Review of Climate Services Governance Structures: Case Studies from Mali, Jamaica, and India

Working Paper No. 236

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Abstract

The development of sustainable climate services is acknowledged as a key step in building climate-smart practices. Further, it has been noted that successful and sustainable climate services have structures of governance that are coherent and transparent for the stakeholders involved. To facilitate a discussion about what governance processes might help sustain climate services for agriculture in Rwanda, the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) commissioned an assessment of case studies on structures of governance for climate services, focusing on national level climate services for agriculture that have been considered successful. The objective of this document is to present an exploration of governance structures for national level climate services—specifically agro-meteorological climate services provided to small-holder farmers—to identify ways in which CCAFS can provide guidance on key principles. This assessment and subsequent analysis are based on 3 case studies: Mali, Jamaica, and India. We explore common themes of effective and sustainable climate services to inform the development of structures for governance of a national level climate service. In doing so, we provide a more granular analysis on three key components: multi-disciplinary working groups, agreements and memoranda of understanding, and monitoring and evaluation processes. For each component, the following themes are noted as key considerations: identification and inclusion of appropriate organizations and key personnel, level of formality, and funding.

Keywords

Climate services; climate variability; agriculture adaptation; governance; policy

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Contents

Acronyms

ACDI/VOCA Previously the Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance, now known by the acronym only

AU Agricultural University

CAMI Caribbean Agro-Meteorological Initiative

CARDI Caribbean Agricultural Research and Development Institute

CCAFS CGIAR Research Program on Climate Change, Agriculture and Food Security

CPT Climate Predictability Tool

CRM Climate Risk Management

CSA Climate Smart Agriculture

CSP Climate Services Partnership

DAMU District Agrometeorological Field Unit

DfID Department for International Development

DRR Disaster Risk Reduction

ENACTS Enhancing National Climate Services

GFCS Global Framework for Climate Services

GTPA Projet d'Assistance Agro-meteorologique au Monde Rural

ICAR Indian Council of Agricultural Research

IAAS Integrated Agrometeorological Advisory Service

ICRISAT International Crops Research Institute for the Semi-Arid Tropics

IMD India Meteorological Department

IRI The International Research Institute for Climate and Society

JaREEACH	Jamaica Rural Economy and Ecosystems Adapting to Climate Change
KVK	Krishi Vigyan Kendras
MoU	Memorandum of Understanding
NMHS	National Meteorological and Hydrological Services
NMS	National Meteorological Service
NGO	Non-governmental Organization
RADA	Ministry of Agriculture extension agency of Jamaica
SDC	Swiss Agency for Development and Cooperation
SMS	Short Message Service
USAID	United States Agency for International Development
WMO	World Meteorological Organization

Introduction

The availability and use of relevant climate information are prerequisites for the development of climate services. However, the achievement of these elements alone is far from guaranteeing the sustainability of climate services. Steps should be taken to move beyond noting success for short term achievements of a sufficient climate service and towards identification of factors that contribute to long-term continuity in service provision.

It has been conjectured that a transparent, stable governance structure with strong connections with users is a common theme of past and current sustainable climate services. Unfortunately, a set of best practices to support the development of governance structures does not exist, therefore adversely impacting the overarching effort of establishing, transferring, and scaling sustainable climate services. Options for structures for governance of national level climate services have not been explored in such detail as climate services themselves. This leaves a gap in the understanding that governance structures are important components of a climate service, and the understanding of critical features for "effective" and "sufficient" governance structures.

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) acknowledges the importance of governace as a key element to bridging the gap between availability and sustainable use of relevant climate information by the agriculture sector, focusing on small-holder farmers. CCAFS commissioned this paper to explore various examples of governance structures for national level climate services of agriculture with the goal to identify lessons learned and potentially moving towards developing a learning agenda for CCAFS and partners.

This working paper was informed by outcomes from technical working groups within the National Consultation Workshop for setting up the Rwanda National Framework for Climate Service in Kigali, Rwanda, December 2017. Structures of governance—as arbiters and promoters of transparency, accountability, and thus potential trustworthiness of the climate services—are necessary. The building of trust cannot be left out of the process—it needs to be incorporated as the primary step in demonstrating credibility and transparency (Street et al., 2015). This paper seeks to outline elements of sustainable and effective and structures of

governance for national level climate services. For each element, key cross-cutting themes will be suggested for consideration.

Methods

We evaluated existing and past examples of implementation of national level climate services for the agriculture sector with a focus on structures for governance. We began with a desk review of 30 documents addressing climate services, which include peer reviewed journals, policy guidance documents, and white papers for inclusion of references to governance structures. To explore further, we chose a case study format, an ideal method when detailed contextual analysis is needed and a limited sample size exists (Y in 1984). As part of the case study analysis, semi-structured interviews were conducted. This process was appropriate given the qualitative attributes of governance structures, including the impacts of the climate services. Table 1 summarizes the themes for exploration for the analysis.

Table 1 Primary organizing themes for the literature review and case study analysis

Theme 1 - Background
Format of the deliverable(s) from the climate service
Names of relevant stakeholder organizations, including key positions within
Names of positions and key personnel from key stakeholder organizations
Role of the private sector
Seasonality of the climate service

Theme 2 – Product Development and Dissemination
Schedule of meetings
Level of spatial granularity for product development
Existence of informal processes
Communication of uncertainty

Theme 3 – Monitoring and Evaluation
Frequency of review for effectiveness
Format of outputs
Contextualization for different users
Processes for review of new technology to potentially enhance the climate service

Literature Review

Climate services developed for national scale activities (National Climate Services) are important elements of national level action plans to address climate and weather risk, across timescales, including climate change and variability (Lechthaler and Vinogradova, 2017). In turn, National Climate Services can potentially reduce risk of climate and weather related impacts on the most vulnerable populations if the services are tailored to specific user needs (Changnon et al., 1990; Miles et al., 2006; Fekadu et al., 2017).

To meet the need to ensure high-quality, relevant climate science and other related meteorological and geophysical research are made available to users, the World Meteorological Organization developed the Global Framework for Climate Services (GFCS) (Hewitt et al., 2012; Lucio et al., 2016). Since the initial development of the GFCS, it is presumed that national level government should have a central role as the source of national level climate services (World Meteorological Organisation, 2011; Hewitt et al., 2012; Giuliani et al., 2017). Within the GFCS, stakeholder identification and understanding of their roles are noted as key steps in developing climate services. Dilling and Lemos (2011) recognizes the importance of an individual stakeholder assessment, noting that the level of risk averseness of those involved in the governance of climate services will vary and may lead to a difference in perception of prioritization. Similarly, Kirchoff et al. (2013) notes that stakeholder interaction is a complex, multi-directional process from knowledge production to user participation.

Recently, a growing interest in climate services is partially driven by the realization of their value to address socioeconomic impacts linked to climate change and variability (Vaughan et al., 2017) and larger scale economic processes (World Meteorological Organisation, 2015). While qualitative and quantitative approaches to assess the value of climate services for society have not led to a consensus of specific best practices, they resulted in the acknowledgement of the need for interdisciplinary value chain structures using raw data, through intermediaries and users to outcomes (Lazo et al., 2008; Morss et al., 2008; Lee et al., 2014). While there is a general agreement of climate services having value, there is a lack of knowledge of the value of their individual parts (Clements et al., 2013). Without this understanding, the establishment of a set of best practices, key principles, or important considerations is hindered. Fortunately, there is a growing body of literature outlining the challenges of existing climate services. This has prompted a discussion on how we can learn

from these examples, transform gaps and failures into identified challenges and goals that can be addressed when revising current, and develop future climate services (Shumake-Guillemot, 2017).

Governance structures for national level public services are dynamic systems influenced and driven by their surrounding social, political, cultural and environmental situations (Hough, 2007). A governance structure, when framed from the perspective of supporting a service that has jurisdiction on a national scale, is an established set of "roles and responsibilities" and institutional arrangements for the parties involved in the planning, operations, modification, and monitoring of a service. While previous work on governance structures specific to climate services is limited, some key findings have emerged.

