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TECHNICAL REPORT

THE CARIBBEAN AGROMETEOROLOGICAL INITIATIVE (CAMI)

AN EVALUATION OF CLIMATE SERVICES

MARCH 2014
This report was produced for review by the United States Agency for International Development (USAID). It was prepared by Stratus Consulting Inc.

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Engility Corporation Contact:
Glen Anderson, Chief of Party, Glen.Anderson@engilitycorp.com
Engility Corporation
1211 Connecticut Ave., NW
Suite 700
Washington, DC 20036

Contact: USAID Global Climate Change Office, climatechange@usaid.gov

Cover Photo: USAID

THE CARIBBEAN AGROMETEOROLOGICAL INITIATIVE (CAMI)

AN EVALUATION OF CLIMATE SERVICES

Prepared for:

United States Agency for International Development
Global Climate Change Office, Climate Change Resilient Development Project
Washington, DC

Prepared by:

Jason M. Vogel
Alexis St. Juliana
Janet Clements
Stratus Consulting Inc.
Boulder, CO

and

David Letson
University of Miami
Coral Gables, FL

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ACRONYMS

ACP-ST	African, Caribbean, and Pacific Group of States' Science and Technology Programme
CAMI	Caribbean Agrometeorological Initiative
CARDI	Caribbean Agricultural Research and Development Institute
CariCOF	Caribbean Climate Outlook Forum
CIMH	Caribbean Institute for Meteorology and Hydrology
CSP	Climate Services Partnership
CTA	Technical Centre for Agricultural and Rural Cooperation
DSSAT	Decision Support System for AgroTechnology Transfer
EU	European Union
GDP	gross domestic product
M&E	monitoring and evaluation
RADA	Rural Agricultural Development Authority
SPI	Standardized Precipitation Index

EXECUTIVE SUMMARY

The Caribbean Agrometeorological Initiative (CAMI) brought together the meteorological and agricultural agencies of 10 Caribbean nations to deliver climate services to farmers. CAMI sought to "increase and sustain agricultural productivity at the farm level in the Caribbean region through improved dissemination and application of weather and climate information using an integrated and coordinated approach" (CAMI, 2010). To meet this objective, the initiative functioned as a forum for regional climate dialogue and information sharing, and it built capacity within and among the partner countries.

The original objective of this evaluation was to assess how effective CAMI was at meeting its stated objective to increase agricultural productivity. However, three years is too short a time to expect CAMI partner countries to develop new agro-meteorological information, create an effective means to share this information with farmers, and convince farmers across 10 countries to change farming activities at a scale where it would be possible to measure increased agricultural productivity. Consequently, this evaluation focuses on four critical potential breakdowns that could and, in some cases, did prevent CAMI from achieving this objective.

However, CAMI partner countries are on the way to achieving this goal. With additional effort, each of these countries can move forward and further develop effective climate services capabilities. CAMI enhanced the regional networking of meteorologists through the Caribbean Climate Outlook Forum. CAMI also improved networking between meteorological and agricultural officers in each member country. This networking led to climate outlook bulletins that were developed or are under development in all 10 CAMI partner countries to communicate a three-month seasonal forecast to agriculture extension agents and farmers. These bulletins universally contained high-quality meteorological data, but usable information on agriculture impacts and interventions varied significantly from one country to the next.

In nearly all the countries, these bulletins were posted online, but this is clearly not the best means to reach most farmers. Nevertheless, this information reached some high-capacity farmers who could understand the complex meteorological forecast data, and these farmers reported using this information to make decisions to increase their productivity – such as crop and irrigation decisions. Some work remains on improving the quality of the agricultural information included in the climate outlook bulletins. Much more work remains on information distribution and building farmer and extension agent capacity if CAMI is to be relevant to more than high-capacity farmers. Since CAMI is over, initiative partners are seeking new sources of funding to continue this work. For most countries, stable funding for ongoing CAMI work is challenging in the long-term due to resource constraints.

Table S.1 summarizes the recommendations for near-term actions to enhance the progress accomplished by CAMI to date.

TABLE S.1. SUMMARY OF RECOMMENDATIONS.

Recommendation	Description
Fortify cross-agency relationships	Meteorological services staff in CAMI partner countries should look for opportunities to collaborate with their agricultural service counterparts. This will help build the agronomy capabilities with meteorological services and meteorological capabilities in agricultural services.
Place additional emphasis on agricultural interventions	It should remain a goal of CAMI partners to clearly articulate crop impacts and agricultural interventions of the meteorological and climate data they provide.
Track information distribution	CAMI partners should track the distribution of climate outlook bulletins to better understand their reach. Options include tracking the number of "clicks" or downloads from websites, tracking the number of hard copies distributed, monitoring attendance at forums, and working with extension agents to track information sharing.
Use interactive information-sharing methods	CAMI partners should focus on information distribution methods that allow interaction with end-users, such as one-on-one contact between extension agents and farmers, forums, outreach to effective farmer organizations, informal farmer networks, and call-in radio programs.
Expand the role of agricultural extension agents	Agricultural extension officers could benefit from additional training on understanding and communicating climate data and agricultural impacts in order to communicate climate information with farmers.
Seek feedback from end-users	CAMI partners should actively seek feedback from farmers on climate outlook bulletins to ensure that key messages are clearly conveyed and that climate services have the information farmers need most.
Continue to refine outlook bulletins	CAMI partners should continue to refine the content of their outlook bulletins based on changing needs – guided by feedback from end-users.
Develop metrics to measure success	CAMI has not yet defined how it is measuring the primary goal of "increased agricultural productivity." CAMI partners should develop a collective set of metrics and begin taking stock of their progress.
Think long-term	Sustainability of CAMI in the future will be a challenge. CAMI is still in the process of scaling-up its climate service and already must seek new funding sources. CAMI partners should seek more stable, longer-term funding if possible.

1. INTRODUCTION

This report presents the evaluation findings of the Caribbean Agrometeorological Initiative (CAMI). Initially, this evaluation was designed to assess how effective CAMI was at meeting its stated objective to "increase agricultural productivity" (CAMI, 2010). However, three years is too short a time to expect CAMI partner countries to develop new agro-meteorological information, create an effective means to share this information with farmers, and convince farmers across 10 countries to change farming activities at a scale where it would be possible to measure increased agricultural productivity. Consequently, this evaluation focuses on four critical potential breakdowns that could and, in some cases, did prevent CAMI from achieving this objective. From this information we can determine areas of success, areas where further work is needed, priorities for future climate services work in the Caribbean, and lessons learned that are applicable to climate services in other locations. See the adjacent text box for a description of climate services.

CLIMATE SERVICES

Climate services share climate information. Climate information is developed by providers who produce, translate, or transfer the information into targeted climate products, predictions, or outlooks for specific audiences in specific sectors. This information can then be used to inform actions by the end-user.

Sources: CSP, 2014; WMO, 2014.

This evaluation of CAMI is one in a series of mid-level[1] evaluations of selected climate services across the world under the auspices of the Climate Services Partnership (CSP) and funded by the U.S. Agency for International Development Climate Change Resilient Development program. CSP is an interdisciplinary network of climate information users, providers, donors, and researchers engaged in knowledge sharing and collaboration around climate services capabilities worldwide (CSP, 2013a). The goals of this evaluation are twofold: (1) to assess the effectiveness of CAMI, and (2) to pilot a time- and cost-effective evaluation methodology for use in future climate services projects and programs. Answers to these questions could help improve the CAMI program and the national climate services that are its legacy, as well as inform other similar climate services programs.

CAMI was a European Union (EU) African, Caribbean, and Pacific Group of States' Science and Technology Programme (ACP-ST)-funded initiative operated by the Caribbean Institute for Meteorology and Hydrology (CIMH). The initiative involved the countries of Antigua and Barbuda, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago (see Figure 1 for a map of the region). CAMI began in February 2010 and ended in early 2013.

1. As two earlier, large-scale evaluation efforts under the CSP were deemed too time- and resource-intensive, a more limited-scope evaluation protocol was developed and called a "mid-level" evaluation.

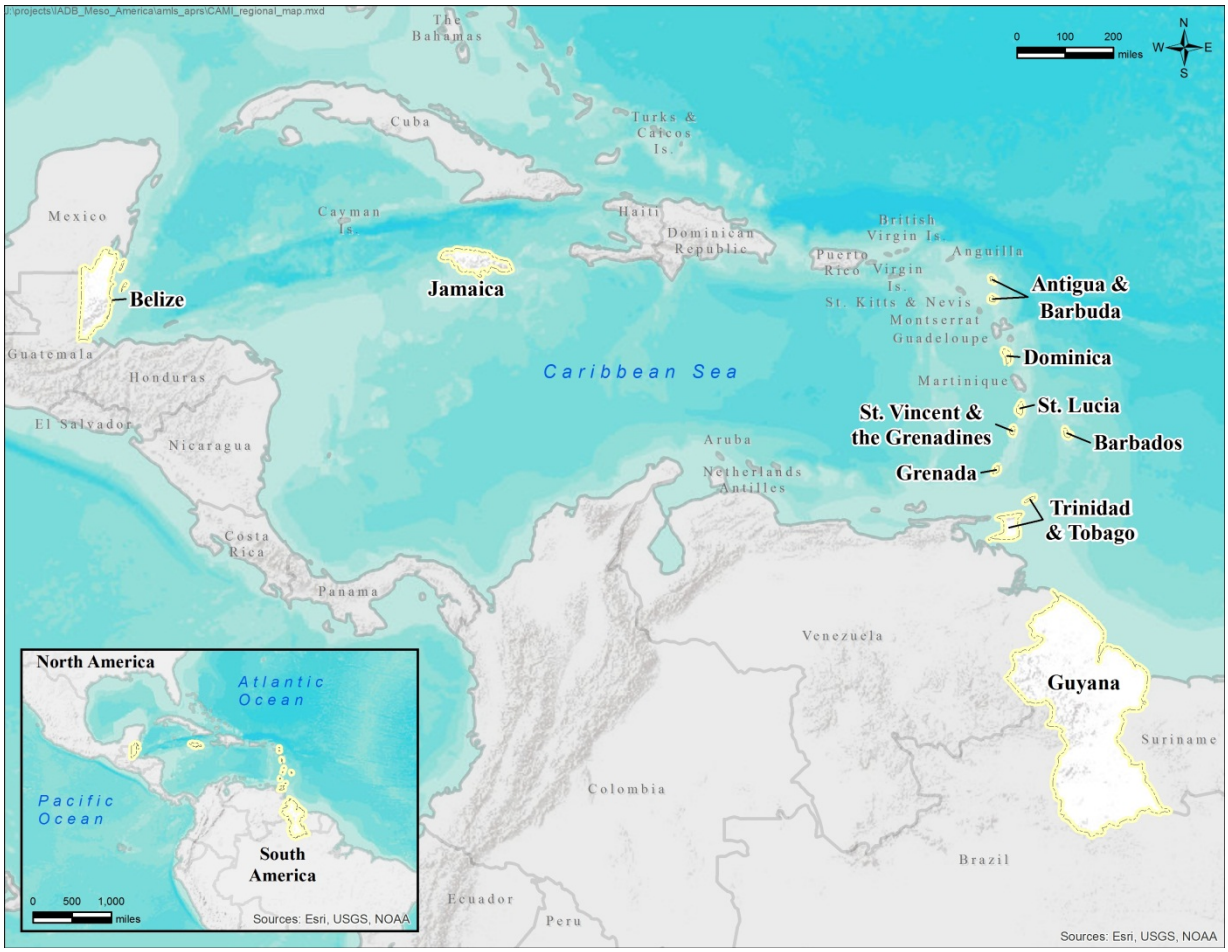


FIGURE 1. MAP OF THE CARIBBEAN WITH CAMI COUNTRIES HIGHLIGHTED.

