1 **Climate Information Services for Adaptation: What does it mean to Know the Context?**

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Climate Information Services for Adaptation: What does it mean to Know the Context?

Abstract

Climate information services (CIS) can reduce climate vulnerability by enhancing information access, knowledge exchanges, and networks. Central to CIS is the need to understand the social and environmental context in which information is used. While researchers have identified many influential dimensions, there lacks rigorous analysis of all the dimensions salient to a CIS case study as well as a model to help CIS implementers design and evolve their CIS in its course. This research addresses these gaps by analyzing a CIS we developed for coffee farmers in Jamaica that introduced new weather and climate information in workshops, text messages, and interviews. We identify nine dimensions related to the information providers, users, and their union, and we show how each influenced the design and evolution of our CIS. We further show their dynamic relations in an analytical model. We argue that the context is emergent, requiring flexible CIS, and that assessing the providers is as important as a focus on the users, which is often the emphasis in CIS scholarship. This study is a demonstration of how varied contextual dimensions affect the design, implementation, and use of a CIS, while also providing empirical detail about a coffee farming and climate context.

Key Words

CIS, climate information services, coffee, climate adaptation, smallholder farming, seasonal climate forecasts

1. Introduction

Climate and weather variability can have harmful and beneficial effects on nearly all sectors of society. Scholars and development professionals have therefore focused on developing the ability of individuals to manage climate risk. At the individual level, activities that can help improve the management of climate risk include access to information, knowledge exchanges, and social networks (Smit & Wandel, 2006). Climate information services (CIS) have recently emerged as a new area of research and practice that integrate these three elements (Brasseur & Gallardo, 2016; Dessai, Hulme, Lempert, & Pielke, 2009; World Meteorological Organization, 2016).

CIS develop, translate, and disseminate climate-related and other relevant information for decision-makers by engaging stakeholders, utilizing appropriate access mechanisms, and responding to user needs (Brasseur & Gallardo, 2016; World Meteorological Organization, 2011). CIS have thus become a comprehensive approach for using technical weather and climate information to reduce vulnerability and develop resilience (Carr & Onzere, 2017). National governments and large donors and science consortiums like the World Bank, CGIAR, and the World Meteorological Organization have invested heavily in programs that improve the use of climate information (Vaughan & Dessai, 2014). In 2014 alone, more than US\$24B was spent on CIS globally, close to the amount spent on weather services (Georgeson, Maslin, & Poessinouw, 2017)

An emerging tenet in the literature on CIS is to “know the context;” that is, information about the climate becomes more usable when created or tailored with an understanding of the decision-maker’s local social and environmental context (Lemos, Kirchhoff, & Ramprasad, 2012). This point has been emphasized in numerous ways (e.g. Kirchhoff et al., 2013; Lemos et al., 2012; Moser, 2010; Vaughan and Dessai, 2014; von Storch et al., 2011). Brugger et al. (2015) asserted that scientists must know how and why decisions are made in order to provide actionable information, while Dilling and Lemos (2011: 684) stated “that many of the constraints and limitations of [climate forecast] use originate in the lack of a broader understanding of the decision-making environments.” It has become clear from this work that the use—or not—of climate information depends on each unique context.

In this analysis, we present a critical explication of a CIS the authors developed and implemented in Jamaica with coffee industry representatives and the national meteorological service, with routine feedback from smallholder coffee farmers. This CIS focused on improving understanding and access to weather and seasonal climate forecasts (SCF) through participatory workshops, text messages, and individual interviews. The research goal was to understand the contextual dimensions that guided the

activities implemented, while coffee industry stakeholders' goals were to enhance their communication with farmers and help them build resilience to weather and climate variability.

Our analysis is founded on a learning-by-doing approach common to a nascent field like CIS where both scholars and practitioners build theory and practice in tandem (Bremer et al., 2019; Harjanne, 2017). As part of this theorization process, we argue that the context should be broadly construed, encompassing the conditions and characteristics of information users, the information providers and their union.

We make this argument by identifying and describing nine distinct dimensions of the context, where each influenced the CIS design, evolution, and efficacy. While each of the dimensions has been the focus of studies on climate adaptation, SCF, and communication, we document how they all combine in a dynamic way to affect a CIS. In so doing, we show the importance of designing flexible CIS that can accommodate changes in the users as well as growth in the providers' knowledge of the contexts. Beyond these conclusions, our analysis is a rare glimpse at the multiple dimensions of implementing a CIS. At the same time as providing empirical detail about Blue Mountain (BM) coffee farming, this analysis serves as a CIS analytical model for both practitioners and scholars that can help information providers make informed decisions about project design, content, and evaluation, among other elements that influence a CIS's efficacy. While CIS involve multiple actors who each benefit from knowing the context, CIS often have an operational component where information comes from somewhere and is stewarded by someone. As such, the responsibility of knowing the context falls heavily on the provider, particularly in situations where information is newly introduced.

