledge-sharing platforms may be beneficial to a spectrum of producers. Platforms tailored specifically to the needs and usage patterns of either smallholders or commercial operations are likely to be most successful. Peer-to-peer platforms become increasingly valuable across time. Enabled by appropriate policies, the potential for scaling of advanced market analytics and knowledge-sharing platforms is greater compared with that of barcoding. This is likely because improved traceability through bar coding would primarily benefit those value chains that supply hotels and international markets. By contrast, enhanced traceability is expected to improve food system efficiency, mostly through increased precision and reduced transaction costs in the movement of products

39 In this analysis, we focus on identifying, for each of the end user hubs, the main challenges confronting the agriculture sector. We then identify, using participatory methods, a set of technologies and associated functions and outcomes. Table 1 and Figure 1-5 show the results of the technology prioritization across hubs. In Grenada, the prioritized technologies address 11 hub-specific and 3 cross-cutting challenges. Next, each technology was assessed across six dimensions: Progress (the current degree of development, use, maturity, scaling, uptake, and profitability of the technology), Policy and enabling environment (the degree to which policy, programs, and investments enable further development, adoption, and impact of the technology), Potential impact (the expected uptake and return on investments of the technology over the next decade), Efficiency (the extent to which the technology enhances food systems efficiency in terms of labor, inputs, yield, transport, and transaction cost reduction), Equity (the degree to which the technology breaks down barriers to equity, particularly in terms of youth and gender inclusivity), and Environment (the extent to which the technology supports environmental sustainability through waste reduction, greenhouse gas intensity reduction, and improved natural resource use efficiency). Each of these is assessed using a number of indicators. The results of the technology identification and assessment are described below, followed by a discussion of the policies, the role of the public and private sector, and the financing options available to support the promotion of the most promising technologies.

40 Disclaimer: These results are based on a combination of desk-research and on stakeholder consultation. The latter includes several with 5 interviews with the government, farmers and farmers association, as well as a one-day workshop with 22 Grenadian key experts in the fields of Agriculture, Policy and/or ICT.

across the value chain. Efficiency was also found to be high for peer-to-peer knowledge exchange platforms, improved knowledge is expected to enhance adoption of practices that improve resource use-efficiency and reduce transaction costs.

Insecure land tenure regimes and poor land-use planning for small-scale farms are the major constraints facing the **Input hub**. Satellite, GPS,[41] and insurance systems are extremely promising in this regard. The same is true for the provision of government services, including extension, water management, and early warning systems. The current level of use of these technologies is limited, and such large-scale services take time to implement. Nevertheless, they are crucial to all types of farmers, and hold great potential for boosting agricultural productivity by unlocking resource-use efficiency, promoting equity, and reducing environmental impacts. As such, identifying funding in the immediate term with the goal of implementing in the medium term is ideal. Policies for the implementation of digital land tenure, land use planning, and government services have yet to be put in place; a supportive policy environment for digital early warning systems is already well established.

The **Production hub** faces significant constraints in terms of a lack of decision support, low labor and resource use efficiency, and a lack of access to finance services. Four of the five most promising technologies identified aim to support farm management decisions: livestock health and location monitoring; Internet-based extension services; SMS / IVR[42] extension services; and advanced analytics to inform extension services. The fifth seeks to reduce labor and increase resource use efficiency through precision irrigation and input application. Livestock health and location monitoring is most feasible in the near to medium term for all farm sizes. In the short to medium term, Internet-based extension services may be helpful to smallholders, but will primarily be feasible for commercial operations, which are more likely to have Internet access. In contrast, SMS / IVR extension services are optimal for smallholders in the short term given existing infrastructure and degree of access. Data and model-driven advisory services would offer much-needed improvements in crop productivity and climate resiliency in the near term. Such services can also help unlock access to finance by capturing critical data to build household financial and farming profiles.

Traceability and transparency are the biggest constraints facing the **Distribution hub**, and automation is the primary means of addressing these obstacles. On the near to medium term, prioritized technologies include the use of robotics for processing and advanced analytics for monitoring and sorting. Robotics require significant upfront investment but may provide significant return over time. On the medium to long term, bar coding and blockchain can enhance traceability, thus facilitating access to international commodity markets.