At the international level, recent investments in climate services (for example, the European Union's Horizon 2020 programs and sub-programs) call for the exploration of governance structures for climate services in order to promote and enable the development, delivery and use of climate services (Street et al., 2015). Similarly, at the national level, Golding et al. (2017) identifies activities prerequisite to the development of climate services, using China as a case study. These include understanding the social and economic situations as well as outlining the existing relevant governance structures. Further, citing lessons learned from Ethiopia and the United States, the International Research Institute for Climate and Society (IRI) finds that mechanisms to foster collaboration—specifically when aligned with pursuance of agreed-upon objectives with set metrics for evaluation—should be a priority in the development of effective and sustainable climate services (USAID, 2012).

In recognition of the need for established and transparent roles and responsibilities, Brasseur and Gallardo (2016) cite the lack of institutional alliances at the national level as a key contributor to failure of national level climate services. In addition, experiential learning from GFCS projects led to the finding that "limited and weak" partnerships between national institutions are notable roadblocks against long-term sustainability of climate services that are functional at a particular point in time (Shumake-Guillemot, 2017b). Furthermore, partnerships should not be limited to the service provider and user. To maximize the economic and social value potential of climate services, attention needs to be placed on the roles and responsibilities of the monitoring and evaluation process of all potential stakeholders (World Meteorological Organisation, 2015).

Additionally, failure to "creating an enabling environment" (which, as defined by the author, consists of structures that bring together principle actors from technical and practical spaces) is a significant burden on the maintenance of national level climate services (Vaughan et al., 2017). In reinforcing the importance of institutional arrangements and alluding to the benefits of clear, defined roles amongst actors, success stories of climate services exist and is driven, at least partially, by a stand-alone central entity that gathers and manages the necessary expertise (Cavelier et al., 2017).

Vaughan and Dessai (2014) establishes a certain set of criteria to gauge the effectiveness of climate services. These have been slightly restated here as: Problem Identification, Tailoring and Communication, Governance Structures and Processes, and Socioeconomic Value.

Additionally, existing frameworks and guidance recognize the need for national level climate services to have "effective coordinating mechanisms" and they stress the importance of involving all "relevant" stakeholders in the process of designing and implementing a climate service (Hewitt et al., 2012). In doing so, there is an increased likelihood for the initial source of the science (usually the national meteorological and hydrological service) to transition from data to service provider.

From the research and experiential lessons learned, there is consensus that for a climate service to be sustainable, a transparent, effective, and sufficient governance structure is necessary. The scope of governance structure must also clearly identify all stakeholders involved and their respective roles and responsibilities. However, best practices and key considerations for the design of governance structures for national level climate services have not been identified systematically or explored rigorously.

This gap points to a persistent challenge in the progress of developing sustainable climate services, while the climate services sector has grown globally into a discreet field (Street, 2016; Harjanne, 2017). As investment in climate services continues to increase, designing climate services at the national level without considering the design of associated governance structures could limit their effectiveness, initially and especially long-term.

To move towards closing the gap left by a lack of guidance for governance structure development, we focus on 3 national level case studies: Jamaica, Mali, and India. From a comparative analysis of each case study, key similarities and differences are distilled. This

initiated a discussion on how key principles and considerations can be presented to move towards guidance in the development of governance structures for climate services.

Case Study Selection

We identified candidates for case studies based on several characteristics (Table 1). For final selection of appropriate case studies, we consulted with climate service development specialists and expert implementers. Regarding geographic context, we were interested in countries that are located in the tropics. From a socioeconomic perspective, we focused on developing rather than developed countries. A qualifying country does not need to have an active national level climate service to be considered for this analysis; however, each country selected happened to have one operational program – even if different from the original or intended format. Given the potential value gained by interviews (both in country and international), to be considered for selection, the authors must have confidence in identifying and connecting with key personnel with familiarity with roles and responsibilities associated with the climate service.

Development of guidelines for semi-structured interviews

Key personnel were identified and interviewed to gauge their perception of contributors to the functionality of the climate service of interest, focusing on elements of governance. The semi-structured interviews were divided into 3 parts, corresponding to the components of the case study design (as noted in Table 1): Background, Product Development and Dissemination, and Monitoring and Evaluation. This interview guidance structure can be found in Appendix 2. The interview begins by asking key personnel about the background of the climate service – addressing basic elements such as names of partners and lead organization, then expanding to include more specific questions about funding and role of the private sector. The second part of the interview consists of questions aiming to outline the process of developing a specific product (e.g., an agro-meteorological bulletin). This include questions regarding the scheduling of meetings, mechanisms for formal and informal input, and qualitative and/or quantitative downscaling processes. Lastly, the interview addresses monitoring and evaluation systems. The goal of this part of the interview was to gain insight to the processes around collected data on the impact of the climate service, and to capture if/how and when the climate service was reviewed and revised.

Case Study Analysis

First, for each case study, an outline of the national level climate service is provided, focusing on the network of partners, roles and responsibilities and funding. Second, we present an overview of the product development and dissemination processes. Third, we explore the monitoring and evaluation processes to both identify systems in how the climate service is assessed for potential value and how the data gained from this system is integrated to a potential revision of the climate service.

Next, we conduct a qualitative analysis to identify common themes, key similarities and notable differences across the case studies. Subsequently, we present key lessons from both the case studies and the outputs of the literature review, focusing on elements of governance around key components: multi-disciplinary working groups, agreements and memoranda of understanding, and monitoring and evaluation processes.

Lastly, to enhance the accessibility and potential usefulness of the information across varying audiences, we present the analytical outputs in two formats: a set of key questions and considerations and a list of research prioritise. The key questions and considerations may be useful for policymakers considering the development of a national level climate service. Meanwhile, the research priorities may be useful both for policymakers in identifying where gaps may exist in the understanding of governance structures, and for the multi-sector research community interested in exploring how to develop a set of best practices for designing governance structures for national level climate services.

Case Studies of National Level Climate Services

India

India's primary climate service for the dissemination of agriculture information, the Integrated Agrometeorological Advisory Service (IAAS), manifests as weekly advisories focused on highlighting the weather conditions of the forecast target period and outlining potential impacts on the agricultural sector. The lead actor of the IAAS is the Agricultural Meteorological Division of the India Meteorological Department (IMD). The parent ministry of IMD service, the Ministry of Earth Sciences, has undertaken the role of performing economic impact analyses of IAAS (Maini and Basu, 2016). The Ministry of Earth Sciences

provides the budget for the IAAS. Communication outlining successes and challenges of implementation and development of the program takes place through a quarterly newsletter, and detailed minutes and proceedings from meetings.

There is an extensive network of partners involved with the IAAS. These partners can be placed into 3 categories: national level government actors, sub-national level government actors, and non-government actors.

Among national level government actors, IMD under the Ministry of Earth Sciences is the lead organization. Two departments within the national Ministry of Agriculture, the Department of Agriculture and Cooperation and the Indian Council of Agricultural Research, are also involved. Four sub-national level government actors are involved: the state-level Departments of Agriculture; Horticulture; Animal Husbandry; Dairying and Fisheries; and Forestry. The State Agricultural Universities are the co-leads at this level. NWith over 680 institutions across the country, the Krishi Vigyan Kendras (KVKs) serve as 'front line' Agricultural extension center interfacing with farmers and are financed by the Indian Council of Agricultural Research (ICAR). The most recent development is the introduction of District Agrometeorological Field Units (DAMUs), which are housed by the KVKs and designed to support the issuance of block level agricultural impact advisories when necessary (Chattopadhyay and Chandras, 2018). Lastly, the three categories of non-government actors involved include development NGOs, media agencies, and telecom providers. Notably, according to an informant interview, the level of involvement of these actors vary significantly, with some abstaining from engagement at times and others periodically increasing or dampening involvement.