This article proceeds first with a review of connecting scientific information to different audiences. In section 3, we describe the research setting: a brief introduction to coffee farming in Jamaica, our CIS, and our methods of analysis. In section 4, we detail how the nine dimensions influenced our CIS. And in section 5, we bring these dimensions together in a dynamic analytical model that can help implementers understand the context, the important dimensions to observe, and why it is important to reflect on the users' and providers' contexts.

2. Literature Review: Contextual Dimensions of Climate Information Use

The use of climate and weather information across different sectoral, cultural, and economic settings has stimulated a growing body of research from scholars of climate adaptation, policy, and science communication (e.g. Mase and Prokopy, 2014; Moser, 2014, 2010; Moser and Dilling, 2011; Tall et al., 2018; Vaughan and Dessai, 2014). This work has revealed numerous barriers and effective strategies that

are related to local conditions. In this section, we summarize the topics that are routinely discussed, with a particular focus on the developing world context. For convenience, we adopt two common terms in the CIS literature, while recognizing they are imperfect (Vaughan, Buja, Kruczkiewicz, & Goddard, 2016): “Information users” (“users,” for short) are those who receive and apply climate and weather information and “providers” are those who transform raw data into more refined forms.

Perhaps the most referenced contextual qualities relate to users’ perceptions of salience, credibility, and legitimacy (SCL) (Cash et al., 2003; Hansen, Mason, Sun, & Tall, 2011; Patt & Gwata, 2002). Salience refers to the relevance of the information to an expressed need and is driven both by information supply and demand. Salience is a function of comprehension and access. If farmers are unable to understand a forecast, they will use it incorrectly or not at all. Likewise, if information is provided via web portals, it will reach only those with Internet connections. Access to climate information in many developing countries is highly uneven, and can be quite low (Vaughan, Hansen, Roudier, Watkiss, & Carr, 2017).

Perceptions of credibility relate to the scientific adequacy of the information being used (Cash et al., 2003) and the credentials and rhetorical skills of information providers (Moser, 2010). Certain messengers like respected community leaders can provide the psychological signals that instill confidence in the information (Moser, 2010). Moreover, interpersonal skills like humility and respect for different perspectives are effective at bridging disciplinary and cultural divides (Brugger et al., 2015). They not only influence perceptions of credibility but also legitimacy. Legitimacy relates to how faithful stakeholders’ values and beliefs are represented, the degree to which the process is perceived as unbiased, and the quality of stakeholder participation in the knowledge production process.

The effects of SCL are profound. They can influence the desire to act, who is empowered or not (White et al., 2010), and who benefits (Patt & Gwata, 2002). Roncoli et al. (2002) showed that West African farmers use traditional knowledge and scientific forecasts in complementary and divergent ways. They concluded that attending to the differences and similarities between traditional knowledge and western science can help introduce technical forecasts in culturally appropriate and locally relevant ways (Roncoli et al., 2002). Additionally, Carr and Onzere (2017) showed that agrometeorological advisories in Mali fit better with male household responsibilities than with female responsibilities, while Patt and Gwata (2002) stated that the goals of national level policy-makers may be at odds with those of individual actors. In the latter case, recommendations can be beneficial on average but harmful to specific people. In this sense, the messenger does not simply convey information, but also brokers power.

Language, and the meanings ascribed to information, present an additional contextual influence. Weather and climate forecasts are often presented in mathematical formats that some users find difficult (Stern & Easterling, 1999) while others less so (Luseno, McPeak, Barrett, Little, & Gebru, 2003). Pre-existing training and experience with probabilities, for example, can influence use (Grothmann & Patt, 2005). Moreover, farmers can use forecasts for cognitive and affective ends (Roncoli et al., 2009), in addition to the instrumental outcomes that often frame the goals of CIS.

As a response to a need to establish SCL, climate information delivery has trended towards more engagement (Mase & Prokopy, 2014). Projects have therefore been designed to be iterative (Meadow, Guido, Crimmins, & McLeod, 2016). The form of engagement, however, is tied to the available project resources, a part of the context that impacts what and how CIS are implemented (Meadow et al., 2015). Furthermore, engagement requires a unique set of interpersonal skills that are often not included in climate science training (Brugger et al., 2015). In these respects, the context includes the providers, making insights from communication relevant.