The **Consumer hub** values product information but faces significant constraints in this regard. As such, the use of smartphone applications for e-labeling and nutritional information is very promising. Providing both tourists and local consumers with information on nutritional value, environmental footprint, and origin would increase the marketable value of high-quality and niche products and supports consumer purchase decision-making. Given each consumer groups' current degree of technology access and utilization, tourist-focused platforms are more feasible in the short term, while local consumers are a medium-term goal. Such systems can also assist in monitoring and tracking food waste and environmental impacts. Such systems can eventually also assist in monitoring and tracking food waste and environmental impacts.

Potential avenues for the public sector

The Grenada National Development Plan identifies information and communication technologies as a goal for the coming years. While this is an important first step, digital agricultural solutions have not yet been recognized or prioritized in national policy. Digital agricultural solutions greatly benefit in an enabling policy environment. As such, it is timely to begin outlining digital agriculture as a medium and long-term policy goal[43] in a National Digital Agriculture Strategy. Herein there is significant opportunity to consult with international actors, including the World Bank, in order to build on what has worked well for other island states and similar economies.

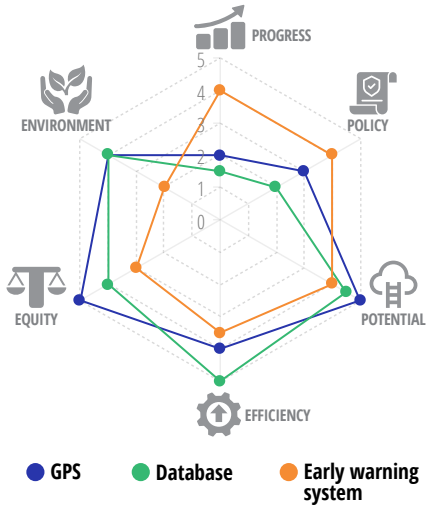
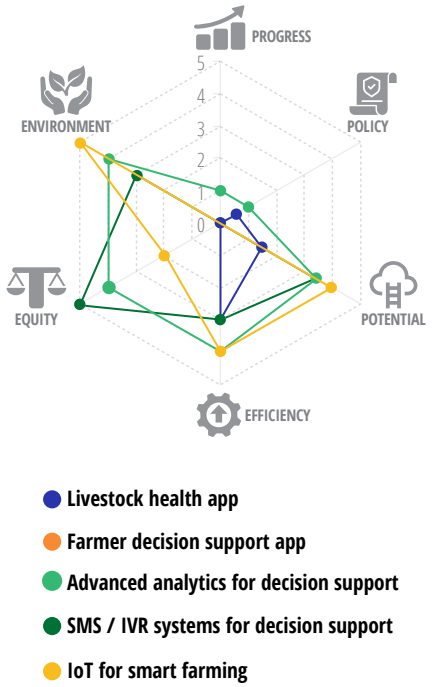
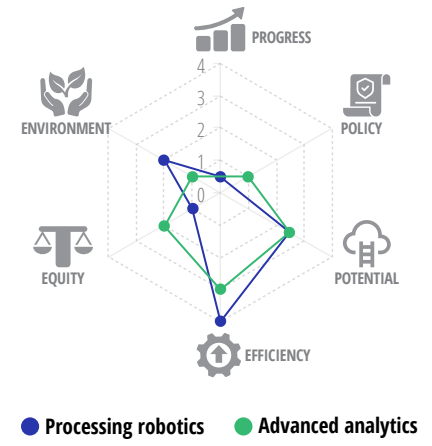
One key role of the *National Digital Agriculture Strategy* will be to pave the way for development of infrastructure and policy that optimizes technology and Internet access for all value chain actors. On the long term, this will enable more advanced technologies and services to be scaled, and will address capacity building and digital literacy issues. In the interim, time-sensitive information should be