While all of these nations are located in the Caribbean and share a common language, they are quite different, each with their own political, geographical, and economic nuances. These differences mean that each nation will likely have to contextualize both climate and agriculture information in appropriate ways. For example, some nations have better-funded meteorological agencies than others. While many meteorological agencies have traditionally played roles for airport authorities with little involvement in agro-meteorology, other meteorological agencies are located within countries' ministries of agriculture, and provide meteorological data to farmers. In most cases, these differences are guided by the role of agriculture in these nations' economies. For example, Belize and Guyana are mainland nations with a significant portion of their gross domestic product (GDP) associated with agriculture. Guyana and Belize are notably different than the other eight CAMI countries because, as continental countries, they have the economies of scale, geography, geology, and market access to support mechanized farming practices and industrial-scale agriculture. This is also the case to a limited extent on the larger islands such as Jamaica. In many island nations, agriculture takes a backseat to tourism or other industries, making it less of a priority for national governments.[2] Additionally, the unique geography of some nations makes large-scale mechanized farming improbable due to mountainous terrain and limited land area, limiting the economic viability of export-based farming.

2. It should be noted that several countries have launched campaigns to improve local food security.

The main objective of CAMI was to "increase and sustain agricultural productivity at the farm level in the Caribbean region through improved dissemination and application of weather and climate information using an integrated and coordinated approach" (CAMI, 2010). To meet this objective, the program included the following specific goals (ACP-ST, Undated):

- Train personnel in agrometeorology, climate, and crop modeling
- Develop rainy season prediction models using seasonal and long-term climate data
- Interpret climate data and weather information for real-time improved crop management decisions, such as irrigation scheduling
- Prepare and communicate user-friendly weather and climate information
- Promote two-way communication between farmers and agencies on weather and climate information
- Develop an effective pest and disease forecasting system through improved crop monitoring and use of modeling approaches (CAMI, 2011a)
- Invest in data protection methods (i.e., digitize physical hard-copy data, which is prone to damage or loss) (CAMI, 2011a).

To provide a clear understanding of CAMI and evaluate its effectiveness, the remainder of this report is divided into six sections:

- ***Section 2 – Methodology.*** This section describes previous efforts at climate services evaluation under the CSP and how this evaluation built on that foundation by developing a logic model and engaging in telephone and in-person interviews.
- ***Section 3 – Background on Caribbean Agriculture and CAMI.*** This section briefly describes the agricultural sector in the Caribbean as well as the history of CAMI.
- ***Section 4 – System Factors in the CAMI Logic Model.*** This section describes the first two steps in the CAMI logic model – "agricultural activity" and "climate impacts."
- ***Section 5 – Potential Breakdowns in the CAMI Intervention Logic.*** This section describes the next four steps in the CAMI logic model, including observations from the five countries that we examined as part of our evaluation. These steps include "information provision on weather/climate and agriculture," "information distribution," "information uptake," and "action by farmer." We also briefly discuss the logic model outcome of "increased agricultural productivity."
- ***Section 6 – Conclusions.*** This section draws conclusions about CAMI based upon the evaluation of the potential breakdowns in Section 5.
- ***Section 7 – Recommendations.*** This section proposes recommendations for enhancing the work accomplished by CAMI so far.

2. METHODOLOGY

While the ultimate goal of CAMI is to raise agricultural productivity, this evaluation must focus on intermediate measures of success related predominately to capacity building. It will likely take several more years before CAMI-associated improvements to agricultural productivity can be distinguished from other sources of variation in farming outcomes. Our evaluation, three years after the initiation of CAMI, focuses on the following, guiding questions:

- As a result of CAMI, do the national meteorological and agricultural agencies have the capacity to produce and distribute high-quality information?
- How are meteorological and agricultural agencies characterizing and assessing farmer's information needs?
- How are meteorological and agricultural agencies tailoring climate information to meet the information needs of farmers?
- Do farmers have access to new or better information as a result of the project?
- Are farmers able to act on the information provided?

The methodology used for this study built on previous efforts under the CSP. Two earlier, large-scale evaluation efforts under the CSP were deemed too time- and resource-intensive. As a consequence, the CSP developed a draft protocol for "mid-level" evaluations (CSP, 2013b). The term "mid-level" refers to the scope of the evaluation in comparison to the two earlier, large-scale efforts. This broad "mid-level" methodological guidance was further refined in a workshop held in Kaffrine, Senegal (Tall and Njinga, 2013). This evaluation of CAMI is one of four case study evaluations conducted using this guidance.

One key conclusion of Tall and Njinga (2013, p. 17) was that "Developing an effective M&E [monitoring and evaluation] framework for the impact of climate services on farmer livelihoods requires local specificity." They further concluded that "Only after an in-depth investigation into farmers' decision-making contexts…can an apt evaluation protocol be developed and the impact of climate services be studied."

We agree with this emphasis on local specificity and farmer livelihoods and have structured this current evaluation with them in mind. This required a two-stage research approach. The first stage was to develop a theory of change and logic model to describe our understanding of the basic functioning of the system being evaluated. The second stage was to engage in semi-structured interviews with key participants in CAMI, including project personnel, meteorological officers, agricultural officers, and farmers.

The following sections describe the methodology used for this evaluation, including the development of the climate services logic model, review of existing programmatic materials, site visits to three countries, and telephone interviews with CAMI participants in two other participating countries.

As an important note, this evaluation occurred after official funding for CAMI had ceased. Nevertheless, many activities started under CAMI are continuing under the auspices of national meteorological and agricultural agencies or with CIMH. For this reason, the evaluation was not intended to determine the final outcome of CAMI, but rather to get a sense of the progress of CAMI thus far and determine if any lessons can be shared with other climate service initiatives.

2.1 DEVELOPING A CLIMATE SERVICES THEORY OF CHANGE AND CAMI LOGIC MODEL

With our emphasis on intermediate measures of success related to capacity building, our task was to examine the supply chain of meteorological service delivery for weak links. The logic model provides a conditional (i.e., "if-then") structure that helps frame and systematically characterizes the CAMI project (Figure 2). It can call attention to the critical elements of not only climate information, but also the social, political, and economic context in which such information is being provided and used. This is important because it is often these social, political, and economic factors that constrain the availability, comprehension, distribution, and significance of climate information.

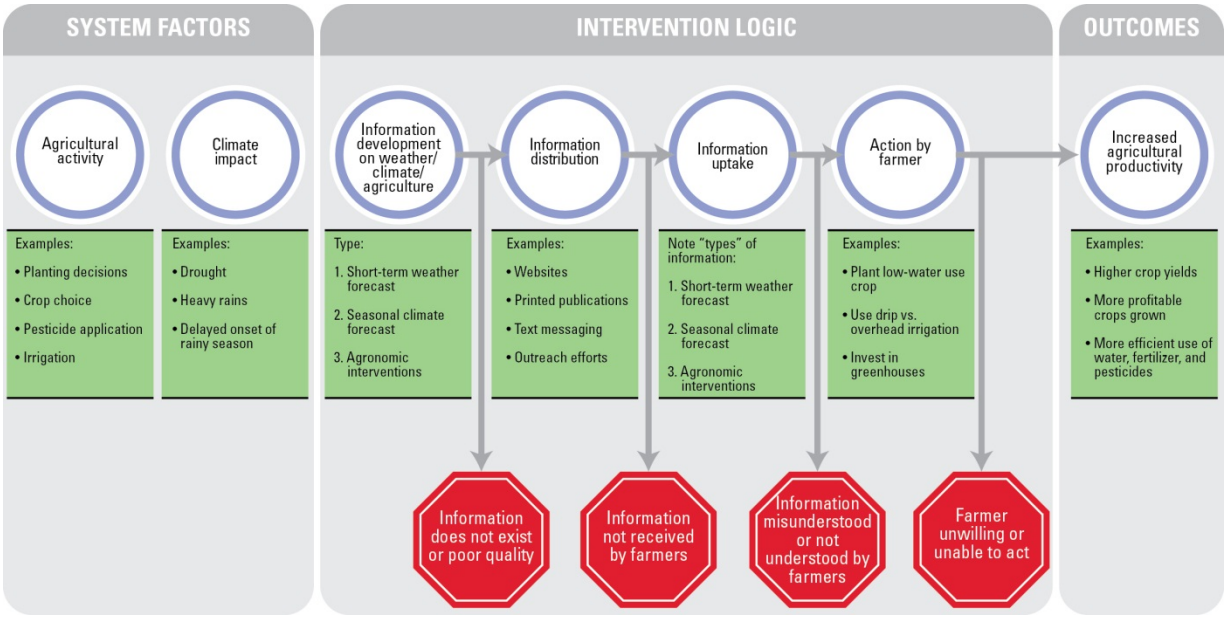


FIGURE 2. CAMI LOGIC MODEL.

Most discussions of climate services begin with scientific information. This is logical because scientists and others involved in climate services feel that scientific information on weather and climate has tremendous potential to improve social and economic outcomes on-the-ground. Thus, a basic climate services theory of change is to provide information on weather and climate in order to change behavior and improve social and economic outcomes. By distilling climate services to this simple idea, developing a logic model to guide the evaluation of CAMI becomes much more tractable and generalizable across contexts.

As depicted in Figure 2, the CAMI logic model starts with the "system factors" of agricultural activity and climate impact, goes through a sequence of four CAMI "interventions," and ends with the "outcome" of increased agricultural productivity. Note that the provision of scientific information is included, but only as one step in the logic model. This broad focus on agricultural activities and the full range of CAMI interventions concentrates the evaluation appropriately on the full situational context.

The logic model presented in Figure 2 is used as a simplified framework to break down the components of CAMI into a logical series of activities that are necessary to achieve success. This facilitates the identification of areas where the lack of progress at one step could cause problems that would prevent CAMI from achieving its objective to "increase and sustain agricultural productivity at the farm level in the Caribbean

region" (CAMI, 2010). Consequently, the first two blue circles in Figure 2 represent system factors that describe the situational context in which CAMI is operating, the next four blue circles represent the intervention logic – the necessary and sequential activities to achieve the program objective, and the final blue circle represents the ultimate outcome of CAMI. Examples are provided in the green box under each blue circle for illustrative purposes. The red octagons represent ways in which the progress from one activity to the next could be interrupted – effectively preventing CAMI from achieving its objective. Each of the potential problems in these octagons is discussed in detail in Section 5.

Note that there are several reasons why the provision of climate services might not lead to the desired outcome of increased agricultural productivity (depicted as red octagons in Figure 2). These include low-quality or inadequate information, poor information distribution, inability of farmers to understand the information, and farmer unwillingness or inability to act on that information. In other words, when evaluating CAMI, the decision context involves more than simply the quality and/or quantity of the information produced by CIMH, national meteorological agencies, or national agricultural agencies.

2.2 REVIEW OF PROGRAM MATERIALS

Over three years, CAMI produced dozens of meeting summaries, several progress reports, and over 100 agro-meteorological outlook bulletins. Before conducting site visits or telephone interviews the evaluation team reviewed these background documents to learn about activities that had been conducted and, where possible, the outcomes of these activities. The meeting summaries from the CAMI partner countries' farmers forums were particularly valuable. These highlight some of the specific challenges and needs for farmers in each country.

2.3 SITE VISITS AND INTERVIEWS

To evaluate CAMI, the evaluators visited three countries – Barbados, Dominica, and Jamaica – to gather first-hand accounts of the activities, outputs, and outcomes of the CAMI project as a whole and how it was implemented in these two countries. We interviewed staff from CIMH, the Barbados Meteorological Services, the Ministry of Agriculture Barbados, the Dominica Meteorological Service, the Dominica Ministry of Agriculture and Forestry, the Meteorological Service of Jamaica, the Rural Agricultural Development Authority (RADA), as well as two Bajan farmers, four Dominican farmers, and one Jamaican farmer. We also attended two presentations that highlighted current and planned CAMI-related activities in Jamaica at the International Conference on Climate Services (held in Montego Bay, Jamaica on December 4–6, 2013). These presentations were developed and presented by staff members from RADA and the Meteorological Service of Jamaica.