Studies on risk communication have shown that when information users became experts in their own right, and are treated as such, their perceptions of credibility and legitimacy are greater (Patt & Gwata, 2002). In a review of climate change communication, Moser (2010) highlighted that the efficacy of communication is influenced by a common understanding of the goals of the communication as well as of the modes of communication. Whereas the goals influence both the design of, and the resource demands on, the communication effort, the modes shape what can be said, the means by which it can be conveyed, and the opportunities for social learning. Participatory workshops, as one mode of communication, have shown promise in increasing the use of SCF (Patt, Suarez, & Gwata, 2005). In fact, many recently implemented efforts deploy participatory forms of engagement, some following farmer field school approaches (Dayamba et al., 2018). Yet, both the mode and goals can be shaped as much by the resources available and the priorities of funders as by the users' needs.

Where present, knowledge brokers and boundary organizations have helped engender SCL, comprehension, access, and facilitated engagement. Brokers and boundary organizations play intermediary roles, performing activities like translating technical information (Guido, Hill, Crimmins, & Ferguson, 2013), facilitating knowledge exchanges, and selecting key participants (Buizer, Jacobs, & Cash, 2016; Clark et al., 2016). The adoption of remote engagement via information communication technologies has helped overcome time and resource constraints characteristic of these activities (Kettle & Trainor, 2015). However, intermediaries and resources are lacking in many developing countries where

national agricultural extension is often hampered by these limitations (Olazabal, Chiabai, Foudi, & Neumann, 2018). And while NGOs and multilateral development projects have provided support, that are often incongruent with local needs (Harvey, Jones, Cochrane, & Singh, 2019). Nonetheless, the presence and capacity of intermediary actors make up an institutional context that helps shape what and how CIS are implemented.

3. Research Setting

3.1. Coffee Cultivation in the Blue Mountains

In Jamaica, coffee is grown in several regions but is concentrated in the relatively higher elevation area around the BMs (Figure 1). There, farmers grow the *coffea arabica* variety Typica. At the time of the last census in 2004, there were approximately 7,000 registered coffee growers in the BMs. The vast majority of these farmers operate farms smaller than five acres.

While the livelihoods of the small-scale farmers in the BMs are diversified, coffee is the preferred income source. BM coffee is world renowned and receives some of the highest prices on the global market (ICO, 2018). Yet, coffee is highly sensitive to social and environmental conditions for several reasons. First, coffee in the BMs is predominantly rain-fed, and periodic droughts reduce quality and quantity. Second, volatile market conditions impinge on the ability of small-scale farmers to manage their farms (ICO, 2013). In times of reduced income, BM farmers respond by using fewer agricultural inputs, leaving coffee trees more susceptible to hazards like plant diseases and droughts (Author, 2018). This occurred in 2013 when a widespread coffee leaf rust (CLR) outbreak affected BM farmers and later between 2013 and 2016 during a severe drought. These shocks made it difficult for coffee farmers to earn a viable income (Author, 2018). Consequently, the Coffee Industry Board (CIB)¹—the statutory body that regulates and promotes Jamaican coffee—has sought ways to improve climate resilience.

In collaboration with CIB, we spent several years working to understand opportunities for climate and weather information to help farmers manage their farms and in particular CLR (Author, 2018). We concluded that better access to weather forecasts and SCF, which were unknown to the vast majority of smallholder farmers despite being disseminated by the Meteorological Service of Jamaica (MSJ), could enhance coffee production. However, this required reducing barriers to accessing and understanding the

¹ In 2018, CIB became part of the newly formed Jamaica Agricultural Commodities Regulatory Authority (JACRA), which includes regulatory boards for several agricultural commodities including coffee. We use CIB throughout this analysis because CIB existed through the majority of our project and to be clear that our results refer to the coffee function of JACRA.

information. The findings provided the impetus for the development of the CIS we report on in this article.

3.2. CIS: Participatory Workshops, Routine Text Messages, and Interviews

The CIS consisted of three distinct activities beginning in June 2017 and ending in August 2018: participatory workshops, text messages, and interviews. This phase was a pilot with CIB expressing interest to continue some activities if cost was justified. Upon the pilot's completion, CIB was seeking additional funds but had not obtained them.

The users of the CIS were primarily smallholder farmers and the providers were represented by the research team, MSJ, CIB, and the Inter-American Institute for Cooperation on Agriculture (IICA). Together, we convened three sets of workshops in June and August 2017 and January 2018. We began sending text messages after the first workshop until August 2018. The interviews occurred between September 2017 and February 2018.

The workshops engaged nine communities clustered in six locations (Figure 1). We convened a total of 17 workshops—three in each of five rural locations and two in a sixth location where we canceled the third workshop due to dangerous travel conditions caused by persistent rain. Each workshop lasted approximately four hours. A total of 406 farmers participated in at least one workshop, of which 142 (35%) were female. A member of CIB worked with community leaders to invite participants.