To formalize the roles and responsibilities, Memorandums of Understanding (MoUs) were signed between the President of India (through IMD) and a specific agricultural university (AU) (Government of India, 2009). Within this MoU, specific responsibilities are outlined for agrometeorological field units (AMFU) and IMD. The AMFU's responsibilities include preparing weather-based advisories, consulting with subject-based experts to enhance the advisories, disseminating the advisories, and liaising with other agencies (such as ICAR, District Agricultural/horticultural/animal husbandry offices, KVKs, etc.). They are also tasked specifically with providing feedback to IMD regarding value of the advisories,

appropriateness of agro meteorological predictive models, crop-weather relationships, and predictive models for climate related pests and diseases (ibid).

The obligations of IMD include providing weather forecasts to an AU and supporting them in the development of meteorological observing systems, such as automatic weather stations and automatic rain gauges. Further, IMD is responsible for providing financial resources to an AU for an AMFU to operate the agrometeorological advisory services. Items funded include salaries, travel expenses, purchasing and maintaining of equipment, human resources operations and other contingent expenses for operating the agrometeorological services such as telephone, stationary, and publications (ibid). This funding was designed to support the service for 5 years with the AU resuming responsibility at that time. The MoU does not explicitly state all IMD funding will end after 5 years, rather it is stated that it is possible to scale back some or all of the funding for the activities and that regardless of the funding provided AU is tasked with continuing all noted responsibilities.

Obligations of the AU include receiving the forecasts from IMD, preparing and disseminating the advisories for districts within the Agro Climatic Zone, organizing awareness activities, maintaining agro meteorological observatories and automatic weather stations and preparing databases for research and advisory purposes. They are also tasked with preparing an annual report submitting utilization certificates and statements of expenditure.

Product Development and Dissemination

Climate services for the agricultural and related sectors are produced in the form of advisory bulletins at three geographic scales: national level, state level, and district level. National level bulletins are issued once weekly while state and district level are issued twice weekly.

The process begins at the national level unit of IMD when a forecast is issued and sent to the state level units of IMD. State units add value to these products, through a downscaling of the national forecasts. Next, this now tailored forecast product is sent to district level units of IMD. It is the role of the district level units to convert these forecasts to agrometeorological suggestions and instructions.

Agrometeorological field units (AMFUs) have been established at the rate of one per agroclimatic zone (130) and are co-managed by IMD and host institutions, which are typically universities and agricultural research centers. It is the role of the AFMUs to incorporate

agricultural expertise into the agrometeorological advisories through interactions with agricultural experts at the sub-national and local level, and also include inputs from national agricultural research bodies. Each AMFU has an appointed nodal and technical officer. These sub-national actors meet at the AMFU (multi-district) level to discuss the national level advisory and discuss local applications of the updated information. The officers of the AMFU act in consultation with agricultural experts, who are usually collocated at the host institution. Interviews with key informants provided evidence that partners do provide input and may be consulted, but did not yield specifics.

The weekly dissemination structure of advisories has been in its current form since 2008 (Tall et al., 2014). The production of agrometeorological information is a year-round process, led by the Agricultural Meteorology Division of IMD. Partner organizations—including agricultural organizations—are involved through formal agreements at the local level. The degree to which the agreements are formalized is unclear. Public-private partnerships are especially important for dissemination. Current private sector actors involved includes Reliance Foundation, Reuters Market Light, Kisan Sanchar, Handygo and Mahindra Samriddhi (Chattopadhyay and Chandras, 2018).

IMD distributes the advisories using three modalities – mass mode, on-demand accessible channels (e.g. website, SMS and voicemail/call-in system), and person-to-person communication outside of the village, which is undertaken by extension agents (Rathore, 2016).

Mass mode dissemination takes place at both the national and sub-national levels using both national and sub-national climate information. Mass mode consists of radio, television, internet and print and social media, and has a large potential audience. However, the specificity of information—including identification of specific actions to take to address a communicated risk—can be lacking. The online portal is updated daily and includes a record of national level advisories (India Agricultural Meteorology Division, 2017).

Outreach at the village level consists of a multi-faceted system. First, an SMS/texting system supports the capacity to maintain a dataset of willing subscribers along with associated contact information. When a new advisory is produced, SMS is sent to all subscribers. The content capacity is limited to a single message, such as an alert pushed out to a targeted village to communicate increased risk of a particular pest. The full advisory cannot be

communicated via SMS. Further, voice messaging services are available, in which farmers can opt-in for regularly scheduled voicemails with tailored agrometeorological information. mKisan is the largest of such systems (Mittal and Mehar, 2012). Third, a call-in system is co-managed with the Department of Agriculture. This system affords the opportunity for agriculture sector interested parties to call a toll-free number and listen to a pre-recorded message. The types of information available vary depending on the district, however, it is likely to include district level weather forecast information, agricultural training material and the opportunity to coordinate farm inputs with a district agricultural officer (DAO).

Another important channel is through farmer extension centers, where electronic kiosks enable access to the advisories, and extension agents, who convey agrometeorological advice (Rao, 2007). Local extension centers and other parties collaborate with the IMD's local units in their delivery of services and advice to farmers.

Monitoring and Evaluation

Acknowledging the importance of monitoring and evaluation of climate services, India established procedures to incorporate feedback from end-users at various stages of use. Incorporating feedback is accomplished through 3 different face-to-face processes, however, the specifics of integration of feedback metrics for the potential revision of any element of climate service are unclear.

First, feedback is tendered from attendants at the annual national level mKisan agriculture exhibition (Rathore, 2016). During this event, farmers were asked for perceptions of usefulness of the climate information provided by the IAAS. Second, the community level presence of KVKs is leveraged to process granular data of strengths and weaknesses. We found this feedback to be produced in an ad-hoc manner, but there is evidence that some information is sent from KVKs to the AMFUs for consideration. Lastly, IMD runs various training programs which call for the assembling of many farmers. This opportunity is leveraged to discuss the value of IAAS and potential improvements. Further, this information is combined into an annual progress report is posted on the program's website (Chattopadhyay, 2014).

Reporting is also undertaken on development of the agrometeorological advisory service as a whole, with a focus on development of the service's technological and outreach components.

A quarterly newsletter and an annual progress report are published online. An annual review meeting is also held and is attended by leadership of the IMD as well as officers of AMFUs. Reports on this annual review meeting are also published online and contain indications of several areas by which the advisory service is set to be improved. These reports indicate that most of the actors in the review process are within the IMD.

The funding mechanism of the Monitoring and Evaluation (M&E) process is unclear. It was determined that the M&E process is fairly well defined, however the process of using outputs of M&E to inform revisions in the climate service is unknown. This is not to say feedback from M&E processes has not led to an improvement in the climate service, only that evidence of this feedback and evidence-based improvement was not found in the literature nor gleaned through interviews.

Jamaica

The Climate Branch of the Meteorological Service of Jamaica (Jamaica Met) is the main actor in the development of agricultural focused climate services. Among the main products produced with regularity is a monthly agrometeorological service known as the Farmers Bulletin[1]. The bulletin targets large-holder as well as small-holder farmers. However, they are formatted for a professional audience with media and extension agents being important actors to communicate the information in a comprehensible way that supports decision making and potentially influencing actions. Initially, all national level agricultural climate services, including the Agrometeorological Bulletin, are produced under the Caribbean Agro-Meteorological Initiative (CAMI), a program funded by the European Union. CAMI is a regional initiative to enhance climate services that began in 2010 and involves other partners such as the Caribbean Institute for Meteorology and Hydrology (CIMH), the World Meteorological Organization (WMO), and the Caribbean Agricultural Research and Development Institute (CARDI) (Vogel et al., 2017). However, the Jamaica Met now has full responsibility for production of the bulletins.

A summary of seasonal forecast and expected agricultural impacts was prioritized as a key component of a climate service. Impact statements provide broad indications of how it may

[1] http://www.jamaicaclimate.net/farmers-bulletin/

impact farmers. Below is an example of such an impact statement: “(t)he outlook for a continuation of dry conditions over some areas in western parishes will require more action from farmers in these areas, to prevent stress on crops which could occur in farming communities which are already seeing dry conditions” (Nov 2017 Bulletin).