The evaluation team used a semi-structured interview protocol based on the CAMI logic model to gather consistent information about climate services from each interviewee, taking into account the different institutional and geographic contexts (e.g., regional versus national institution, country, small island versus mainland country) as well as the different interviewees (e.g., CIMH, national meteorological and agricultural agencies, farmers). A prepared list of topics and questions informed and directed the interviews, but the interviewees were encouraged to discuss what was of greatest interest to them. The interviews were open and informal. Primary topics varied depending on the interviewee. For instance, questions directed to CIMH and country meteorological and agricultural officers emphasized their training activities, the creation of outlook bulletins, and outreach to farmers (see Figure 3); while questions directed to farmers emphasized access, understanding, and use of climate information. A list of interviewees is included in the appendix.

2.4 TELEPHONE INTERVIEWS

Using the same semi-structured interview protocol outlined in Section 2.3, the evaluators conducted telephone interviews with three farmers from Grenada, and three staff members at the Grenada Ministry of Agriculture, Lands, Forestry, Fisheries & Environment. In Guyana, the evaluators spoke with a staff member from the Hydrometeorological Service within the Guyana Ministry of Agriculture and an agronomy researcher from the Guyana Sugar Corporation. These interviewees allowed us to improve our understanding of CAMI, and ensure that we covered a broader range of geographical and socioeconomic contexts. See the appendix for a list of all interviewees.

FIGURE 3. A JAMAICAN FARMER AND AGRICULTURE EXTENSION AGENT DISCUSS A RAIN GAUGE IN ST. JAMES PARISH.

3. BACKGROUND ON CARIBBEAN AGRICULTURE AND CAMI

3.1 CARIBBEAN AGRICULTURE

In many CAMI countries agriculture is vital to GDP or workforce.

Figure 4 provides GDP and workforce data for CAMI countries. While agriculture may not contribute significantly to GDP in every country, it plays an essential role in regional economic development since it supports a large part of the workforce in locations such as Dominica, Saint Lucia, and Saint Vincent and the Grenadines. The limited size of these island countries, and the consequent difficulty in diversification, can leave them quite vulnerable to natural disasters, political events, and business cycles. Caribbean island nations have a history of cooperation, in recognition of their own resource limitations and vulnerability. The sustainability and expansion of agriculture output, which has been a key contributor to poverty reduction worldwide, is a critical economic and social issue in the Caribbean as well. Table 1 provides examples of agricultural products produced by each of the countries.

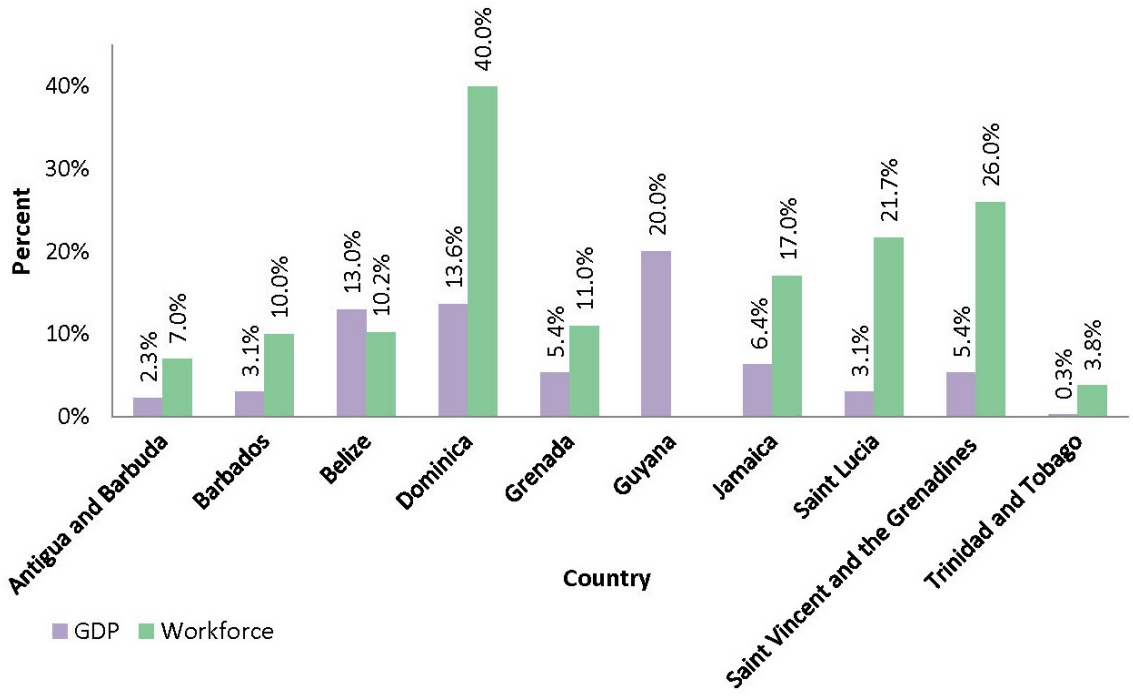


FIGURE 4. AGRICULTURAL CONTRIBUTION TO GDP AND WORKFORCE IN CAMI COUNTRIES.

Source: CIA, 2013.

TABLE 1. KEY AGRICULTURAL PRODUCTS IN CAMI COUNTRIES.

Country	Products
Antigua and Barbuda	Cotton, fruits, vegetables, bananas, coconuts, cucumbers, mangoes, sugarcane, livestock
Barbados	Sugarcane, vegetables, cotton
Belize	Bananas, cacao, citrus, sugar, fish, cultured shrimp, lumber
Dominica	Bananas, citrus, mangos, root crops, coconuts, cocoa
Grenada	Bananas, cocoa, nutmeg, mace, citrus, avocados, root crops, sugarcane, corn, vegetables
Guyana	Sugarcane, rice, edible oils, beef, pork, poultry, shrimp, fish
Jamaica	Sugarcane, bananas, coffee, citrus, yams, ackees, vegetables, poultry, goats, milk, shellfish
Saint Lucia	Bananas, coconuts, vegetables, citrus, root crops, cocoa
Saint Vincent and the Grenadines	Bananas, coconuts, sweet potatoes, spices, small numbers of cattle, sheep, pigs, goats, fish
Trinidad and Tobago	Cocoa, rice, citrus, coffee, vegetables, poultry, sugar
Source: CIA, 2013.	

Any analysis of agriculture climate services in the CAMI network must begin by acknowledging the challenges that face growers throughout the Caribbean. As noted by Compton Bourne, President of the Caribbean Development Bank (Bourne, 2008):

> Agriculture faces several problems of input supply and capital stock. Improved chemical inputs – fertilizers, pesticides – are imported and subject to externally driven movements in prices. The agriculture labor force is an aged one with diminishing entrants of young workers and entrepreneurs who can bring new energy and ideas to the sector and sustain or increase pre-existing levels of labor utilization. Much land has been reallocated from agriculture to other sectors, principally residential construction or tourism. This trend reflects relative rates of private returns to investment in agriculture, residential real estate development, and other land-based production activities. In addition to the loss of land there seems to be a problem of inadequate capital stock evidenced in vintage stocks of farm equipment and farm buildings in need of maintenance or replacement. In effect, there is a production capacity problem in Caribbean agriculture. Farm incomes and supply reliability can also be adversely affected by natural hazards such as floods, tropical storms, and droughts. The small production units typical of Caribbean food crop production set a low ceiling on potential farm incomes absolutely and relative to incomes which could be earned by professionals and entrepreneurs in other sectors.

In other words, inadequate climate information is only part of the problem with Caribbean agriculture. And even advances in agricultural productivity due to the provision of climate and agriculture information to farmers could be offset by a wide range of other socioeconomic factors affecting agricultural productivity in the Caribbean.

Despite poor access to international markets for crops, growers in Barbados, Dominica, and Grenada sell produce to domestic markets (and to neighboring islands in the case of Dominica). The majority of this domestic market, however, typically involves selling produce through distributors to hotels and restaurants, which in turn is highly dependent on the tourism sector. Growers told us that they do not attempt to compete in international markets because doing so would require them to meet burdensome international

sanitation standards and for their governments to negotiate advantageous access to international markets and/or other nations. This limited access to international markets and other constraints of Caribbean agriculture fundamentally limit CAMI's ability to achieve the outcome to "increase agricultural productivity" in absolute terms. Consequently, it is important to view CAMI's efforts to increase agricultural productivity in relative terms – potentially including reducing losses in agricultural productivity or increasing farm profitability even if total farm output decreases.

3.2 CLIMATE AND AGRICULTURE

Agriculture is inherently tied to climate variability and climate change. Climate variability has posed significant issues for Caribbean agriculture for many years in the form of drought, heavy rains, and hurricanes and severe storms. For example, the impacts of climate have been dramatically illustrated in Dominica due to Hurricane Dean (CARDI, 2011a), Grenada due to hurricanes from 2004 to 2005 (CARDI, 2011b), and St. Lucia and Saint Vincent and the Grenadines due to Hurricane Thomas in 2010 (CARDI, 2011c, 2011d). Beyond climate variability, there are several specific climate change impacts of concern for agriculture in the Caribbean: changes in precipitation, changes in temperature, and changes in the frequency and strength of tropical storms and hurricanes. Higher temperatures will increase evapotranspiration and vegetative water demand. Low latitudes, such as in the Caribbean, will likely see decreases in agricultural yields because these lands are often already near biological temperature or moisture thresholds. Changes in precipitation patterns may create periods of drought or longer dry seasons not experienced previously. The projected increased frequency or severity of extreme events like floods, droughts, and storms will have further effects on agriculture and food systems through increased soil erosion, soil salinization, and crop stress. These changes will impact the length or timing of the growing season, and the presence or persistence of pests (including fungal and bacterial diseases, invasive plant species, insects, or animals).

3.3 CARIBBEAN AGROMETEOROLOGICAL INITIATIVE

CAMI was proposed by CIMH Director, Mr. Adrian Trotman, who served as principal investigator for the EU grant that supported CAMI. He is the single person most responsible for CAMI's success. The unique role of CIMH in CAMI is worth highlighting. Most meteorologists working in the Caribbean have been trained at CIMH and thus know each other through this crucial professional network. CIMH has a history of mutually beneficial data sharing and research that pre-dates CAMI, and this has made CIMH a logical choice as a collaborative platform.

CAMI was intended to fill a perceived information need among farmers in the Caribbean; however, that need was not satisfied by the limited existing distribution of highly complex meteorological data to farmers at the country level. It was presumed that providing meteorological information and agricultural interventions to farmers would enable them to make better farm-level decisions that would increase and sustain agricultural productivity. In pursuit of this agenda, CAMI engaged in a number of activities to (1) provide technical training, (2) collect data, and (3) gather input from farmers (see Table 2). These CAMI activities were proposed to build skills and resources within and among their partner organizations and to engage farmers to determine what kinds of outputs would be most useful from CAMI.

TABLE 2. ACTIVITIES CONDUCTED BY CAMI, ORGANIZED BY PRIMARY OBJECTIVE.