We designed the workshops drawing on a growing body of participatory CIS activities for agriculture, mainly implemented in the developing world (Chandra, Dargusch, McNamara, Caspe, & Dalabajan, 2017; Dorward, Clarkson, & Stern, 2015; Hansen, 2015; Mwanga, Kisanga, & Dinh, 2017; Roncoli, Orlove, Kabugo, & Waiswa, 2011; Srinivasan, Rafisura, & Subbiah, 2011; Winarto, Stigter, Prahara, & Anantasari, 2011). The workshops facilitated conversations with the farmers about climate and the role of weather and climate information in their coffee management. Table 1 displays a workshop agenda from the first workshop series to provide detail about our engagement with the farmers during these events.

Following the first round of workshops, the MSJ began sending weather and climate information via text messages to the participants who volunteered for the pilot project. Each week on Monday and Thursday the MSJ sent a weather forecast for the next 3-day and 4-day periods, respectively. An example of the weather forecast text is: "Thu: Partly cloudy with showers. Fri: Mainly fair and hot. Sat-Sun: Fair mornings, isolated afternoon showers." The MSJ also sent a seasonal precipitation forecast once a month

when the forecast was publicly released and also occasionally included a seasonal temperature forecast. An example of this seasonal precipitation forecast is: “Seasonal rainfall forecast: total rainfall for Aug, Sept, Oct is more likely to be below normal (50%) than normal (30%) or above normal (20%).” We sent text messages to 372 unique farmers and a total of 42,979 texts messages were sent. We also conducted phone interviews with 166 farmers which included opportunities for farmers and researchers to discuss the text messages, workshops, and farming conditions. We provide more details on the interviews in the next section.

3.3. *Methods of Analysis*

During the workshops, two members of the author team recorded group discussions using participant observations. We complemented our observations with semi-structured phone interviews of the participants beginning after the second workshop. Each month we interviewed a random selection of approximately 20 participants from the pool of farmers who participated in at least one of the first two workshops (referred to as Random Group hereafter; n=104). For the random group, we asked questions predominantly about the meaning and use of the information. Additionally, each month we also interviewed an unchanging set of 12 farmers, two from each of the six communities (referred to as Tracked Group hereafter; n=62). We were, however, not always successful in contacting each farmer every month. We tracked this group to understand how perceptions and use of climate information changed over time. All interviews lasted about 20 minutes. A member of the author team completed all 166 interviews. We conducted content analysis on participant observations and interviews to identify key themes, and we provide descriptive statistics of the random group interviews as well as representative quotations from the both the tracked and random group interviews.

4. Nine Dimensions of the Users and Providers Contexts

We identified nine contextual dimensions that were all influential in our CIS. They fall into the three categories of the end users, the providers, and their union. In this section, we elaborate on the reasons each dimension is important for a CIS—drawing on the literatures of science communication, CIS and climate adaptation—and how each dimension manifested in our CIS. Table 2 provides their overview. While there are interrelations between these dimensions, it is instructive to look first at each individually. We then discuss their relationships in Section 5.

4.1 *The Context of the Information Users*

4.1.1 Main Concerns

In order for a CIS to be useful it must be salient and address a problem (Cash et al., 2003). In science communication, effective translation utilizes frames that resonate with a user's core beliefs and values, and thus provides meaning to ideas (Nisbet & Mooney, 2007). In a CIS, therefore, understanding what is of concern will enable information to be fit for purpose and to be received more openly. The latter is particularly important when new information is introduced.

In our case, the coffee farmers experience multiple persistent and overlapping stressors (Author, 2018) that have affected coffee production (Figure 2). In 2008, for example, the global economic recession lowered the prices farmers received for their crop, thus limiting their purchase of fertilizers. By 2012, the coffee trees' weakened state from inadequate plant nutrition and care likely contributed to the first widespread outbreak of CLR in Jamaica. Low plant nutrition has been associated with CLR elsewhere (e.g. Avelino et al., 2015).

Given this, we framed the CIS as a tool to help farmers decide when to apply inputs. The first workshops drew connections between weather and climate and management decisions (Table 1). However, by the second workshop series, coffee's farm-gate price fell by half. When we asked farmers to describe their main challenge to their coffee production, about 95% stated the low coffee prices (87 of 92 respondents in the Random Group; 12 farmers did not answer).

By the second round of workshops, the price shock influenced the workshop dynamics. At the workshops, our CIB partner fielded many questions about price, often from frustrated participants. The price drop also appeared to limit the importance of the weather and climate forecasts. One farmer stated during dialogs about forecast use: *"If farmers had sufficient inputs, they would have been able to spray their fields instead of watching their berries spoil and their crops destroyed"* (workshop, August 2017). This change caused us to reframe the next set of workshops, focusing on how weather and climate forecasts could increase yields to offset some of the impacts of lower price.