The funding situation to support the development of the products—including staff time, associated production, and dissemination costs such as conference planning—is unclear. Key informants at Jamaica Met noted that executing development, coordinating dissemination, and managing feedback have been more time consuming than anticipated, and that additional funding could be useful to promote quality control of each element.

Product Development and Dissemination

Jamaica Met leads the development of the Farmers Bulletin. Within Jamaica Met, the Climate Branch is exclusively accountable for the production, dissemination and periodic review of its efficacy.

Sections within the Farmer Bulletin include a descriptive summary of observed conditions over the past month including measures of rainfall and high temperatures in areas of the country that experienced notable conditions. The bulletin also contains a table for 17 meteorological stations (covering 14 parishes) presenting observed precipitation, the precipitation's deviation from the climatological average for the month, and a calculated value for Standard Precipitation Index (a drought monitoring index) accompanied by an explanatory legend. This table is followed by a descriptive discussion of this index and its meaning for conditions in parts of the country. Data visualizations may also be included to aid in communicating the spatial distribution of the aforementioned climate and environmental variables.

In addition, seasonal forecasts are included in the bulletin. The primary seasonal forecast product is a 3-month forecast of temperature and precipitation. This is derived using the Climate Predictability Tool (CPT) developed and implemented by Jamaica Met in partnership with the International Research Institute for Climate and Society at Columbia University (IRI). For each of the 17 meteorological stations the CPT provides the percent likelihood of below normal, normal, and above normal precipitation.

Development and dissemination is formally supported by the Ministry of Agriculture's agricultural extension agency (RADA), and a development agency, ACDI/VOCA (previously the Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance, now known by the acronym only). Collectively these organizations make up a multi-disciplinary working group that oversee the bulletin development. The goal of the working group was to provide a dialogue platform to ensure appropriate targeting of likely users and identifying the users' needs.

While the members of the working group are fixed, external groups are able to hold guest status within the working group. These external groups can have significant influence on the development of the climate service. Examples of external organizations to hold guest status include the United States Agency for International Development (USAID), IRI, and the Climate Services Partnership (CSP). The overarching objective of the working group was to: "advance national agricultural climate services, targeting the needs of small-holder farmers and commercial agriculture in managing climate related risks, especially drought" (Spence, 2016). The working group developed a work plan and assigned roles and responsibilities, which subsequently received high-level endorsement and support for implementation (Furlow, 2014).

Within the multi-disciplinary working group, Jamaica Met leads the development of the Farmers Bulletin by providing analyses on various spatiotemporal scales. This may ultimately lead to the production of climate and weather advisories, which would be included in the bulletin. RADA would subsequently receive these advisories and assign agents to support dissemination to community level small-holder farmers on a face-to-face basis.

ACDI/VOCA's Jamaica Rural Economy and Ecosystems Adapting to Climate Change project (JaREEACH) is a USAID funded venture with the goal of providing farmer and extension agent training (Dormer, 2015). Contributing to the development of useful bulletin content, JaREEACH is a co-sponsor of farmer forums, affording the opportunity for face-to-face interaction between farmers, RADA, and meteorological service agents. These interactions allow for an additional modality for RADA to disseminate information as well as afford an opportunity for feedback direct from farmers. According to key informants, Jamaica Met representatives at times collaborate with RADA agents and provide training opportunistically

(for example, when visiting the field to install a new automated weather station) (Interview with Brown and Spence, 2016).

Coordination of the working group has experienced shortfalls in recent years, with current status and function unclear. According to key personnel interviewed for this research, a defined meeting protocol—in terms of invited personnel, periodicity, and content—does not exist (Interview with Spence, 2016). The loss of an internal "champion" for the program within the extension agency was a key factor, as one representative from Jamaica Met stated. Further, one Jamaica Met representative claimed a lack of partners in positions that would sustain institutional support proved to be an additional challenge in maintaining a regularly scheduled meeting and enforcing accountability for role and responsibility, leading to a lack of a standard product development structure. While RADA is a partner in dissemination of agrometeorological information and in providing training services for farmers, there is currently no regular meeting for planning purposes.

Monitoring and Evaluation

Currently, a formalized mechanism to capture feedback metrics from farmers does not exist. In addition, protocol does not exist whereby feedback can influence the revision of the bulletin. As such, even if information of potential value was collected and categorized in a manner for it to be potentially useful, systems to ensure this information is leveraged were not identified. The efficacy and reliability of the bulletins thus remains unknown and contributes to the persistence of a gap between user perception and producer perception of value.

This holds true for both value of the information and functionality of dissemination modalities. Further, there has not been a regular review process for the dissemination and use of the Farmers Bulletin, although an evaluation of quantitative accuracy of the geophysical forecasts is regularly conducted, according to interview with Jamaica Met representatives. This evaluation does not capture the potential impact of the bulletin on specific decision-making processes of the farmers.

It should be noted that Jamaica Met only employs two staff members who are tasked to contribute to the production of the Farmers Bulletins. The responsibilities of these two staff members extend past the bulletin, resulting in limited time available to dedicate to this task. There also may have been a recent interruption or postponement of this service; as of January

2018, the most recent bulletin was released November 2017 according to the website where Jamaica Met officially releases the bulletins (JamaicaClimate.net).

While formal processes for monitoring and feedback may not exist, key informants interviewed did note that feedback is gained through informal discussions during agriculture extension processes (interview with Brown and Spence, 2016). This mechanism is not captured as a mechanism within the roles and responsibilities of the governance structure. It is unclear if the information gained is available for consideration of how the Climate Service can be improved.

Mali

As early as the 1970s, Mali's National Meteorological Office (Météo Mali) convened a non-hierarchical working group tasked with bringing climate and weather information to farmers in order to inform decision-making (Hellmuth et al., 2007). The production, dissemination and evaluation of climate services in Mali is governed by the Projet d'Assistance Agro-meteorologique au Monde Rural (GTPA)- (in English, Project for Agrometeorological Assistance to the Rural World) (Diarra, 2012). GTPA's status was initially informal and has progressed to the current formal legal status completed with its own constitution. The main national level climate service product issued is the Agro-Hydro-Meteorological Information Bulletin (Bulletin d'Information Agro-Hydro-Météorologique Décadaire). This service is disseminated at the frequency of every ten days (three times per month) during the rainy season (approximately May to October). This is one of the first examples of a formalized climate service in Africa, with planning and testing began in 1982 with a group of 16 farmers. The project began to be expanded to reach more than 2,500 numbers of farmers in the early 1990s (Tall et al., 2014).

GTPA is a type of multi-disciplinary working group chaired by the National Directorate of Agriculture—which serves as the main actor—and coordinated by the National Directorate of Meteorology (Vida, 2017). Other parties on the working group include the National Agricultural Directorate, Institute of Rural Economy, Crop protection service, Livestock National Directorate, National Water and Forestry Directorate, High Niger Valley organization, Malian Cotton development company, Agency for the Safety of Aerial Navigation in Africa, National Internal Affairs Directorate, Agricultural Markets Observatory, National Radio, and National Television. The role of private sector was discussed at the 2016

launch of the ENACTS (Enhancing National Climate Services) rainfall dataset and project in Mali, with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) noting the role of their involvement as a regional stakeholder as well as calling for the "shared responsibility" between many public and private actors (Nenkam and Traoe, 2016). However, other than an application developed by a private sector company, Manobi, to allow farmers to check market prices (Magesa, 2015), the specifics around the formality of public-private partnerships is unknown.

The Swiss Agency for Development and Cooperation (SDC) supported the project from initial design and development in the mid-1980s until 2005. Since 2005 funding has been provided by the national government in Mali, although specifics on amount and source within the national budget are unclear. Although the initial (and existing) design was bolstered by external funding, the expectation was always that national and local government would eventually take ownership and maintain a sustainable system for production and dissemination of agricultural sector focused climate services (ibid). The current funding space does not afford the opportunity to scale up advisory services to new users, however Météo Mali continues to support existing communities with climate-smart agricultural advice during the May-October season (Carr and Owusu-Daaku, 2016).