Activity	Time-frame	Involved parties
Data rescue CAMI countries each collected 30 years of precipitation data to improve the robustness of its meteorological forecasting (CAMI, 2012). In some cases the available data were not in a digital format or were held in multiple locations within a single CAMI country, complicating any attempted use.	2010–2011	CAMI staff Meteorological agencies
Rainy season modeling A workshop to assist the meteorological agencies to model rainfall and temperature (Stoute, 2010).	June 2010	Agricultural agencies CAMI staff CARDI Meteorological agencies
Communication workshop A workshop to identify the information needs of extension agents, farmers, ranchers, foresters, fishers, media, and the general public. It also explored the best modes of communication (Stoute, 2011).	April 2011	Agricultural agencies CAMI staff CARDI CTA Farmers Meteorological agencies
Pest and disease modeling A training session covering monitoring, modeling, modeling approaches, crop protection, and climate variability and agricultural impacts (CAMI, 2011b).	April 2011	CAMI staff CARDI Meteorological agencies
Farmers forums A series of stakeholder workshops for awareness and capacity-building exercises among farmers and extension officers. Each CAMI country conducted up to two workshops with farmers to discuss climate, climate change, and their impacts on farmers. One lesson from these discussion sessions was the need for better communication of forecasts to farmers. Information may be overly complex or may not convey what to do with the information. Farmers want assistance in determining what to do in response to the forecast. These sessions also covered preferred communication modes (CAMI, 2010).	2011–2012	Agricultural agencies CAMI staff Farmers Meteorological agencies
Crop simulation A training session covering the crop simulation model DSSAT (Stoute, 2012).	2012	CAMI staff Meteorological agencies

Primary objective categories:

- Technical training
- Data collection
- Gathering input from farmers

CARDI: Caribbean Agricultural Research and Development Institute.
CTA: Technical Centre for Agricultural and Rural Cooperation.
DSSAT: Decision Support System for AgroTechnology Transfer.

Building upon the insights gained from these activities, CIMH and partner meteorological and agricultural agencies developed climate outlook bulletins. A collaboration of all of the region's meteorologists and CIMH, known as the Caribbean Climate Outlook Forum (CariCOF), compiles a regional climate outlook bulletin through a consensus decision-making process. This bulletin is released monthly and forecasts climate, particularly precipitation, three months out by projecting the likelihood that precipitation will be "above-normal," "normal," or "below-normal" (Figure 5).

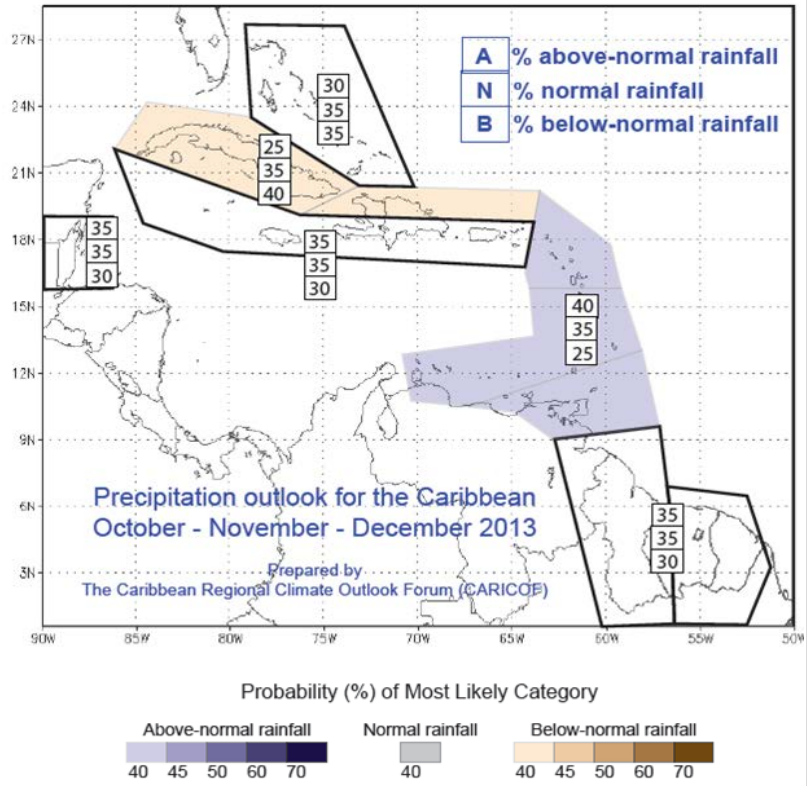


FIGURE 5. RAINFALL OUTLOOK PREDICTION CREATED BY CARICOF FOR OCTOBER–DECEMBER 2013.

Note that the region is separated into several climatologically similar subregions, each of which has a vertical row of numbers indicating the likelihood of above-normal, normal, and below-normal rainfall over the following three months.

Source: CIMH, 2013.

Regional bulletins are produced by CariCOF and CIMH while each nation produces (or intends to produce) bulletins with localized information (see Figure 6). These bulletins vary in their content among countries. Most include fairly extensive discussions of weather from the past month and limited forecast information for the upcoming 1–3 months, including rainfall predictions and sometimes temperature predictions (see Figures 6 and 7). The outlook bulletins vary most in drawing connections to agriculture. Several bulletins have no mention of agriculture and only provide the meteorological forecast. Some draw some basic connections and provide recommendations on when to irrigate or store water, for example (see Figure 8 for an example from Barbados). Few of the bulletins provide concrete agricultural advice with details, for instance, on what to plant and when. But in at least one of the countries that we evaluated, Jamaica, they had dramatically improved upon the initial CAMI-inspired work through further development of their meteorological and agricultural information development capabilities (see Figure 9).

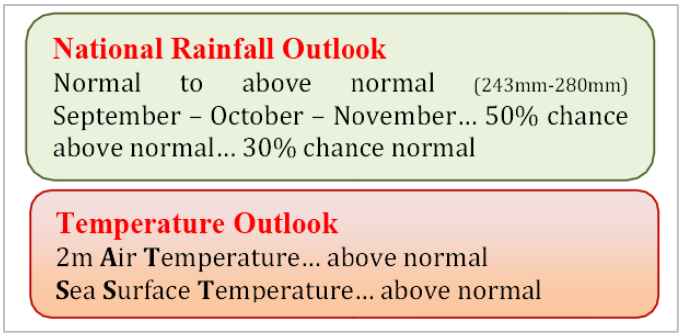


FIGURE 6. EXAMPLE OF LOCALIZED METEOROLOGICAL INFORMATION INCLUDED IN THE AUGUST 2013 OUTLOOK BULLETIN FOR ST. VINCENT AND THE GRENADINES.

Source: St. Vincent and the Grenadines, 2013.

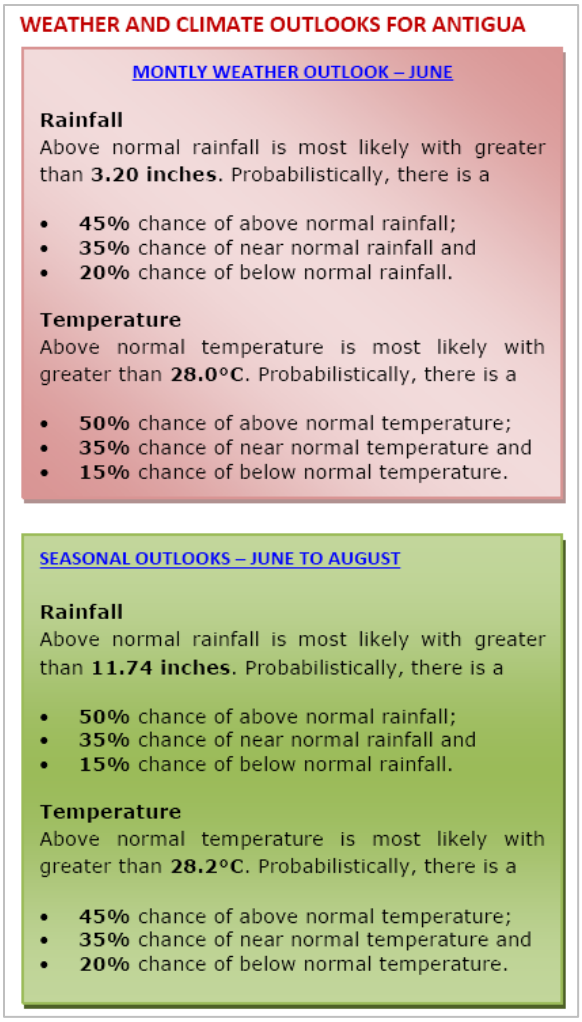
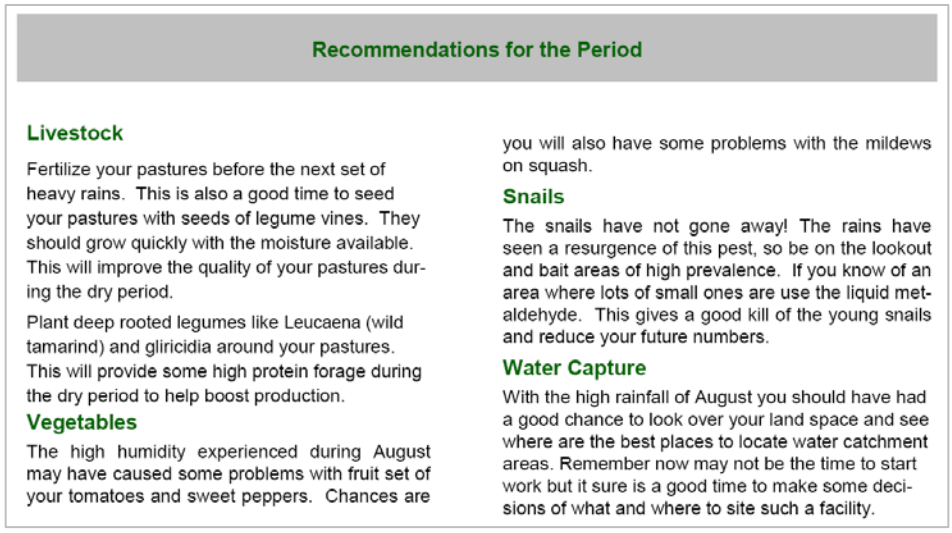


FIGURE 7. EXAMPLE OF LOCALIZED METEOROLOGICAL INFORMATION INCLUDED IN THE MAY 2013 OUTLOOK BULLETIN FOR ANTIGUA AND BARBUDA.

Source: Antigua and Barbuda Meteorological Service, 2013.



Recommendations for the Period

Livestock

Fertilize your pastures before the next set of heavy rains. This is also a good time to seed your pastures with seeds of legume vines. They should grow quickly with the moisture available. This will improve the quality of your pastures during the dry period.

Plant deep rooted legumes like Leucaena (wild tamarind) and gliricidia around your pastures. This will provide some high protein forage during the dry period to help boost production.

Vegetables

The high humidity experienced during August may have caused some problems with fruit set of your tomatoes and sweet peppers. Chances are you will also have some problems with the mildews on squash.

Snails

The snails have not gone away! The rains have seen a resurgence of this pest, so be on the lookout and bait areas of high prevalence. If you know of an area where lots of small ones are use the liquid metaldehyde. This gives a good kill of the young snails and reduce your future numbers.

Water Capture

With the high rainfall of August you should have had a good chance to look over your land space and see where are the best places to locate water catchment areas. Remember now may not be the time to start work but it sure is a good time to make some decisions of what and where to site such a facility.

FIGURE 8. AGRICULTURAL INFORMATION INCLUDED IN THE AUGUST 2013 OUTLOOK BULLETIN FOR BARBADOS.

Source: Barbados Meteorological Services, 2013.