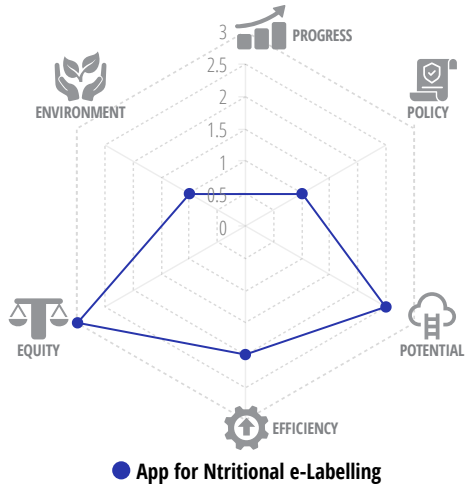
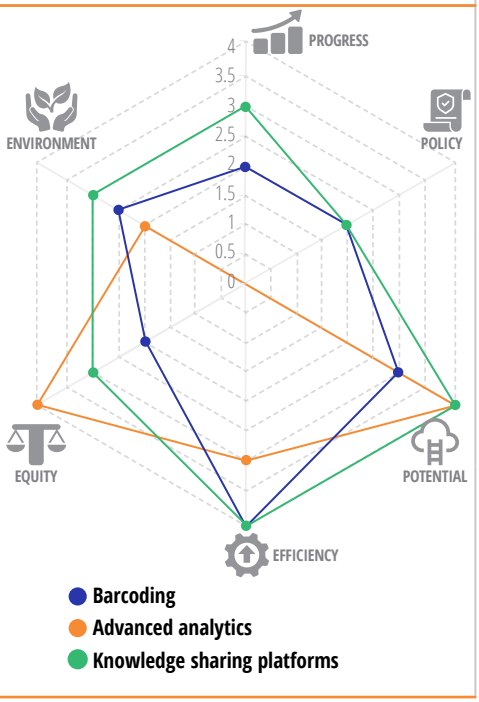
41 Geographic Positioning Systems.

42 Short Message Service / Interactive Voice Response.

43 Fitzroy, "Grenada National Agricultural Plan 2015-2030."

Assessment of digital technologies across the food-system in Grenada

	Challenge	Technology	Outcome	Analysis
INPUT HUB	How to improve the land tenure situation for smallholder farmers?	**Satellites/GPS information for land tenure determination**	Information for Implementing land tenure policies	
	How to improve Government services (extension, water, etc)	**Database technologies for governmental services (land, water management, extension, etc)**	Improved Government services for farmers and companies	
		Remote sensing/analytics for early-warming systems	Information for farmers to make timely decisions in crop management	
PRODUCER HUB	Effective and Efficient Farming Systems based on quantitative information	**Sensors/applications for real-time location/health information on livestock**	Better information on dispersed livestock systems to control health problems	
		Computer/smartphone applications for decision support farmers	Improved decisions in crop management to enhance efficiency and thus farmers income	
		Advanced analytics + user software for (digital) extension services	Improved extension advice in crop management to enhance efficiency and thus farmers income	
		SMS / IVR systems for decision support for lower tech farmers	Improved decisions in crop management to enhance efficiency and thus farmers income	
		IoT for input information/ smart farming/irrigation	Improved decisions in crop management and irrigation enhance efficiency and thus farmers income	
DISTRIBUTION HUB	Better efficiency of processing processes	**Robotics for processing mechanisation**	Reduced labor for higher quality processing of farm products	
		Advanced analytics for monitoring and sorting (post-production/ distribution)	Enhanced quality of final products by sorting and monitoring	

	Challenge	Technology	Outcome	Analysis
CONSUMER HUB	Lack of information access to nutritional, environmental footprint and origin information	**Smartphone applications for e-labeling and nutritional information**	Tracking and tracing enables all parties in the value chain to trace back in case of problems or for marketing	
CROSS-CUTTING HUB	Tracing and Tracking in the value chain	**Bar coding for tracebility**	Tracking and tracing enables all parties in the value chain to trace back in case of problems or for marketing	
	How to improve the market information for farmers and other players to make choices in the value chain	**Advanced analytics/Apps for market analysis**	All parties in the value chain make choices on crops, processing, storage etc. based on market information	
	Scaling of new approaches and the use of digital technologies	**Platforms for peer-to-peer knowledge sharing**	Widespread use of technologies by sharing of information and demos with peers	

conveyed via SMS / IVR[44] such that all farmers are able to access the service. The priority services for development in Grenada are outlined below.