Product Development and Dissemination

The processing of information inputs and the creation of agrometeorological advisories takes place directly within meetings of the GTPA. The interagency structure of the GTPA supports collaboration even though the groups have explicit roles. Tall et al, 2014 outlines roles responsibilities related to the development and dissemination process as follows:

"The groups that participated in the Mali project had different, but well-integrated roles. The users defined the weather and climate-related data and products they needed. Farmers collected local rainfall data and then sent that information to the multidisciplinary working group. The Meteorological Service analysed the data. The extension services, and research groups, and Ministry of Agriculture worked on issues related to food production, crop health/protection, and choice of crop varieties. The rural development agencies focused on capacity building and information. And finally, the media disseminated the agrometeorological information."

The term “users” in this quote may refer to the farmers who were consulted during the establishment of the program, however correspondence with key informants in Mali indicated that there could be regular communication between the GTPA and other farmer activist organizations.

The type of information communicated in the advisories includes weather observations, forecasts on various timescales and advice on agricultural practices (Carr 2014). Further, Carr 2014 outlines specific products generated for the Agromet Assistance program which include: Climatological Crop Calendars, Climatological Sowing Dates, Estimates of Water Requirements of the different crops in each of the major agro-climatic zone, and Crop Water Balance computations at the end of each dekad and information on risk for Dry and Wet spells. Another unique product offered is the probability that rainfall over the next 10 days will deviate from what is needed compared to the climatological plant water demand (for that 10 day period). Diarra 2012 adds that planting date guides are disseminated to a select group of farmers that have been provided with and trained to use a particular type of rain gauge that facilitates use of said guide.

In an institutional assessment of Mali’s GTPA, Moussa et al. 2012 describes several elements that contributed to its success. The GTPA was assessed as an effective forum for collaboration between multiple departments as well as farmers. One of the drivers of the effectiveness was the ability of the GTPA to support “sustained relationships” among parties through their work. Further, the national government’s commitment to the program was acknowledged as a key factor. This commitment—commonly referred to as “institutional buy-in”—was demonstrated by committing to take over budgetary ownership of the program from donors in 2001 (Buontempo et al., 2017; Moussa et al., 2012). This expression of high level national government interest and fiscal action came at a critical moment relative to the potential sustainability of the climate service. When the funding was re-allocated, the program was not able to continue scaling up, although services continued.

Monitoring and Evaluation

Mali Agro-Hydro Advisory services are unique relative to others (including Jamaica and India) as they were initially established as an action to respond to an emergency situation (Carr and Owusu-Daaku, 2016). The demand for a rapidly developed service unfortunately did not allow for a resource and time allocation for the integration of monitoring and

evaluation protocol (Carr 2014). The lack of monitoring and evaluation processes was identified in the early 1990s and led to the establishment of stakeholder workshops. From 1993-2005 biennial stakeholder workshops were held in each of the six districts of initial implementation. In 2012, Diarra noted, that Meteo Mali has and may still maintain structured communication with the Council of Ministers (Diarra 2012). Diarra continued that activities associated with the Village Plans of Reduction of Risk (PVRR) included an evaluation of "precision and reliability of" for 10 villages, however it is unclear how that data was processed and if it was used to potentially revise or improve the climate service. It is unclear if any documentation from the evaluation component of these meetings is available and if these workshops (or other types of interactions) are currently operational.

Analysis

This section will present the results of the country level analyses in a format that allows for comparison between the three. First, we identify similarities and differences that emerged from the case study assessment. Next, key lessons from the case studies and literature are noted, focusing on 3 themes: Multi-disciplinary working groups, agreements and MoUs, and monitoring and evaluation processes.

Notable similarities and differences

Identifying similarities and differences across the case studies is an important first step in gaining insight into the some of the potential valuable ingredients that make up an effective, sufficient, and sustainable governance structure.

Throughout the analysis there was an overarching theme consistent across all case studies whereby the lead role for all climate service related activities was held by the National Meteorological Service (NMS). However, a key difference in each country was the format of NMS internal organization, which subsequently promoted different styles of leadership. For example, to oversee the climate service related activities in India, IMD developed a specialized internal division, IAAS. While both are subordinate sections of the NMS, it is unclear to what extent the climate branch and IAAS are similar and different in their roles.

In Jamaica, the Climate Branch had been set up and tasked with "maintaining a current database of the climate of Jamaica and for the utilization of this data in informing productive sectors of the country." The Climate Branch sits at the Jamaica Meteorological Headquarters and consists of various sections, including a Data Acquisition Section, Data Processing Section, and Applied Meteorological Section. While the latter is tasked with "addressing the needs of clients," all Climate Branch staff may be involved in the production of climate services. In Mali, a subordinate section of the NMS is not designated.

Additionally, India and Jamaica rely on structured, regularly scheduled interactions with public universities for consultations regarding climate service development methods and monitoring and evaluation strategies. Jamaica and India have established MoUs with the universities they regularly interact with to formalize this relationship. This contrasts with the case in Mali where interactions with public universities may occur, however are likely to be informal and potentially opportunistic.

Another similarity across all case studies is the existence of a multi-disciplinary working group. While the makeup of working groups and other advisory groups will vary, the motivation behind them appears to be consistent for each country: a multi-disciplinary working group should include all possible stakeholders that may be involved in the development, dissemination, use, and monitoring and evaluation components of the climate services. While this multidisciplinary working group is a feature of each case study country, the composition of each country's is different as mentioned. In India, the private sector is included (as radio and other media are invited to participate) while in Mali, there is engagement with mobile applications developers. However, the role of the private sector is not explicitly identified in Jamaica. Similarities in the makeup of the working groups can be found in the inclusion of other national government and civil society level organizations other than the NMSs. This is noteworthy because while the NMS is usually the lead organizations, they are not the only national level organization that has influence, which could be anticipated as impact of the climate services transcends the usual NMS mandate.

A key difference can be found in the existence, level of formality and structure of data, and information sharing agreements. In Jamaica, there is an inter-organizational sharing agreement between Jamaica Met and the National Irrigation Committee. In Mali and India, our research did not indicate the existence of any agreements which specifically note data and

information sharing. However, it was noted that casual and informal agreements are likely to exist and could potentially lead to more efficient data transfer through difficult to monitor channels such as SMS, facebook, and whatsapp in certain situations (such as in times of disaster preparedness and response).

Amongst the three monitoring and evaluation processes, India's is unique. In India, there is a formalized structure of feedback led by the KVKs to afford information sharing between the users and providers at district and state levels.

Another notable dissimilarity is apparent in the frequency of meetings of the multi-disciplinary working group and development of the climate services. In India and Jamaica, meetings are set to occur year-round, and agro meteorological climate services are developed in a consistent fashion regardless of month or season. This format suggests continuous engagement of the multi-disciplinary working group. This contrasts with the situation in Mali where the service is only active in the rainy season (approximately May to October).

Key Lessons

From the 3 case studies, key lessons can be distilled when considering what some important principles of governance structures for sustainable national level climate services could be. The key lessons are presented here are clustered around 3 themes: Multi-disciplinary working groups, Agreements and MoUs, and monitoring and evaluation processes. For each of the themes, the following elements exist: identification and inclusion of key personnel, level of formality and funding. These 3 features are linked to the more overarching national level governance themes of representation, accountability, probity, and effectiveness (Ashburner 2003).

Some common traditional formats of national level governance for public sector services include the hierarchy approach, market forces approach, and the network format (Brugnoli and Colombo 2012). It should be noted the case studies do not fit into one particular format of identified traditional forms of governance.

In all case studies, information on the funding streams was difficult to compile. This may be due to the sensitivities around releasing budgetary information for national level services. Important aspects of the national level budget allocations related to the climate service governance structure that should be explored include size of budget, ministry and department

in which allocation authority resides, and the year to year fluctuations of the budget (and subsequent impact on governance structure) for the active duration of the climate service.