This example illustrates two points. First, the main concerns can change, thereby necessitating dynamic framing. A constant framing would have jeopardized the attention and trust of the farmers. Second, framing goes beyond capturing attention. It also requires linking abstract information to concrete actions. We therefore discussed in the workshops how forecasts can improve the timing of input applications in order to make their limited resources more efficient.

4.1.2 Audience Characteristics

Knowing the audience is a key, if not defining, characteristic of effective communication. Diverse audiences may require different communication modes, have different concerns, and desire different information (Carr & Onzere, 2017; Dilling & Lemos, 2011). By matching the information to the audience, information providers can design appropriate frames and goals, and send useful messages (Vaughan & Dessai, 2014).

In our case, it took close inspection to reveal six distinctions at the farmer-level that influence the use of climate information for decisions on agricultural inputs (Table 3). The influence of elevation is one example. At higher elevations, the cherries on trees ripen at the time when CLR begins to spread. However, farmers are prohibited from spraying fungicides at this time due to chemical residue limits on harvested cherries. Other farmers not harvesting, however, can treat the disease. Another example of farmer-level differences that affected the utility and efficacy of the information was awareness of proper CLR treatment. Farmers who were unaware that CLR-infected leaves are best treated by spraying the underside of the leaves would not reap all benefits from a forecast that helped them decide when to spray. (See Table 3 for other examples).

The farmer differences were therefore key in two decisions we made. First, we included only weather and climate information in the text messages and excluded recommendations. Advice for applying chemicals, for example, could have benefited some farmers, while possibly harming others. Second, because forecast information without agricultural knowledge would yield more limited results, we designed the workshops to explicitly link the forecasts to farming practices. Furthermore, because farmers had no prior experience with SCF we suspected a multiple-part workshop series was needed.

4.1.3 User Decisions

Scholars argue that a focus on the decision-making context is needed to guide the creation, translation, and provision of climate information (Goddard, 2016). In this respect, information can be fit for a purpose (Lemos et al., 2012). Knowing when a person needs to act—say, to plant a crop variety for an upcoming season—can help information providers deliver the right information at the right time.

In our workshops, we discussed the timing of on-farm activities. Farmers plant seedlings in the spring and fall and fertilize and spray chemicals during specific months. Within this seasonal calendar, the days of these activities are conditioned by the actual or anticipated weather, making weather forecasts a useful tool. One farmer stated: “*Based on the message that came yesterday, I decided to spray some coffee as the*

weather would be good for it. Over the weekend, [the text message] said there would have been rains in the afternoon, so in the morning I decided to burn some grass” (Random Group interview, September 2017).

Similarly, the SCF could inform longer-term planning. Farmers, for example, could anticipate needing fungicides if the spring rains were expected to be above-normal. While the workshop identified opportunities for SCF use, the interviews revealed however that farmers were unable to use them for two principal reasons. Most prominently, the fall in coffee price had restricted their ability to plan. Many farmers could not pay for both labor to harvest the cherries and fertilizers. Consequently, farmers chose to hire labor so that cherries would not rot, thereby prioritizing present concerns over future production. The second principal reason relates to the comprehension of the SCF, which we discuss in the next section.

In our team’s discussions prior to the workshop, we considered only sending SCF based on the project’s focus of seasonal timescales and because fewer texts would minimize communication costs. However, with a context unfavorable for SCF use, and because farmers had immediate uses for weather forecasts, we decided to send both weather and SCF information. We also recognized that SCF may become useful at a future time. Providing weather forecasts that had immediate value helped the farmers experiment with and gain trust in SCF even if they did not use them in an instrumental way. The tradeoff, however, was an increase in cost from more frequent communication that reduced the duration of the pilot texting.

4.1.4 Meanings of Information Communicated

Language barriers are a common challenge in communicating climate information. Non-scientists and scientists often interpret technical language differently (Bruine de Bruin & Bostrom, 2013). Risk communication specialists have therefore stressed the importance of identifying where providers and users differ in their understanding of scientific information (Taylor, Dessai, & de Bruin, 2015). This is particularly important for the communication of SCFs, which are often presented as shifts in the probability of tercile categories, a level of abstraction that presents challenges for many users (Stern and Easterling, 1999).

In our case, we were concerned that farmers would not understand the language of both weather forecasts and SCF and that text messages did not allow for clarification. We therefore focused each workshop on discussing the meaning of the forecasts and testing the language used in the messages. We further conducted interviews for additional feedback.