Digital agricultural solutions offer important opportunities to improve existing public services and use of the same. Investments from within the governments and through multilateral development banks, such as the World Bank, are needed to fully leverage these opportunities. For example, the development of foundational database technologies and e-government systems would support better land and water resource management. App-based nutrition information can support health campaigns as well as the marketing of niche products through the tourist industry. Extension services can be provided at far less time and money cost using digital solutions. Importantly, our assessment shows that database technologies for governmental services, such as land tenure, would increase farmer tendency to invest in their farms.

Digital solutions would also support the development of national markets and overall GDP. Data collection and analytics would inform market system logistical optimization, strategic import/export planning, national pest and disease management, and overall agricultural risk reduction strategies.

Weather information services foster producer resiliency in the face of extreme weather events, thus increasing overall national productivity and nutritional security. Augmenting

44 Short Message Service / Interactive Voice Response.

existing early warning systems with crop- and location-tailored weather advisory services would enable farmers to fully prepare for hurricanes and other extreme weather events. Digital solutions can deliver such messages far more efficiently than traditional advisory services.

Our review of challenges and constraints suggests that, in addition to technological development, capacity building would bring significant improvements to the Grenadian agricultural sector. Recommended areas of focus include quality control, business management, marketing, use of climate information, farm innovation, and digital literacy. These key strategies will underpin the development and use of novel digital technologies for climate risk reduction, market intelligence, enhanced resource use, and access to credit and incentives.

Potential avenues for the private sector

The private sector is crucial for advancing digital agricultural solutions, as well as introducing economies of scale and profitability. For example, advanced analytics can increase profitability and mitigate environmental impacts by reducing unnecessary producer input costs and optimizing yield. Big data analytics in weather forecasting can greatly augment the efficiency of advisory services, insurance schemes, and financial services. Currently, there is no digital agriculture start-up in the country providing any of these types of service. Nevertheless, there are several important opportunities in terms of promoting private investments and entrepreneurship in the digital agriculture space. In the short term, establishing sustainable business models, building infrastructure, and bringing existing technologies into the country at accessible prices are key steps to lowering the barrier for lean start-ups. In the long term, capacity building in programming, digital literacy, and entrepreneurship will support the establishment of a robust workforce in the digital agriculture space.

Finance options

One of the greatest challenges for all end-user hubs on Grenada is economies of scale. This island country is inherently limited in terms of its tiny population. Adoption rates near 100% and/or collaboration with neighboring countries may well be necessary to reach economies of scale in any digital solution.

This also implies that substantial support from the national government, private sector, and/or international donors is crucial in order to innovate, accelerate, and monetize any digital solutions.

At the moment there are no major digital agriculture programs or investment funds in Grenada. However, the Grenada Development Bank offers small loans of up to US$2,000; this is an important source of funding for start-ups and farmers seeking to invest in digital innovation.

Outlook

Grenada has laid a foundation for digital agricultural solutions. Connectivity and subscription rates are high, and the number of individuals using Internet is increasing. This suggests important opportunities for digital solutions to the major challenges facing Grenadine agriculture.

Our research suggests that stakeholders who focus their efforts on Internet-based information sharing and advisory services, data analytics, bar coding, SMS / IVR, and GPS are most likely to bring high-impact solutions to Grenada's agricultural sector. Supportive national policy, public-sector investment, private-sector engagement in innovation and monetization, research and development contributions from organizations such as **The World Bank, CGIAR** and **FAO**, and international donor support, will all be crucial to ensuring the success of such solutions.

Integrating digital solutions into the Grenadian agricultural value chain will enable stakeholders to make better informed decisions and address the core challenges within the food system. Digital technologies are a solid basis for solutions such as land tenure legislation and water and land management practices. Through the utilization of decision support applications, including digital extension services, farmers can increase both production and environmentally sustainable practices. Joining efforts implemented by other countries will significantly reduce the cost of development and open the way for the agricultural sector as a whole to transform towards a higher level of environmental sustainability, equity, efficiency and prosperity.

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The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), led by the International Center for Tropical Agriculture (CIAT), brings together some of the world's best researchers in agricultural science, development research, climate science and Earth System science, to identify and address the most important interactions, synergies and tradeoffs between climate change, agriculture and food security. www.ccafs.cgiar.org.