Multi-disciplinary working groups

The existence of a multi-disciplinary working group was noted in each case study. Firstly, as present in all case studies, while there are numerous stakeholders involved with a particular climate service, the NMS are the lead organizations. Subsequently, their lead role is explicitly noted as such in the governance structure. From the case studies, it was shown that the working groups vary in terms of formality, scope, and format. However, each included stakeholders from a variety of sectors and organizations. This mix of sectors, organizations, and individuals in key positions from each differ across case studies, but some similarities were present. Some types of organizations were found to be constant throughout the case studies, including agriculture extension services, national level private sector, telecommunication companies, and media organizations representing interests from the private and public sector.

From the case studies, it was also noted that key actors within organizations can drive sustainability of a governance structure, and thus the climate service. These individual actors, or champions, have significant influence on whether a climate service will initially succeed or fail, but additionally on the sustainability of the climate service. For example, interviews with key actors in Jamaica revealed that champions were crucial in identifying additional key actors, organizing the roles and responsibilities and overall, convening the group to bring the right people at the table. It was further shown that when the champions were unable to be involved, for a variety of reasons, the collaboration dissolved.

When discussing multi-disciplinary collaborations, in the cases of Mali and Senegal (Kaffrine, Senegal), Tall et al. 2014 stated that, in both cases, interdisciplinary working groups benefited from arrangements whereby parties had clear, differentiated roles, and strong integration. In the case of Mali, “The groups that participated…had different, but well-integrated roles.” This supports the notion that clearly defined coordination terms are needed to maintain integrity of the climate service governance structure. In Jamaica, the initial working group convened to develop the climate service benefited from clear role assignments. However, coordination issues between organizations led to the erosion of clarity of roles and responsibilities.

Agreements and MoUs

The existence of roles and responsibilities within the construct of a governance structure is identified in each case study, as well as in the research, as important elements of a sustainable climate service. However, in the existing body of research, the specific agreements and mandates that afford the establishment and sustainability of a governance structure have been explored less rigorously. Reasons for this paucity in information can be attributed to the challenges in acquisition of information on the formal structures that exist. Additionally, informal and semi-formal agreements and arrangements (despite some being particularly influential) are by definition difficult to analyze, especially as both the set of involved stakeholders and the roles and responsibilities of those stakeholders are likely to be fluid. These informal stakeholders and their roles can potential shift based on weather and climate type, magnitude, perceived "extremeness," season, and influence from external forces—such as the private sector and international donor organizations.

In response to the identification of challenges in maintaining regularly scheduled topical dialogue, the GTPA in Mali moved to established its own constitution to outline coordination. The stability and sustainability of climate services in Mali is at least partially attributable to this action.

MoUs also exist in Jamaica and India. However, both were identified to be less specific to a particular element of the climate service and more as a method to promote various types of engagement. Further, in both Jamaica and India, formal MoUs exist with the academic sector. In India, an MoU outlines an agreement for data and information sharing between IMD and the State Agricultural Universities, both of whom are on the multi-disciplinary working group. In Jamaica, an MoU has been established between Jamaica Met and the University of the West Indies.

In Jamaica, it was noted that changes in the content of the MoU can occur, with the change process initiated by Jamaica Met. The process of changing the governance structure of the climate service in Jamaica must also include a change in the MoU, which would act as the primary force in motivating any potential changes in the makeup of the multi-disciplinary working group.

It is necessary to consider the temporal intervals between engagement steps across all sets of actors. For example, having set dates for convening meetings of the multi-disciplinary working group is necessary to promote structure, afford buy-ins, and increase stakeholder prioritization of this task amongst others. In Jamaica, key informants explained that one of the primary reasons for the lack of operational climate services was the failure to establish agreed-upon meeting intervals, leading to a situation where opportunistic meetings were more likely to interfere with regularly scheduled tasks. That said, it was noted that when there was dedicated funding for a mandated NMS role to engage with climate service processes, there was a higher likelihood of sustained engagement. The lesson learned in this case is that if NMS dedicated staff time can be noted within the governance structure and if the governance structure could establish formal temporal intervals for meetings and decision, there may be a higher likelihood of a sustainable climate service.

Monitoring and Evaluation Processes

Amongst the case studies, only in India was a clear structure for monitoring and evaluation identified. However, while there are 3 noted processes for evaluation in India, there is no clear process of how the information produced is evaluated by the leadership of the service. This gap in end-to-end process of monitoring and evaluation leads to a situation where valuable information from the users and intermediaries is not being leveraged to influence potential beneficial shifts in the design of the climate service.

In Jamaica and Mali, interviews with key informants did note mechanisms for monitoring and evaluation, however in both cases the processes were informal, occurring at irregular intervals. Interviewees noted that in both cases, the farmers' perception of value of the climate service was assessed during agriculture extension activities, mostly through informal and sporadic conversations. It is unclear if and how the information gleaned during these interactions was coded and used to improve the climate service.

In all cases, it is unclear if the information, after being interpreted, is used to justify shifts in the current design of the climate service. A challenge in using information gained during monitoring and evaluation processes is to consider how it is used to shift an element of the climate service and further, what level of information (quality, robustness and representativeness) is needed to justify changes in any element of a climate services. Adding additional complexity to the notion of justifying change, it seems likely that level of

information needed may differ depending on the target group, such as the multi-disciplinary working group or the perspective of the end users, such as small-holder farmers.

Discussion

Key considerations are noted, presented in a format that could potentially be a resource to a group that is considering governance structures for new or existing climate services. The section concludes with suggestions for research priorities for the increased exploration of various angles of governance structures for national level climate services.

Key climate service design questions and considerations

This section provides a set of questions and considerations that can be useful for those interested in developing a governance structure for a national level climate service. The rationale for including these elements is based on feedback gained after presenting preliminary results at two events with two different sets of participants. First, at the 5th International Conference for Climate Services (ICCS) in Cape Town, South Africa in March 2017, key similarities and differences of the governance structures identified in each case study were presented in the session, 'What are effective climate services?' The participants at ICCS included government officials, development and NGO practitioners, private sector representatives and physical and social science researchers. Second, during the National Consultation Workshop for setting up the Rwanda National Framework for Climate Service in Kigali, Rwanda, December 2017, preliminary results were presented for discussion in the breakout group tasked with exploring potential governance structures. In Rwanda, the majority of participants represented government and academic research organizations International development organizations and some representatives from the private sector were also present within the governance working group. Discussions within this working group were especially important in prioritizing the key questions and consideration found here, as this group was tasked with specifically exploring how governance structures could be established in a way that would promote inclusivity, flexibility, and sustainability. These three themes are influencers of the following list.

How flexible should the governance structure be?

One key element of a governance structure for a public service is flexibility (Grant et al. 2007). Even if a climate service governance structure has been deemed sufficient, many have not existed long enough to be tested for appropriateness of flexibility, which by extension can include the concepts of governance structure elasticity, rigidity, and restrictiveness (Majone 1997). There are rapidly changing best practices for processes that are central to establishing a sustainable climate service (for example, the appropriate geophysical data selection), acceptable monitoring and feedback processes, and suitable socio-political and economic conditions. Acknowledging this sensitivity of various elements of the climate services to technological and cultural/socio-economic changes and improvements, the governance structure should be designed in a way to afford a space for discussion and expert judgment. Further, the governance structure should be flexible to the degree that it affords the opportunity to discuss shifts in technology and reflect on how the climate service could be improved by integrating such changes and improvements, as well as consider the potential "winners" and "losers" that may develop due to a change in the climate service (O'Brien and Leichenko 2000). Any potential shift in the climate service should include a discussion on how that shift could impact the most vulnerable communities that the climate service currently serves.

What are some methods of ensuring funding is sufficient and sustainable?

While it may be ideal to rely on funding streams solely from national budget processes, it is likely that supplementary sources will be required (Hewitt et al. 2012). Stakeholder organizations beyond the NMSs could be approached and presented with value-based cases for them to support program financially. While project funding from international donor organizations have been useful sources in the development and initial implementation of climate services (such as in Mali), it is noted project funds are not ideal to maintain the sustainability of the climate service and of the associated governance structure, and can lead to a decrease in their effectiveness (Vaughan and Dessai 2014).