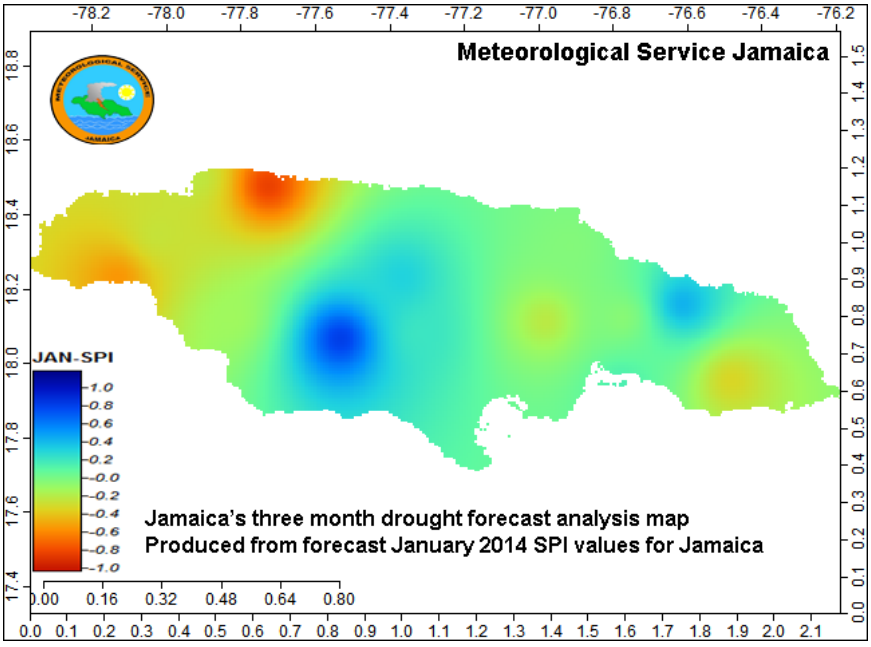
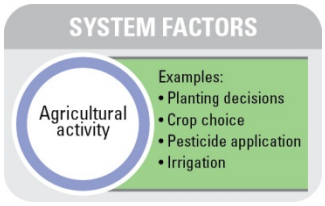


FIGURE 9. A THREE-MONTH DROUGHT FORECAST FROM JAMAICA. The forecast at the end of January indicates near-normal conditions across most areas. However, abnormally dry periods are likely over parts of the western parishes. The Standardized Precipitation Index (SPI) is used to monitor conditions on a variety of time scales, namely 1-month, 3-month, 6-month, 9-month, and 12-month periods. This temporal flexibility allows the SPI to be useful in both short-term agricultural and long-term hydrological applications.

4. SYSTEM FACTORS IN THE CAMI LOGIC MODEL

The first two steps of the CAMI logic model characterize the context that frames and informs the CAMI intervention categories. These first two steps are "agricultural activity" and "climate impact."

4.1 AGRICULTURAL ACTIVITY



Farmers in the CAMI countries engage in a variety of agricultural activities, mostly at a small scale (i.e., 0.5 to 8 acres). Large farming operations, typically operated by the most economically successful farmers, were reported on the scale of 30 acres, but were not common. In some countries there are remnant plantations on the order of 50–200 acres. In Jamaica, we interviewed a wealthy farmer who owned and managed more than 130 acres, but again, this is reportedly not common in most areas of the country. These large plantations, however, are on the decline and were reported to be "a thing of the past." In Guyana, a continental country, farming operations as large as 10,000 acres were reported. Guyana and Belize are notably different than the other eight CAMI countries because, as continental countries, they have the economies of scale, geography, geology, and market access to support mechanized farming practices and industrial scale agriculture.

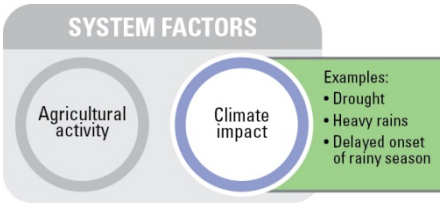
On the whole, most farmers in the CAMI countries have small plots of land and most of the work must be done by hand because the economics and geography of these small islands do not facilitate much mechanization. This also prevents the development of large-scale export industries. The farmers we spoke with in Barbados each worked 25–30 acres of land. The farmers we spoke with in Dominica, a much more mountainous island, each worked between 0.5 and 17 acres.[3] This was similar to Grenada, where we were told that the majority of farmers worked less than 10 acres of land, often in multiple, disjointed plots. In the Montego Bay area of Jamaica, where we conducted our interview, most farmers reportedly work between 2 and 5 acres of land in relatively mountainous areas, and it was reported that there remained about a half dozen 100 + acre farms island-wide.

The farmers we interviewed engaged in a number of agricultural activities that were the focus of our analysis. They made decisions about what and when to plant, about whether to invest in greenhouses and other capital investments, about how and when to irrigate their crops, about what to do when threatened by a hurricane, and about the application of fertilizers and pesticides. The farmers and government agriculture officers that we interviewed mentioned that these decisions were often constrained by a number of non-climate factors, including national import and export laws, regional markets, unavailability of cold storage facilities, market gluts, poor information availability, inconsistent government support, and international trade rulings.

Nevertheless, we took these non-climate stressors as a given and based our analysis on the agricultural activities mentioned above. While these activities are perhaps self-evident, focusing on them ensures that later steps in the logic model are grounded in the reality of farming and farm decision-making in CAMI countries.

3. To work 15 or 17 acres on Dominica, these farmers had to work multiple plots as there are very few places to find a contiguous parcel of more than a few acres suitable for farming.

4.2 CLIMATE IMPACT



On the island countries in particular, there was significant sensitivity to climate due to micro-variation in topography and weather. For example, the higher elevations of Barbados support broccoli and tomato production, which cannot be supported at lower elevations. Rainfall and temperatures on Dominica vary dramatically from coastal areas to inland, higher-elevation areas, with significant implications for crop choice, irrigation needs, and more. Additionally, conditions on distinct portions of Caribbean island nations can experience very different weather due to different wind patterns. Furthermore, farmers in the region are used to dealing with a dry and a wet season that can have significant implications for agriculture. But variations such as a dry-dry season, wet-wet season, wet-dry season, or dry-wet season can cause significant crop losses and poor harvests. It is in these variations in the dry and wet seasons that most interviewed CAMI participants expressed optimism that climate forecasts could assist farmers.

In interviews with CIMH personnel, national meteorological and agricultural agencies, and farmers, it became clear that a variety of climate events impact agricultural activities. This includes the possibility of a delayed rainy season, severe rainfall events that could affect the effectiveness of fertilizers and pesticides, and drought or delay of the rainy season that could affect crop productivity. A number of additional concerns with the impacts of weather were raised, particularly by farmers. In Jamaica, for example, the agricultural extension agent and farmer we spoke with were more concerned with daily/monthly weather information versus climate data, as weather impacts were a major concern. However, because this evaluation focuses on the usefulness of two – three month climate forecasts, we address weather-related agriculture impacts only in passing.[4]

4. Note that 10-day weather bulletins were cited as a priority by several meteorological services. In some cases, an emphasis on the 10-day bulletin rather than a 3-month climate outlook may be a matter of priority in a resource-constrained environment.

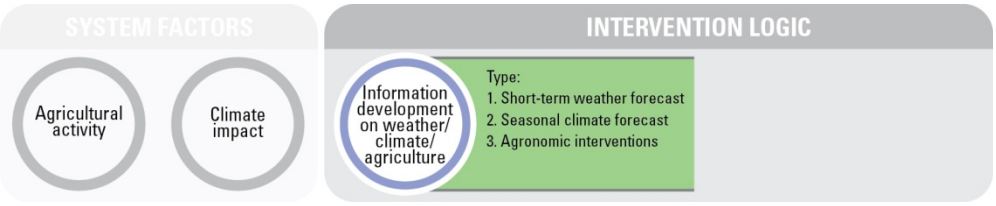
5. POTENTIAL BREAKDOWNS IN THE CAMI INTERVENTION LOGIC

The third through sixth steps of the CAMI logic model highlight potential breakdowns in the series of intervention steps that lead from agricultural activities to the objective of increased agricultural productivity. These steps include:

- Information development on weather/climate and agriculture
- Information distribution to farmers
- Information uptake by farmers
- Action by farmers.

For illustrative purposes, the potential breakdowns include the possibility that under "information provision," the information does not exist or is of poor quality. Under "information distribution," even if the information is of high quality, it may not be received by farmers. Under "information uptake," even if farmers receive high-quality information they may not understand or may misunderstand that information. Under "action by farmer," even if a farmer receives and understands the high-quality weather/climate and agriculture information, he/she may be unwilling or unable to act on that information. Each of these potential breakdowns was recognized through our methodological development of the logic model, and we explored each one during field visits, in-person interviews, and telephone interviews. The final step in the logic model, "increased agricultural productivity," is discussed here briefly, but drawing conclusions about whether the provision of climate services actually accomplished this objective was empirically difficult for a number of reasons described in Section 5.5.

5.1 INFORMATION DEVELOPMENT ON WEATHER/CLIMATE AND AGRICULTURE



The evaluation team did not provide a technical review of the quality of the climate forecasts provided by CIMH regionally or by each meteorological office nationally. However, we did note that the process for developing these forecasts provides a number of opportunities to ensure quality. For example, the regional climate forecast produced by CIMH underwent a process of technical review through CariCOF, which was established in March 2012. While the regional seasonal bulletins were originally based on CIMH forecasts, they have evolved into a consensus process through CariCOF, which allows meteorological officers and

climate forecasters to come to a technical consensus for a seasonal forecast (see Figure 5 for an example). There are reportedly 18 participants in CariCOF representing 25 different territories. Their consensus forecast is released as a regional bulletin, which is a World Meteorological Organization-driven process. Furthermore, CariCOF holds a general assembly once per year to update stakeholders (including ministry personnel, extension agents, permanent secretaries, nongovernmental organizations, CARDI, and the Caribbean Farmers Network) on their process improvements and forecasts, as well as the forecast implications for various socioeconomic sectors, including agriculture.

While technical personnel at CIMH said that they work in a data-limited environment (with 146 weather stations over 25 territories), they also claimed that the existing data were adequate to work with, although it would not be sufficient for academic research purposes. Still, as part of CAMI, participating countries shared past meteorological information with CIMH. This was, in part, to increase the robustness of their modeling, and also to improve recordkeeping and the digitization of data where it had not occurred in the past. Despite adequate meteorological data, it was suggested that data on agricultural impacts were not as well developed regionally and presented a limiting factor in the context of developing information packages suitable for use in the context of Caribbean farming practices.

Between 2010 and 2012, CAMI hosted a series of workshops for meteorological and agricultural officers. These sessions emphasized modeling of rainfall, crops, pests, and crop diseases. While most staff had training and experience, when interviewed, staff in multiple countries noted the benefits of the training sessions. Nearly every interviewee from a national meteorological and agricultural agency noted the particular value of networking across their respective areas of expertise. Meteorological agencies reported being limited to servicing aviation in many CAMI countries prior to the initiative.[5] And most agriculture officers reported that they had not previously considered climate forecasts as within their purview.

After the initiative, working relationships across agencies were developed and a new purpose was instilled in most of the meteorological agencies. Agriculture officers seemed to recognize value in the climate forecasts, but did not indicate a clear sense of purpose across countries as the meteorological officers did. Several interview participants noted that, through CAMI, additional attention and resources have been devoted to their respective offices. This has included additional staff training, the hiring of new staff, and the placement of staff with integrating skillsets in sister agencies – such as individuals with agrometeorological skills being placed in the meteorological or agricultural agencies (depending on the country). In Jamaica, for example, the CAMI program has helped to garner additional resources and foster the development of new initiatives, including the development of a national three-month forecast, training of extension agents in the use of climate information, and the development of a climate information working group for the agricultural sector, among others.[6]

This is consistent with our observations that meteorological data were readily available both in the regional and the national bulletins, but information on the agricultural implications of that data was uneven across countries and generally scarce. In fact, we encountered dramatically different enthusiasm and capacity across

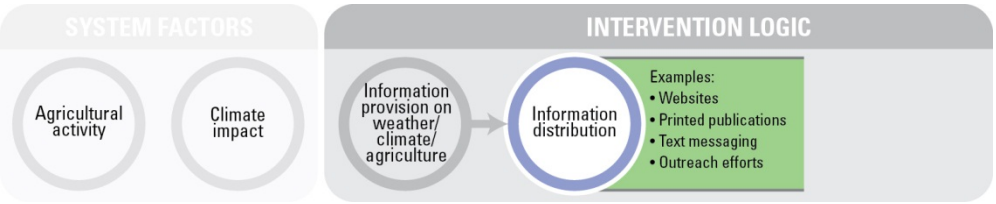
5. The provision of meteorological services is expensive for a small island nation. Historically, meteorological agencies have largely served aviation interests in the Caribbean. Without meteorological services, Caribbean island nations would have no international flight service, putting their tourism-based economies at a significant disadvantage relative to their nearby rivals.