We structured the workshops in two ways to facilitate learning. First, we discussed weather forecasts before the SCF because most farmers had experience using the former. Many farmers were aware of forecast uncertainty because weather forecasts in Jamaica are issued for the entire island even though local conditions vary substantially. We therefore learned that many farmers understood probabilities and preferred their inclusion in the texts. Second, the workshops focused on how SCFs convey the likelihood of total rainfall and on the meaning of the following terms used by MSJ to describe total rainfall: “above normal”, “below normal”, and “normal.” Creating a common vocabulary is important because farmers differed in their understanding of the SCF. One farmer stated that normal meant “*isolated rainfall*” whereas another stated “*normal rains in the past are when farmers could go into the fields and get work done*” (workshop, August 2017). We also learned through interviews that farmers imbued meaning into the forecasts that extended beyond the technical definition, including assigning notions of frequency and intensity of rain, while also struggling to articulate a meaning of the SCF (Figure 3).

We therefore made several decisions based on farmers’ interpretation of the forecast language. First, we tailored the SCF texts to include probabilities. Second, because farmers interpreted the forecasts in different ways, with a majority unable to state a meaning, each workshop focused on discussing the exact information conveyed in the SCF. Moreover, we learned from our interviews that the farmers’ ability to state the correct meaning of an SCF did not substantially improve over time as might be suspected with greater exposure. Therefore, upon completion of the pilot project, we recommended more engagement with the farmers to develop a common lexicon and increase understanding.

4.2. The Context of the Information Providers

4.2.1 Capacity to Engage with Users

In CIS scholarship, analysis of the context is often focused on the users (e.g. Goddard, 2016), while that of the providers is emphasized less. This overlooks the role of the providers in engendering trust and bridging divides (e.g. Moser, 2010). Furthermore, participatory activities are often used to connect users and providers, rendering a high importance to facilitation and listening skills and assumptions of the audience. Because providers play as important a role on the efficacy of CIS as users, the capacity of the providers is therefore a relevant dimension to critique.

In our case, the context of the providers was important in two ways. First, the small-scale farmers feel neglected and marginalized by the more powerful members in the supply chain. Many farmers voiced comments such as, “*As the small farmer we do not feel connected to the coffee system. We feel as though we are alone and no one is really there to advocate for us and speak on our behalf*” (Random Group

interview, February 2018). This statement reflects a general sense that coffee institutional representatives, along with other organizations, supports only the larger farmers' interests. At times, the farmers were visibly frustrated with our team.

At other workshops, we were perceived to have power and authority. One farmer stated: *"You are here talking about how the farmer can take care of the coffee, but not talking to the buyers how to take care of the farmers"* (Workshop, August 2017). This farmer viewed our role as brokering better relationships between the small-scale and coffee buyers. It was not surprising, then, that some of the workshops became a rare opportunity for the farmers to voice their grievances. In one August workshop, the farmers questioned a member of CIB about the price fall for nearly half of the workshop. In this way, the composition of our team influenced what we discussed. Moreover, this example shows that providers need to recognize at the outset their position of power with respect to the users.

A second way our context influenced the CIS was the result of our sometimes false assumptions of the farming reality. This played out during the third workshop series in a demonstration to illustrate the value of having knowledge of the future climate. We gave farmers hypothetical money and asked them to choose an investment strategy based on a forecast. After the demonstration, one farmer asked us, *"What if you did a more real to life thing and say you don't have anything to invest?"* A member of our team responded, *"You must have something,"* to which the farmer rhetorically asked, *"Can I come to you for it?"* In this case, our preconceptions were that most farmers had the ability to purchase at least some inputs and what they lacked was information about the future. This assumption led us to use valuable time at the workshops to present an unrealistic, and perhaps misguided activity. It also ran the risk of alienating our audience. It further demonstrates the importance of stating assumptions and questioning them.

4.2.2 Resources

CIS that are user-driven necessarily involve collaboration with decision-makers (Brasseur & Gallardo, 2016). In this way, CIS are a transdisciplinary process (Schuck-Zöller, Brinkmann, & Rödder, 2018) that have unique engagement challenges. Developing working relationships and then sustaining collaboration among different partners are resource-intensive processes that are amplified by the multifaceted and changing context. The dynamic context requires flexible project management and team composition.

Coffee farming, like most occupations, is embedded in complex management systems. In order for climate and weather information to be introduced in ways that are attuned to this complexity, we needed to first develop relationships with CIB and MSJ. Prior to implementing the CIS, we spent several years

working with these organizations to understand opportunities for climate and weather information (Author 2018). This process helped develop trust among all participants, and provided the necessary time to develop roles. For example, the MSJ wanted to send the text messages due to their mandate as the national authority for weather and climate information. The IICA and CIB developed the agronomic aspects of the workshops. And the university team helped provide coordination and data analysis that shaped project design.