To what degree should the private sector be involved?

This is an important consideration—both as an independent consideration and as a cross-cutting theme—as private sector may influence various aspects of climate services, and thus governance (Siddiqi et al. 2009). In each of the case studies there is a level of involvement of

the private sector. However, as the private sector captures various types of organizations, the type of engagement can widely vary. For example, in Mali, the private sector is noted as a key stakeholder, yet it is not clearly stated how the private sector is acknowledged within the multi-disciplinary working group. It is likely that in this case, as well as others, the private sector is called in on an as-needed basis, potentially motivated by the need for expert judgment, to provide feedback on a shift in technology or the prevalence of a new system that may impact the climate service.

Another example of private sector engagement, as noted to occur in Jamaica and India, is the role of the private telecommunications companies to disseminate information. In West Africa, private companies are providing weather forecasts for rainfall in partnership with private telecommunications companies, sidestepping the national level government oversight and potentially setting up a system whereby standards and protocol for assuring a high quality of climate service are bypassed. In developing the governance structure, it may be useful to discuss the existence of any private sector organizations or consortium operating in country providing a similar service (or the barriers of entry to do so). Further, if one goal of the governance structure is to include the mandate to monitor all climate services, the existing and potential future private sector climate service providers and private sector climate service affiliated companies should be identified. This can be valuable information in considering potential inclusion of private sector organizations within the multi-disciplinary working group. The potential roles and responsibilities of the various private sector organizations are too wide to explore in depth here.

How specific should data selection processes be noted in the governance structure?

Selection of the data—including climatic, environmental, and socioeconomic, both prognostic and historical—is a non-trivial process and depending on how it is done can drastically change the potential effectiveness of a climate service (Vaughan and Dessai 2014, Mason et al. 2015). In developing the governance structure for climate services—more specifically, in identifying the relevant stakeholders and their roles and responsibilities and depending on the climate service(s) of interest—it may be important to clearly outline the process of data selection and data quality evaluation. The following questions may be useful to reflect in doing so: Who defines the baseline for the climatic and environmental elements of the climate

services? Is there a minimum level of accuracy/skill that a forecast must prove before it is considered for inclusion within the climate service? What are the thresholds when action must be taken?

Who holds the burden of accountability?

In monitoring and evaluation of the effectiveness of the climate service, there should be clearly outlined roles within the governance structure. This could include identifying who is the lead in the uptake and processing of metrics showing impact of the climate service. Further, it may be useful to include within the governance structure clearly-noted periodicity of monitoring and evaluation procedures that can align with a periodic review of the effectiveness of the climate service. Doing so may limit the need to address specific questions of accountability, as these processes are designed to distribute the accountability burden across the actors within the governance structure. Some questions to ask in determining how to address accountability of challenges in climate service effectiveness include: Is there an objective process with agreed upon metrics to evaluate the functionality and effectiveness of a climate service? Is this explicitly codified in the governance structure? If yes, who or what organization is responsible for defining these criteria?

Should revision protocol be captured in the governance structure?

As the process of development and implementation of a climate service demands a certain level of rigor, so should the revision of that climate service. At times a perceived failure of a climate service can lead to an emotional reaction and a situation where a certain element of the climate service bears the burden of accountability. Further, depending on the climate risk the service is designed to address, the return period of the use of the climate service could be short enough where a "quick fix" is desired in order to prevent the perceived failure to occur again, which may lead to one or a small number of relevant actors making a decision without a proper review. There is an opportunity for noting within the initial development of the governance structure to include language to address this risk and acknowledge that while the situation may arise for a perceived "quick fix," it should be reviewed by a meeting of relevant stakeholders—perhaps the same stakeholders included in an existing multi-disciplinary working group. While extreme events may test the effectiveness of climate services, these events also offer opportunities to explore the flexibility of the climate service itself as well as the governance structure.

Even if not stimulated by the occurrence of an extreme event, the process of revision of climate services should be noted explicitly within the governance structure. Relative to the discussion on the role of the private sector, these discussions of a potential change in the climate service should capture the emergence of new technology and new data—which could lead to the invitation of key external actors not involved in the multi-disciplinary working group. The identification and initiation of these key external actors could be decided on at the regularly scheduled meetings of the multi-disciplinary working group.

In some ways, the notion of a governance structure for the revision process can be considered as a standalone yet interconnected process. An example of a situation in which a review of the climate service may be ideal is an emergence of technology—such as a new rainfall forecasting methodology, which would lead to a question of whether integrating that new forecast into the climate service is beneficial. Questions that should be considered in such case can include: Will this lead to increased forecast accuracy throughout the entirety of the target area? During all seasons? Does it work better for periods of extreme rainfall? What are the costs of implementing this system? Can this potential revision be sufficiently supervised by the current members of the multi-disciplinary working group (led by the NMS)? The first three of the above questions allude to the notion of potential of winners and losers relative to the current method.

Is there an ideal periodicity for governance structure roles and responsibilities?

The type of climate or environmental condition the climate service is intending to address may also provide guidance in the frequency and regularity of roles and responsibilities. For example, a more frequent schedule for various processes may be required if the climate service of interest is related to short-term and rapid-onset climate and weather extremes—in other words, cases where rapidly changing climate information and vulnerability data may drastically change the scope and distribution of action. In these cases, a formal process also may not allow for the agility needed to react to changes.

For meetings, engagements and other structured tasks, some temporal intervals that should be considered:

Seasonal: While the perception of seasonality will vary from region to region, it is important to consider the benefits of roles and responsibilities to take place before, during and after a

season. Depending on the climate service, the time period defined as 'during the season' could be an opportunity for monitoring impact of the climate service relative to the current season's 'performance', where performance can refer to how the season is performing relative to 'normal' or how it is performing relative to the information presented in the climate service of interest.

Annual: Some tasks, meetings and decisions should take place on an annual time interval, which may align with budgetary decisions at the national government level.

Quarterly: Especially in areas that do not experience a particular season of the climate or environmental risk that the climate service is addressing, quarterly time intervals may be ideal. For example, if there is an equal chance of risk of a climate hazard happening at any time of year (such as flash flood risk in areas that see equal chances for extreme rainfall throughout the year, and other land cover and socioeconomic factors are static).

Non-structured: In many cases it may be important to have spontaneous engagements to discuss the climate service. It is important for a governance structure to be flexible enough to support engagement based on extreme circumstances. This may be more important in some countries more than others, as there may be a limited pool of actors that are able to address climate situations that are not addressed by a climate services. Engagements on this time interval can be triggered by an increased risk as defined by a forecast, observations of the current situation, unexpected shift in political situations such as conflict or population displacement, a sudden shift in intended target of the climate service, or the emergence of technology that may lead to changes in the fundamental processes of the climate service.

The need for deviations from an established periodicity of roles and responsibilities may be required, especially in times of political and social change, natural disasters, or periods where both occur. In considering guidelines within the development of a governance structure, it may be valuable to account for this potential deviation to decrease the likelihood of a loss of integrity of the noted roles and responsibilities. In this sense, it may be possible to employ one or more timescale.

Research Priorities

From this analysis we have distilled a set of priorities where we have identified a need for future research relative to understanding key principles of governance structures for national

level climate services. The criteria for inclusion on this list is subjective, however it has been guided by interactions with various stakeholders at the same events noted above. We note that there has been a recent review of research priorities for climate services more generally (see Vaughan et al. 2016), and while there may be some overlap the list below focuses solely on the governance and governance related elements of national level climate services.

Is the goal 'good governance'? Or will 'good enough' governance suffice?

Due to the unfortunate reality of limitations in funding and resources, research has suggested that depending on a specific countries context, national level governance could be more accessible if a "good enough" level is aspired for (Gindle 2007). Further, studies show that focusing on a country's cultural history provides insight in the feasibility of achieving different levels of governance (Hewko 2002). Unpacking the concepts of "good governance" and "good enough" or "sufficient" governance resonates with thinking on the ideas of Quality of Government, Soundness of Government Institutions, and Government Effectiveness—which have been mentioned relative to climate related national level services (Holmberg et al. 2009, Daoud et al. 2016) but not for national level climate services, specifically.