6. CAMI partners are in the process of seeking additional funding to train agricultural extension officers on climate information and climate change issues. The first training was proposed to occur between January 13, 2014 and April 4, 2014 at CIMH in Barbados.

countries for technical officers in the agriculture ministries to translate meteorological data into information on proposed interventions. This was clearly recognized in Jamaica, where the meteorological agency and RADA are revising their bulletin to include more information on agricultural interventions. We also encountered significant variation in the continuity and sustainability of the data efforts started under CAMI. Continuing funding was found for most nations to sustain the progress made thus far, but the necessary expansion of information provision efforts has no clear funding stream. For example, CAMI included only 10 Caribbean nations, and many others have indicated interest in joining. However, such efforts await resource availability.

In summary, we did not evaluate the technical quality of the scientific information provided by CIMH or national meteorological agencies. We did note, however, that information on agricultural implications and interventions was far less prominent, consistent, and actionable than meteorological information. Ultimately, getting national meteorological and agricultural agencies collaborating together may be one of the most significant legacies of CAMI.

5.2 INFORMATION DISTRIBUTION TO FARMERS



Following the creation of climate information and information on agriculture interventions, the information must make its way to end-users, in this case agricultural extension agents and farmers. In CAMI, the distribution of the outlook bulletins varied across partner countries. However, bulletins for all countries except Grenada and Trinidad and Tobago are available on the CAMI website for public access.[7] Grenada has not yet produced outlook bulletins, but plans to do so in 2014. In Dominica, the meteorological and agricultural agencies split the cost of printing the outlook bulletin so they could pass out hard copies. The role of agricultural extension agents in the distribution of this information varied widely. While in all countries the agricultural agency was involved in the CAMI project, it was often unclear whether the agricultural agency was actively promoting and distributing the climate outlook bulletin through agriculture extension agents or other means.

Many interviewees noted that some of the farmers forums were particularly useful because Mr. Adrian Trotman of CIMH was able to explain the science of climate forecasting in simple terms and also able to connect climate events to specific consequences for agricultural crops and pest and disease outbreaks. In multiple countries it was reported that these interactive discussions helped generate buy-in by the farmers present. Furthermore, CAMI held a communications workshop in 2011 to begin a dialogue among meteorological and agricultural officers and extension agents, farmers, and others. The sessions covered preferred modes of communication in addition to exploring how to frame information for specific audiences. But little follow-up effort has been reported in either CIMH outreach to farmers or workshops for capacity

7. Trinidad and Tobago produce and post a 10-day weather forecast on their meteorological agency website. This was Trinidad and Tobago's preference over producing a seasonal forecast, and also an outcome of CAMI.

building among country meteorological and agricultural officers. CAMI partners, however, are reportedly seeking additional funding to conduct training sessions with agricultural extension officers.

A number of potential communication modes exist to ensure that the climate outlook bulletins reach farmers. Some of these communication modes were used by national meteorological and agricultural agencies, but many were reported by farmers as their primary means of gathering information, and were not yet being used to distribute the bulletins. These communication modes are discussed below.

Website. All of the CAMI project participants that we spoke with provided their climate outlook bulletins on a website – typically either the meteorological or agricultural agency's site. For those farmers with internet access and the necessary technological skills, the internet provides an easy option for information distribution. For government agencies, this is the lowest-cost option for information distribution. However, except for high-capacity farmers, characterized by their relative youth and education, and their ability to understand and desire to use complex climate data, very few farmers reported having internet access. Even farmers with internet access often were unaware that the climate outlook bulletin was available on a website (more often they received them through email). Ironically, of four lower-capacity farmers we spoke with in Dominica (where hard copies of the climate outlook bulletin were produced for distribution), the only one who had ever seen the bulletin had internet access and his wife could access the information for him. The farmers we spoke with in Barbados were highly educated and routinely used the internet, including proactively accessing the climate outlook bulletins in order to gain a competitive edge in the marketplace. Interestingly, web analytics were not used to track who sees or reads the climate outlook bulletins or with what frequency.

Government email distribution. Several countries' agricultural agencies reported emailing the climate outlook bulletins to a small email list. It was unclear how these email lists were compiled, but there did not seem to be a formal mechanism to request inclusion on the email list. Instead, the email lists appeared to be informal and put together by agriculture officers to reach known farmers' association representatives and other active and influential people in the agriculture community.

Farmers' associations. There are a number of farmers' associations both for individual countries and for the Caribbean region. For example, in Barbados there are two major national farmers' associations – the National Union of Farmers and the Barbados Agriculture Society. Regionally, the Caribbean Farmers Network was repeatedly mentioned in multiple countries as playing an important information distribution role for farmers. In Grenada, one farmer suggested that the Northeast Farmers Organization would be a good mechanism for distributing climate information once the meteorological agency begins developing outlook bulletins.

Informal networks. Informal networks appeared to be the primary means of climate outlook bulletin distribution on Barbados. But these networks were limited to high-capacity farmers. These farmers formed a tight-knit group that provided mutually beneficial support, particularly regarding farming techniques, crop selection, market behavior, and other variables that could provide a competitive advantage in the marketplace. While this communication mode was clearly limited in scope, the people using it were among the most likely to understand and take action on the information contained in the climate outlook bulletins. More generally, word-of-mouth was reported to be an important means of information distribution among all farmers in most of the locations where we gathered information.

Radio. Radio was a common means of sharing weather information in several of the countries. On Dominica, all four farmers cited the radio as their primary means of receiving information. This included weather reports as well as agriculture-specific information. The agriculture agency on Dominica broadcasts a radio program

once weekly on agricultural issues of relevance or interest to the local community. This included issues such as pesticide over-use, the hazard of specific pests and diseases, and mitigating soil loss. It was unclear whether any attempt had ever been made to push the climate outlook bulletin content through the radio programming, although interviews had been held, for example, with Mr. Adrian Trotman of CIMH, who spoke of the importance of climate change for agriculture. In Grenada, two of the farmers expressed their reliance on the radio for short-term weather forecasts. Additionally, in Grenada the Ministry of Agriculture, Lands, Forestry, Fisheries & Environment frequently contributes to a weekly, two-hour call-in radio program when they have relevant news to share with farmers. Agricultural agency staff noted this as a potential venue to share climate information once Grenada begins to produce outlook bulletins.

Television. Television was cited by one farmer on Grenada as a primary source of information on weather. This farmer felt that other farmers in his area also use the local television weather forecast, which is broadcast after the nightly news. He felt the short-term broadcast met his information needs, but also stated that a long-term outlook forecast would be helpful. A number of challenges exist in using television developed for the entire island to provide content to the specific audience of farmers. However, the prevalence of television as a medium for weather information suggests that it holds some potential for communicating about climate as well.

Text messaging. Although most agencies have not used text messaging to communicate about agriculture in their country, some farmers and agriculture officers suggested text messaging as a potentially good form of communication. Most farmers in CAMI countries have cell phones instead of land lines, but they do not all have the quality of telephone or the technological capacity to effectively text message. The ability of many farmers to use text messaging was questioned by government staff in several countries and by some of the farmers themselves. In Jamaica, RADA staff have used text messaging to warn farmers about extreme events. However, many farmers reportedly did not receive the texts.

Farmers forums. Farmers forums were held in each CAMI country as part of the CAMI process. The attendance at these forums varied from country-to-country. In Barbados, we were told that the forums did not attract many farmers, but rather attracted representatives from farmers' associations and plantation owners and managers. It was suggested that the purpose of these forums was to educate potential outlook users on meteorological terminology (e.g., What does "scattered showers" mean?) and the services available. To the extent that these forums did engage some fraction of the farming population, they might provide a model for distributing the climate outlook bulletins. Guyana shared that they held additional forums with similar content outside of the CAMI supported forums.[8]

One-on-one outreach efforts. One-on-one outreach often already occurs through agriculture extension agents. However, the quality and extent of this outreach effort reportedly varied from one country to the next. For example, it is quite labor-intensive on an island nation as large as Jamaica. In Barbados, agriculture officers did not know whether the agricultural extension agents proactively reached out to farmers to share this information. And at least one farmer on Barbados felt that the agriculture agency was out of touch with the needs of farmers. This contrasts dramatically with Dominica where the agriculture extension agents seemed to play an outgoing role in connecting farmers, including attempting to get the climate outlook bulletins into the hands of farmers. However, the success of extension agents in Dominica appeared limited

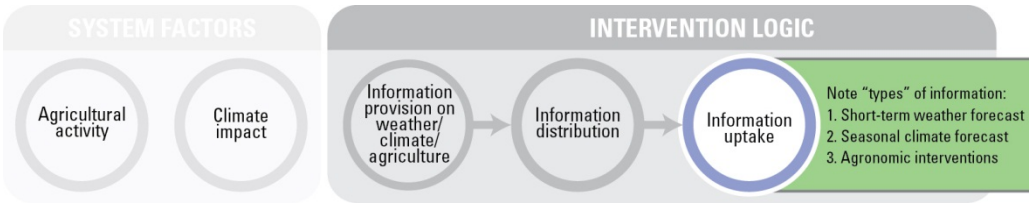
8. CIMH staff have encouraged CAMI partners to continue farmers forums after the initiative's formal end, particularly at the beginning of the wet and dry seasons. Guyana was one of the few instances of such continuing fora that we encountered.

as only one of the four farmers we visited had ever seen a climate outlook bulletin. Interviewees in Guyana reported relying on their extension agents to share information with farmers and help farmers interpret the information in the outlook bulletins. Farmers in Jamaica also seem to rely on extension agents for information and advice. However, many extension agents have not integrated the use of climate information into agricultural activities.

Hard-copy distribution. Hard-copy distribution was undertaken by some CAMI countries. The meteorological and agricultural agencies did this in Dominica because they understood that many of their farmers would not have access to the internet. It is not clear how these hard copies were distributed, but it was suggested that they might be posted on community bulletin boards, displayed at schools or churches, left at agricultural supply stores, and perhaps handed out to farmers at regular meetings with agriculture extension agents. We note, however, that of the four farmers interviewed in Dominica, not one had ever seen a hard copy of the climate outlook bulletin. Grenada, which plans to issue its first climate outlook bulletin in 2014, plans to distribute hard copies at import and supply shops where farmers are likely to visit.

There are many options to share climate services with farmers. While email and internet options are easy, low-cost, and sustainable, they are not the best way to reach farmers. From the farmers forums it might seem that text messaging and cell phone alerts are popular among farmers; however, the forums may have biased farmers by showing them a video from the World Meteorological Organization on disseminating agricultural information via text message. None of the farmers or agriculture officers interviewed felt that text messaging was a popular option for sharing information. In farmers forums and interviews, popular options included informal networks, one-on-one outreach, and radio programming. To a lesser extent, farmers indicated internet or email, farmer's associations, forums, and hard copy distribution as preferred information channels.