Yet, we were not always able to meet the resource demands. For example, our initial information dissemination plan included CIB leading the development of a seasonal bulletin to be shared by CIB and Jamaica's Rural Agricultural Development Authority (RADA). However, CIB and RADA's other commitments prevented the development of the bulletins.

Moreover, we considered other models of engagement such as farmer field schools and the Participatory Integrated Climate Services for Agriculture approach (Braun, Jiggins, Röling, van den Berg, & Snijders, 2006; Dorward et al., 2015). However, the communities' remoteness made it difficult to hold workshops in more than six locations. Furthermore, a combination of the high cost of workshops and busy farmers, led us to convene three half-day events instead of more numerous events characteristic of field school models. We also provided a travel stipend and lunch to compensate for attendance. Despite this, only 9% of all participants attended all three workshops. We thus concluded that we needed to better incentivize participants to attend all three workshops but also surmised that even with full attendance we would have needed more than three workshops.

4.2.3 Project Design

Projects designed to be responsive to learning and to reflect critically on how research builds adaptive capacity to climate risks are important activities in generating useful knowledge for planning, policy, and implementation (Preston, Rickards, Fünfgeld, & Keenan, 2015). Projects that are reflective recognize that users and providers lack relevant facts, the context is dynamic, and that all actors need to continually bridge knowledge divides (Lemos & Morehouse, 2005). From the provider's perspective, an iterative approach allows assumptions to be reframed, conclusions to be redrawn, and activities to be modified—adjustments likely to be a constant during the project.

Reflexivity is both a summative and formative process. It is formative in the sense that it is unrealistic for providers to have the full picture at the outset. For example, prior to the workshops, our team had not discussed the weather and climate information with the farmers. At the first workshop, we therefore were

unsure if farmers would understand probabilities. Only after our interactions did we decide that the widespread use of weather forecasts was a foundation on which to use probabilities in the SCF. While this is only one example, in each of the eight other sections we highlight other changes that occurred as the project evolved. They argue for a malleable approach able to adjust as understanding builds and the external context shifts.

Project design should also have a summative assessment in order to reveal final outcomes and identify process challenges and best practices. What works and why remains key knowledge gaps in CIS (Vaughan & Dessai, 2014). In our case, we collected household baseline data in 2016 to compare with a final future assessment. While we do not report this comparison in this analysis, pre- and post-intervention assessments are often used to evaluate instrumental effects: a relative increase in yields among users of climate information, for example. Our pre-assessment was geared mostly towards instrumental-type outcomes. However, our interactions and observations during the workshops strongly suggest that assessments should consider a broad set of information use outcomes that include cognition, affect, social inclusion, and other measures of subjective wellbeing. The importance of inclusion was stressed by one farmer who stated: *"Attending the seminar here and giving our cell numbers now make us a part of the system. We are in the know, we are privileged"* (workshop, August 2017). Psycho-social aspects as well as social and human capitals are key metrics in resilience and vulnerability, but less emphasized in evaluations of CIS (e.g. Tall et al., 2018).

4.3 Union of the Users and Providers Contexts

4.3.1. Communication modes

Many aspects of the context affect the mode of communication and who delivers it, which in turn effect the impact of the information conveyed (Moser, 2010). In the BM, coffee farmers live in remote communities and have limited access to technical support services. The CIB, which provides the principal extension support for the BM, has only three extension officers for the approximately 3,600 BM farmers. The remoteness of the communities and their limited interactions suggest existing extension channels based on face-to-face interactions are insufficient for frequent communication. Moreover, although the MSJ has provided SCF on their website since 2012, nearly all farmers who participated in the pilot had not seen one before our workshops. The elements that affect communication are thus a combination of the users' and providers' contexts.

For our CIS, we relied on two communication modes: text messaging and group and one-on-one interactions. Text messages enabled frequent communication to a large number of farmers at an

inexpensive cost. Additionally, texts were suitable because the BM farmers have a high literacy rate and there is widespread cell phone coverage and usage in the BMs. MSJ became the communicator of the text messages due to existing institutional responsibilities. But while this effort fit its mandate, MSJ has limited human and financial resources, and how to sustain the texts beyond the pilot program was an underlying concern. We embarked with the knowledge that only if the study made a compelling case for future funding would we seek a future solution. However, sustainability was never resolved in this pilot phase.

Any mode of communication, however, presents tradeoffs: a 160-character text, for example, is passive and one-way, but it is also relatively inexpensive. Passive forms can be effective communication modes (e.g. Carr and Onzere, 2017), but in-person conversations that facilitate inquiry may also be needed and are often more effective at developing understanding and informing actions (Lee, Lee, & Schumann, David, 2002).