Formatting and design and presentation of best practices

In consideration of what the best practices for supporting the development of governance structures could be, it is worth considering options for their format. Would a set of key principles or best practices specifically for development of governance structures be useful for the climate service community? If yes, research on appropriate formatting and standards may be necessary and would likely require coordination with other communities such as social scientists, cognitive neuroscientists, and graphic designers (Dym et al. 2005, O'dell and Grayson 1998).

Rigidity and flexibility of the Governance Structure

Acknowledging climate services involve technology that is rapidly changing, how can a governance structure be designed to be both rigid enough to be effective in the current state and flexible enough to manage the processes needed to consider potential value-add to climate services from new and emerging technologies? Can an ideal level of rigidity (flexibility) be prescribed for a certain case? While research has been done to explore trade-offs (benefits and drawbacks) of rigidity and flexibility (Ndulu and O'Connell 1999), climate service governance structures have not been explored specifically.

Data governance (or, governance for management of data quality)

Assessment and communication of data attributes is a noted challenge within the applied science community. This is particularly true in climate services, specifically related to the selection of datasets (and the criteria used to identify a most appropriate or sufficient dataset). These challenges are also present in communicating complex inherent attributes of the data (and by extension, the service), such as uncertainty, particularly in the context of influencing policy (Smith and Stern 2011). It would be useful to explore the potential for a well-designed governance structure to capture these issues, identifying protocol for affording expert-informed discussions if the ability to confidently select both the best, most accurate, dataset fit for the service, as well as an appropriate method to communicate the quality of the data used within the service. Alternatively, if a governance structure does not capture the ability to assess the quality of the underlying climate data, how could they assess the opportunities that arise to modify/improve the system? This can expand on work on data governance which attempts to clarify the role of data in decision making, deeming data itself as an asset (Khatri and Brown 2010, Wende 2007). Lastly, we should increase exploration of methods of data ownership and data sharing amongst members of the multi-disciplinary working groups, focusing on the role of MoUs and other types of agreements.

Funding structures

There are sensitivities around providing insight to funding structures of current and past climate services. Understanding these funding structures is a key step in order to evaluate best practices and provide suggestions of how a governance structure can reflect funding allocations and appropriations. This has been identified as a primary challenge in studying governance, especially related to funding constraints and dependencies (Lynn et al. 2000) and has been noted to be an important consideration of other national level services, such as health systems (Boyce 2001). As an in-depth review of climate service specific funding structures does not yet exist to the authors' knowledge, we recognize this as a gap in knowledge and suggest prioritizing it as an important element for future review.

The role of informal processes on the sustainability of governance structures

While these systems must be identified and assessed as potential drivers of overall impact of the climate service, the value of these systems may deteriorate if formalized within the context of the governance structure. The interplay between formalized governance structures

and informal systems and activities, some of the latter involving stakeholders within the formalized governance structure, should be explored further, especially through the lens of accountability and sources of trust. It is also noted that while some informal activities can be identified and probed for potential contribution of value of the climate service of interest, it is likely that there will continue to be some unknown informal activities that could be significant factors in the success or failure of a climate service. More research into the potential contribution of unknown informal processes to the perceived success of a governance structure would be useful.

Incentive structures

Lastly, the incentive structure of engagement with the processes outlined in the governance structure should be research in more depth. Research shows that access to information and skills to produce a service may not motivate personnel to always carry out their mandated tasks (Azfar et al 1999). This may be a future challenge for the development and sustainability of climate services, however a well-defined, trusted, flexible and transparent governance structure will decrease the role of individual (both personnel and organizational) discretion, reduce informational asymmetries between nodes along the dissemination pathway and increase the likelihood for perceive value from the users (Milgrom and Roberts 1992).

Conclusion

The three case studies of Mali, Jamaica, and India—based on interviews and literature review— allow for insight into the governance structure for national level meteorological climate services for agriculture.

From this research, we add credence to the notion of governance structures of climate services being a critical element. We caution that if the established structures for governances are not interconnected with the users from the initial development process, they will not be effective, sufficient nor sustainable. Further, the building of trust cannot be left out of the process in developing structure for governance and needs to be incorporated as a primary step in demonstrating credibility and transparency. Structures of governance—as arbiters and promoters of transparency, accountability, and thus potential trustworthiness of the climate services—are necessary.

The analysis suggests that institutional arrangements, roles, and responsibilities need to be clearly postulated if a climate service is to be established as functional and sustainable system. These elements—and by extension the service(s) being governed—can only be sustained if regulated by a governance structure. In some countries, this takes form via an official decree or ministerial order.

While we initially intended to analyze funding structures for each of the elements within the governance structure, including key positions of relevant organizations, this information proved difficult to acquire.

More research is needed to develop a better understanding of the key ingredients of governance structures for national level climate services. While we stop short of defining necessary components of all governance structures, we identify multi-disciplinary working groups, agreements and memoranda of understanding, and monitoring and evaluation as important considerations by those exploring the potential for developing a governance structure. For each of these components, the following themes should be prioritized as first order topics of consideration: identification and inclusion of key organization and specific influential personnel within those organizations, the degree of formality of the structures of governances and ultimately, and funding mechanisms.

Ultimately, we do not suggest a definitive set of minimum standards or best practices to identify pathways to guide the development of a governance structure for effective, sufficient and sustainable national level climate services. As such, important questions remain: Does such a prescriptive set of guidelines need to exist in order to develop a “sufficient” or “best” governance structure? Would a rigid set of minimum standards for sustainable governance structures be a useful tool to frame thinking of how national level climate services are developed?

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Appendix 1: Individuals consulted

Organization	Individuals
IMD	Nabansu Chatopadhyay
Jamaica Met Service	Glenroy Brown Jackie Spence
AIMS (Africa Institute for Mathematics)	Charles Kimpolo
United States Agency for International Development (USAID)	Kevin Coffey
International Research Institute for Climate and Society (IRI)	Cathy Vaughan Teddy Allen Nachiketa Acharya Steve Zebiak Haresh Bhojwani
Clark University	Edward Carr
Caribbean Institute for Climatology and Meteorology	Cedric van Meerbeeck
CCAFS	Desire Kagabo

Appendix 2: Interview structure outline

Background

Name of climate service

Format/type of climate service (eg. bulletin)

Name of the lead organization, if there is a single lead

Names of other partners.

Names of key partners which have an elevated role

If any, status of existing Memoranda of Understanding (MoU) and/or Terms of Reference (ToR) between partners

How is the climate service funded? Who are the key actors in appropriating and allocating funds for the climate service?

Has any of the above changed throughout the existence of the climate service?

How are scientific advances in relevant climate, weather and social science topics evaluated for potential influence on the climate service?

Is the private sector involved in any way?

Product Development and Dissemination

Are there scheduled meetings?

Are separate products developed for each targeted sub-area? Or is there downscaling/tailoring at a level further downstream? If yes, how is this downscaling/tailoring approved/monitored?

How are the products disseminated?

Has any of the above changed throughout the existence of the climate service?

Monitoring and Evaluation

How often is the climate service generally reviewed?

What are the parties involved? Do they have defined roles and responsibilities?

What are the outputs generated from the M&E processes?

Is the climate service designed to address systematic changes? (such as improvements in technology (both in agricultural practice and in geophysical science) or changes in targeted user groups (or changes in needs of existing user groups)?

How is this information integrated back into the review of existing climate services?

Has any of the above changed throughout the existence of the climate service?

Table 1 - Characteristics of selected case studies			
Case study characteristics	**Mali**	**Jamaica**	**India**
Developed/Developing Country			
National level climate service for agriculture existing or did exist	existing	existing	existing
Latitude	tropics	tropics	tropics
Key informants known?	yes	yes	yes
Age of climate service	20+ years	few years	10+ years
Were multiple stakeholders involved?	yes	yes	yes
The climate services were sustainable for more than 1 year			

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