5.3 INFORMATION UPTAKE BY FARMERS



Following the creation of weather/climate and agriculture information and its successful distribution, the CAMI intervention pathway could still break down if farmers do not understand or misunderstand that information. Certainly most farmers have proven their capacity to use information by their ability to earn a livelihood. The issue here is whether the investment in skill acquisition necessary to make the productive use of probabilistic information products (e.g., Figure 5) is a good use of their limited time. And if it is not, whether that probabilistic information can be simplified and communicated in a way that is understandable and relevant. Those farmers that access a climate outlook bulletin must be able to take that information and then apply it to their unique situation. This relies on two key factors: (1) farmers understand the meteorological information, and (2) farmers can translate meteorological information into its agricultural implications. Without satisfying the first of these factors, the farmer may not be able to act because the information is overly complex or technical. Even if you satisfy the first factor but not the second, farmers could make misinformed decisions by misinterpreting the precipitation information in a way that causes them to take incorrect actions (e.g., planting a crop at the wrong time).

Thus, it is essential that the information (in the form of a climate outlook bulletin or otherwise) be targeted to farmers to convey the projected meteorological conditions in clear terms, and for the meteorological information to be translated to agricultural impacts and interventions. First, the provided information should tie the meteorological conditions to agricultural impacts. For example, if drought conditions are expected, the information should state that heavily water-dependent crops will not produce high yields or may not even germinate. Second, the provided information should suggest agricultural interventions to address the potential impacts. For example, if drought conditions are expected, the information should state that farmers should plant an alternative crop that is drought-tolerant and/or store water for irrigation.

Information uptake is one of the most difficult steps in the CAMI intervention logic to explore systematically. This is because very few, possibly even none, of the CAMI countries had any mechanisms in place to collect feedback from farmers on any of the CAMI activities – including farmers forums and the climate outlook bulletins. In Barbados, the climate outlook bulletins include only contact email addresses for feedback or comments. However, agriculture officers reported, in seeming contradiction, that they did not have feedback mechanisms in place and expressed low confidence that such mechanisms would be effective. Similarly, no other CAMI countries reported actively soliciting feedback, although many others also list contact numbers or email addresses on outlook bulletins. We are not aware of any concerted effort by any CAMI country to use web analytics to identify and track who was accessing the climate outlook bulletins and with what frequency. Consequently, we are left with anecdotal information as the sole means of developing a preliminary understanding of whether and how the climate outlook bulletin information was digested by farmers.

Farmer capacity played a key role in the answer to this question as described in Section 5.1 (Information Provision on Weather/Climate and Agriculture). Most Caribbean farmers are reported to be older, with little formal education, and limited motivation to deviate from traditional farming practices. This "average farmer" may need very specific information on agricultural interventions in order to change their behavior based on climate projections. But it is certainly possible to change their behavior. It was reported, for example, in the Barbados farmers forums, that Mr. Adrian Trotman of CIMH was able to engage participants, including some typical farmers, by describing in common terms the climatological reasons why certain crops were not germinating. Upon understanding the cause and effect of the climate on crop behavior, farmers reportedly began to immediately see value in Mr. Trotman's knowledge and take the remainder of the farmers forums quite seriously.

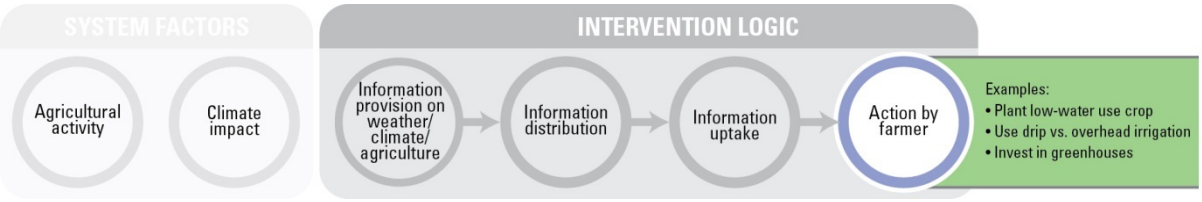
Notably, the key information component needed to ensure engagement was the agricultural implications of the climate information. This is described in more detail in Section 5.1, but in summary, meteorological information was provided with consistency across CAMI countries, while the agricultural impacts were provided inconsistently. It is interesting to note that interviewed agriculture officers in Guyana suggested that providing climate and agriculture information directly to farmers would not be fruitful. Instead, they reported that the extension agents worked directly with farmers one-on-one to describe the seasonal precipitation outlook and what it would mean for their particular circumstances. This sentiment was echoed in Jamaica. This suggests an important role for capacity building among the farmer population.

On the other hand, there are high-capacity farmers who can and do understand and make use of the complex meteorological forecasts. We had an opportunity to speak with two such high-capacity farmers in Barbados, and it was clear that they understood the information in the Barbados climate outlook bulletin. One of these farmers reported having an extensive collection of literature on the implications of climate and other factors on crops, pests, and disease that allowed direct use of the climate forecast to make informed decisions. The farmer that we interviewed in Jamaica – one of the 100 + acre farmers – was also capable of making use of

complex meteorological forecasts. These high-capacity farmers understood not only the implications of climate information for their crops, but also for the market conditions that would evolve under such climatological conditions based on their understanding of farmer behavior island-wide.

The information provided by CAMI is only valuable if it is understood by farmers. The national climate outlook bulletins generated by national governments under CAMI have already provided some high-capacity famers with information that they can understand and use. However, to reach the larger population of lower-capacity farmers, national meteorological and agricultural agencies may need to refine their information and convey not just meteorological data, but also agricultural actions in simple and clear terms. This could involve, for example, engaging in capacity-building activities with farmers, farmer's associations, or agriculture extension agents.

5.4 ACTION BY FARMERS



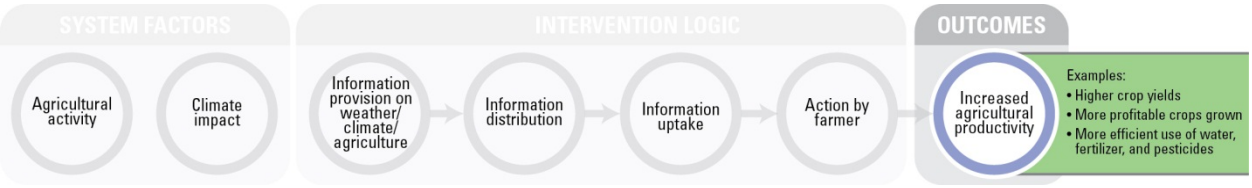
Assuming that high-quality, relevant information is developed, successfully distributed, and understandable to farmers, farmers still have to act on that information before agricultural outcomes can be improved. With the appropriate information, farmers should be able to take action to reduce impacts or take advantage of projected climate conditions. However, not all farmers will have the resources to act. For example, if a drought is predicted and the information provided by a national meteorological or agricultural agency recommends that farmers store water, not all farmers will have the capacity or resources to store water. Alternatively, some farmers may understand the information provided, but choose not to act because they do not trust the information source or because they prefer to engage in traditional farming practices that may be less sensitive to climate factors.

In our discussions with farmers in Barbados and Dominica, we heard from farmers who had used their national climate outlook bulletins to make different decisions about farming practices based on climate information. This ranged from decisions about pesticide and fertilizer application based on near-term weather forecasts, to decisions about which crops to plant, how to set up irrigation systems, and when to irrigate based on seasonal projections of precipitation. When we asked farmers who were unaware of the climate outlook bulletins whether such information would cause them to change their practices, they had a more mixed outlook. Some of them confirmed that such information actually would be useful and would generally lead them to make decisions as suggested above. Others freely admitted that they had more trust in traditional farming practices. In Grenada, one agriculture officer suggested that many local farmers had more trust in the local farmer's almanac than in scientific projections. Older farmers, in particular, were less apt to change their practices based on the outlook forecast. In Jamaica farmers suggested that climate information could be used primarily for irrigation and fertilization decisions.

Small-scale farmers in the Caribbean may not have the resources to act on data provided by the CAMI partner countries. Likewise, they may not trust CAMI data as much as their existing sources of information, such as traditional farming practices or fellow farmers. CAMI participating countries must keep in mind that their agricultural recommendations should be scaled to inform farmers with adequate resources, as well as those with limited resources. Over time and through ongoing collaboration with agricultural agencies and

agricultural extension agents, each country's climate outlook bulletin could become a trusted resource for more and more farmers.

5.5 INCREASED AGRICULTURAL PRODUCTIVITY



In this element of the logic model, the outcome of interest is the objective of CAMI, to "increase and sustain agricultural productivity at the farm level in the Caribbean region through improved dissemination and application of weather and climate information using an integrated and coordinated approach" (CAMI, 2010). For purposes of this evaluation, we propose that "increased agricultural productivity" means that farmers are more economically successful. From an anecdotal perspective, there are clear examples of farmers using the climate information to increase their productivity in terms of crop yields and economic gains – but only among high-capacity farmers that (1) can access the climate outlook bulletins in an electronic format and (2) are sophisticated enough to translate the meteorological information into agricultural interventions on their own.

However, three years is too short a time to expect CAMI partner countries to develop new agro-meteorological information, create an effective means to share this information with farmers, and convince farmers across 10 countries to change farming activities at a scale where we can measure increased agricultural productivity. An ideal second-tier option would be to identify specific intermediate outcomes as yardsticks for measuring progress, such as the number of climate outlook bulletins produced or the number of times a bulletin was accessed on a website. But CAMI did not identify such intermediate outcomes and such a metric-driven evaluation of progress was not within the scope of this current evaluation. Consequently, we focus on intermediate progress in each step of the intervention logic, which was done in detail in the above sections. Our findings are summarized below.

Information development on weather/climate and agriculture. The majority of CAMI countries have the ability to produce accurate climate information. While the CAMI participating countries had existing technical meteorological capabilities, in some cases CAMI improved their technical competency and capacity. Moving forward, the partner countries need to focus on providing not just meteorological data, but also on applications of meteorological data that clearly articulate crop impacts and agricultural interventions.

Information distribution. Through CAMI, lines of communication have been opened with farmers. The farmers forums held across the Caribbean brought meteorological agency officers and farmers together. The production of climate outlook bulletins provides an ongoing opportunity for outreach to farmers. Still, there is room for CAMI countries to further refine appropriate modes of communication to distribute climate forecasts. Part of this process will include identifying the best means for getting climate information into the hands of farmers. This distribution of information has not yet been tackled in a significant way in any of the CAMI countries that were part of this evaluation.

Information uptake. CAMI's farmers forums and communications workshop have helped meteorological and agricultural agencies officers consider how to convey climate information to farmers. There is a general understanding among meteorological and agricultural officers that information should not be overly complex,

and that information should be conveyed in multiple ways if possible (e.g., written text and diagrams). It is difficult to gauge CAMI's success in this area. Most of the farmers interviewed for this evaluation had not seen the outlook bulletins, and therefore could not inform us about their level of comfort with the information presented. High-capacity farmers clearly did understand the information. However, the consensus among nearly all interviewees was that the majority of farmers would not be able to understand the current climate outlook bulletins without significant assistance.

Action by farmers. While there is evidence that farmers are interested in high-quality data, they must be able and willing to act on information. The high-capacity farmers that we interviewed reported that they were using the information in the climate outlook bulletins to make decisions, especially about crop and irrigation. However, many farmers may not have the financial resources to invest or they may not trust the information provided. These issues will become more important as the CAMI partner countries continue to expand their activities to reach more farmers.

Unfortunately, there is almost no way to quantitatively determine how much of the economic success of farmers is due to good farming practices (or the use of climate information). Definitive metrics of "increased agricultural productivity" are at present hard to come by. For example, it is nearly impossible to collect reliable information on agricultural production in most CAMI countries because most food production is fruits and vegetables on small plots of land sold to the local market, either by individual farmers or through in-country distributors. As such, there is no centralized data collection on total amount of produce and land in production, variety and quantity of crops grown, etc. While the quantitative evaluation of farm productivity and profitability is certainly possible, it would require a more intensive effort than is feasible under the current evaluative process.

6. CONCLUSIONS

While three years is too short a time to expect CAMI partner countries to develop new agro-meteorological information, create an effective means to share this information with farmers, and convince farmers across 10 countries to change farming activities at a scale where we can measure increased agricultural productivity, CAMI and many of its partner countries have made significant progress. With additional effort each of these countries can move forward and further develop effective climate services.

CAMI enhanced the regional networking of meteorologists through CariCOF. CAMI also improved networking between meteorological and agricultural officers in each member country. This led primarily to climate outlook bulletins that were developed by most of the 10 countries to communicate a three-month seasonal forecast to agriculture extension agents and farmers. These bulletins contained high-quality meteorological data, but information on agriculture impacts and interventions varied from one country to the next.

In nearly all countries, these bulletins have been put online, but this is clearly not the best means to reach most farmers. Nevertheless, this information reached some high-capacity farmers who could understand the complex meteorological forecast data, and these farmers reported using this information to make decisions to increase their productivity – such as crop choice and irrigation decisions. Some work remains on improving the quality of the agricultural information included in the climate outlook bulletins. Much more work remains on information distribution and building farmer and extension agent capacity if CAMI is to be relevant to more than high-capacity farmers. Since CAMI is over, initiative partners are seeking new sources of funding to continue this work. For most countries, stable funding for ongoing CAMI work is challenging in the long-term due to resource constraints.

In brief, CAMI has made tremendous progress in the short time that it operated. Many of its successes were focused on the early stages of the CAMI intervention logic – mostly on the production and compilation of high-quality meteorological information with potential agricultural implications. However, many critical steps in the CAMI intervention pathway have not yet seen significant effort or attention. On balance, CAMI made significant progress in a short time and has set in motion a number of critical components for a successful climate service. We summarize some of our specific conclusions in the bulleted lists that follow.

Process-based conclusions:

- CIMH facilitated networking among meteorological officers in the participating countries.
- Mr. Adrian Trotman, director of CIMH, provided significant leadership on most CAMI activities and laid the foundation for many of CAMI's successes.
- Jeffrey Spooner, Director of the Jamaican Meteorology Service, has similar stature among Caribbean meteorologists; the quality of information services from the Jamaican Meteorological Service is widely recognized in the region.
- CIMH played an important facilitation and capacity-building role for many of the CAMI country meteorological and agricultural agencies, including, through their training activities, data sharing, and outreach efforts, providing new skills, new networks, and new staff.

- The CariCOF consensus process for developing a regional climate forecast ensures forecast quality, builds capacity among the region's meteorologists, and facilitates outreach to forecast stakeholders.
- The 10 participating countries shared up to 30 years of meteorological information with CIMH. This was, in part, to increase the robustness of their modeling, but also to improve recordkeeping and the digitization of data where it had not occurred in the past.
- CAMI was highly successful at expanding the focus of many national meteorological agencies from aviation to a broader view of climate services – not just to agriculture, but potentially other client sectors (e.g., forestry and fisheries) as well.
- CAMI successfully developed a dialogue among national meteorological agricultural agencies. In countries such as Jamaica, it helped to garner additional resources from outside funding agencies to continue or improve the program.
- In contrast to the national meteorological agencies, national agricultural agencies did not have a pre-existing regional network and, consequently, varied significantly in capacity, effectiveness, and motivation across countries.

Weather/climate and agriculture information provision conclusions:

- Both the regional and national meteorological forecasts appeared to be high quality, with built-in quality control procedures
- Information on the agricultural impacts and interventions of the meteorological forecasts was uneven across countries and generally scarce
- Few climate outlook bulletins provided concrete, actionable agricultural interventions, for instance, on what to plant and when, based on the climate forecast.

Information distribution conclusions:

- Most CAMI countries have only distributed their climate outlook bulletin on a website or through small, informal email lists, methods which do not reach wide audiences.
- The primary communication modes reported by farmers appeared to be informal networks and agriculture-specific radio programming, neither of which has yet been targeted by CAMI. Both hold the strong potential for broader distribution of climate services.
- It was unclear in many CAMI countries whether the agriculture agency actively promoted and distributed the climate outlook bulletin through agriculture extension agents or other means.

Information uptake conclusions:

- A small group of high-capacity farmers was able to understand and make use of the complex meteorological forecasts, even without accompanying information on agricultural impacts and interventions.
- Most Caribbean farmers were reported to be older, with little formal education, and limited motivation to deviate from traditional farming practices.
- To reach the larger population of lower-capacity farmers, national meteorological and agricultural agencies may need to refine their information and convey not just meteorological data, but also agricultural actions

in simple and clear terms. This could involve, for example, engaging in capacity-building activities with farmers, farmer's associations, or agriculture extension agents.

- Through CAMI activities, including the communications workshop and farmers forums, many of the countries are thinking critically about how to best convey information to farmers, in language and diagrams that the majority of farmers can understand.

Actions by farmer conclusions:

- Farmers using their national climate outlook bulletin reported making different decisions about which crops to plant, how to set up irrigation systems, and when to irrigate based on seasonal projections of precipitation
- Farmers not using their climate outlook bulletins expressed that scientific climate forecasts would have to compete with traditional farming practices, farmer's almanacs, and other sources of information to change their behaviors.

Increased agricultural productivity conclusions:

- Even advances in agricultural productivity due to the provision of climate and agriculture information to farmers could be offset by a wide range of other socioeconomic factors affecting agricultural productivity in the Caribbean, such as national import and export laws, regional markets, unavailability of cold storage facilities, market gluts, poor information availability, inconsistent government support, and international trade rulings
- It is nearly impossible to collect reliable information on agricultural productivity in most CAMI countries because most food production is on small plots of land and sold to the local market, with no centralized data collection on the total amount of produce and land in production, variety and quantity of crops grown, etc.

7. RECOMMENDATIONS

- *Fortify cross-agency relationships.* In many countries, CAMI was the first opportunity for meteorological and agricultural service staff to work collaboratively. Meteorological services staff must continue to collaborate with agricultural service staff for CAMI-initiated efforts to succeed in the future. Moving forward, CAMI partners should look for opportunities to collaborate with their agricultural service counterparts; this will help build the agronomy capabilities with meteorological services and meteorological capabilities in agricultural services.
- *Place additional emphasis on agricultural interventions.* While some participants identified this is a challenge, it should remain a goal of CAMI partners to clearly articulate crop impacts and agricultural interventions of the meteorological and climate data they provide.
- *Track information distribution.* Currently, CAMI partners do not have a sense of how many farmers they are reaching through their primary climate service – outlook bulletins. In the future CAMI partners should aim to track the distribution of outlook bulletins to better understand their reach. Options include tracking the number of "clicks" or downloads from websites, tracking the number of hard copies distributed, monitoring attendance at forums, and working with extension agents to track information sharing.
- *Use interactive information-sharing methods.* CAMI partners should focus on those information distribution methods that allow interaction with end-users. These methods could include one-on-one contact between extension agents and farmers, forums, outreach to effective farmer organizations, and call-in radio programs. In particular, outreach to informal networks has the potential to spread climate services, due to farmers' reliance on peers for guidance. These methods provide opportunities to ensure that information is conveyed clearly, and allows end-users to provide valuable feedback.
- *Expand the role of agricultural extension agents.* Agricultural extension agents have great potential to communicate climate information with farmers. However, many agricultural extension officers could benefit from additional training on understanding and communicating climate data and agricultural impacts. CAMI partners are already seeking funding to conduct training sessions with agricultural extension agents to increase their capabilities with regard to climate information.
- *Seek feedback from end-users.* CAMI partners should actively seek feedback from farmers on outlook bulletins. This will help ensure that key messages are clearly conveyed, and that their climate services have the information farmers need most. Options for actively seeking feedback include soliciting feedback at farmers forums, tracking questions on radio programs, setting up automated web-based surveys, having agricultural extension officers actively distribute surveys, or sharing websites, email addresses, or telephone numbers where users can provide feedback.
- *Continue to refine outlook bulletins.* Just a few years into CAMI, it is clear that partner countries are still working to determine what information is most valuable for farmers. CAMI partners should continue to refine the content of their outlook bulletins based on changing needs – guided by feedback from end-users.
- *Develop metrics to measure success.* The evaluators are aware that CAMI has not yet defined how it is measuring the primary goal of "increased agricultural productivity." This goal can be measured through

several metrics. CAMI partners should develop a collective set of metrics and begin taking stock of their progress.

- *Think long-term.* Sustainability of CAMI in the future will be a challenge. CAMI is still in the process of scaling-up its climate service and already must seek new funding sources. CAMI partners should seek more stable, longer-term funding if possible.

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APPENDIX. LIST OF INTERVIEWEES

TABLE A.1. INTERVIEW PARTICIPANTS.	
Name	**Affiliation**
Ashley Adams	Guyana Sugar Corporation Inc.
Lisa Agard	Caribbean Institute for Meteorology and Hydrology
Kennedy Alexander	Farmer in Dominica
Lawrence Anselm	Farmer in Dominica
Ryan Grell Anselm	Dominica Ministry of Agriculture and Forestry
Earala Baptiste	Farmer in Grenada
Austin Bell	Dominica Ministry of Agriculture and Forestry
Jason Bennett	Jamaican Rural Agricultural Development Authority
Joseph Braveboy	Farmer in Grenada
Glenroy Brown	Meteorological Service of Jamaica
Donessa David	The Hydrometeorological Service of the Guyana Ministry of Agriculture
Evangeline Devonish	Ministry of Agriculture Barbados
Rositta Fevrier	Farmer in Dominica
Kenton Fletcher	Grenada Ministry of Agriculture, Lands, Forestry, Fisheries & Environment
Michael Forde	Farmer in Barbados
Evans Gooding	Farmer in Grenada, and President of the Northeast Farmers Organization
Dalkieth Hannah	Farmer in Jamaica
Keeley Holder	Farmer in Barbados
Samuel Inniss	Ministry of Agriculture Barbados
Annie Carriette Joseph	Dominica Meteorological Service
Felix Leslie	Dominica Ministry of Agriculture and Forestry
Winston Magloire	Dominica Ministry of Agriculture and Forestry
Sonia Nurse	Barbados Meteorological Services
Fitzroy Pascal	Dominica Meteorological Service
George Phillip	Grenada Ministry of Agriculture, Lands, Forestry, Fisheries & Environment
Madeline Rafael	Farmer in Dominica
Cavell Rhiney	Jamaican Rural Agricultural Development Authority
Petra Grell Shillingford	Dominica Ministry of Agriculture and Forestry
Jacqueline Spence	Meteorological Service of Jamaica
Jeffrey Spooner	Meteorological Service of Jamaica
Shontelle Stoute	Caribbean Institute for Meteorology and Hydrology
Reginald Thomas	Dominica Ministry of Agriculture and Forestry

TABLE A.1. INTERVIEW PARTICIPANTS.	
Name	**Affiliation**
Trevor Thompson	Grenada Ministry of Agriculture, Lands, Forestry, Fisheries & Environment
Adrian Trotman	Caribbean Institute for Meteorology and Hydrology
Adisa Trotter	Dominica Ministry of Agriculture and Forestry
Cédric Van MeerBeeck	Caribbean Institute for Meteorology and Hydrology
Delia Weeks	Dominica Ministry of Agriculture and Forestry

U.S. Agency for International Development

1300 Pennsylvania Avenue, NW

Washington, DC 20523

Tel: (202) 712-0000

Fax: (202) 216-3524

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