In designing the CIS, we recognized that most farmers would be unaware of SCF and all the ways weather and climate information could inform coffee management. Text messaging alone was therefore an inadequate method to meet our goals. We included the workshops to share information and facilitate discussion, which would make the content in the texts more accessible. To gauge how the information was received, during the second and third workshops and interviews we asked farmers about specific text messages we had sent and we tailored the communications accordingly. In this way, the workshops were testbeds to refine the information in the messages.

4.3.2. Goal Alignment

From a provider's perspective, CIS are often initiated to improve existing management decisions and generate an instrumental effect. Yet, the ability to influence behaviors—particularly at the individual level—is often predicated on economic development (Eakin, Lemos, & Nelson, 2014). Therefore, in cases where economic capacity is low, instrumental outcomes may be aspirational, at least in the short term. On the other hand, users can derive other benefits. In our case, the initial reason for developing the CIS did not ultimately align with the benefits the farmers received. We had to adjust our goals and expectations.

As we prepared for the first workshop, the goal of the CIS was to inform the best time to apply fungicides and fertilizers. Based on results from previous work (Author, 2018), we found that farmers perceive plant nutrition and disease control as critical for good yields. However, the high costs of inputs prevent many

farmers from using them at recommended levels. In this resource-limited environment, wasted inputs are irreplaceable and the importance of proper allocation and efficiency are heightened.

However, because of the dramatic fall in coffee price, many farmers could not purchase inputs at all. The information we were providing, therefore, could not inform resource allocation as intended. One farmer summarized this, stating: *"I would like to do some fertilizing but I am unsure as to when this will be done as I am awaiting some money to purchase the inputs"* (Tracked Group interview, October 2017). In fact, after six months of interviews, we saw only slight evidence that farmers used the weather forecasts to inform decisions and only one farmer stated he had used a climate forecast in this way.

Yet, the messages and workshops had other, potentially more significant benefits. For one, many farmers liked having the texts easily accessible on their phones. Additionally, the workshops and messages conveyed a sense of importance to a group who perceive themselves to be neglected and excluded from industry-level decision-making. As previously noted, one farmer expressed his gratitude for inclusion: *"Attending the seminar here and giving our cell numbers now make us a part of the system. We are in the know, we are privileged"* (workshop, August 2017). And another farmer expressed both surprise and appreciation for the workshops, stating: *"You all are from the CIB? They never come here."* (workshop, January 2018).

Although we did not document much use of the information in coffee management, we observed social benefits. The ones we have mentioned—convenience and inclusion—were observed along with others such as awareness and edification. While these may not contribute directly or immediately to behavior change, they could prepare for instrumental uses. This is particularly salient for project evaluations. Measuring outcomes cast only in terms of informing decisions may miss important benefits. In our pre-assessment, we did not measure psycho-social effects and under-emphasized cognition and elements of social capital. We therefore missed an opportunity to evaluate the effects of the CIS on these components.

5. Discussion

In the course of this analysis, we have described the context of the BM coffee farmers, how our knowledge of this context grew, and how both fostered changes in our CIS activities. We did not anticipate many of these changes, in part because they are dynamic and interrelated. We show their relationships and direction of influence in Figure 4. While this model does not depict all the possible links, we show those that were the most consequential during our CIS.

In section 5.1 below, we elaborate on two pathways that we experienced, which can be traced as a set of nodes connected by arrows in Figure 4. The first traces the project at its early implementation and design phase, while the second follows links that occurred at a later project stage. We then reflect on insights this model reveals.

5.1 The Dynamics of the Context

The first pathway begins with the initial conceptualization of our CIS, where we hypothesized that the 2013 outbreak of CLR was causing hardship for the BM coffee farmers given their *Audience Characteristics*. (The capitalized and italicized terms are our contextual dimensions in Figure 4). Prior to the CIS, our baseline survey in 2016 conveyed that CLR's impact on production was one of the *Main Concerns* across the BM coffee industry. Consequently, we oriented our activities to inform *Decisions* on when to apply treatment and plant nutrition and to provide expectation of the seasonal rainfall; the latter would provide clues about the potential severity of the disease in future months. The *Main Concerns* thus dictated what *Decisions* we targeted. The *Decisions* then influenced the *Project Design* by compelling the inclusion of both weather and climate information, two different timescales that reinforced the effect of the other. The *Project Design*, in turn, affected both the *Resources* required and the *Communication Mode*. Taking the *Resources* first, our transdisciplinary team needed to include expertise in agriculture extension, disease management, meteorology, and climate so that we had the necessary *Capacity to Engage* with the farmers on the issue of linking the forecasts to farming activities. The *Project Design*, the *Resources* of our project team, and the *Audience Characteristics* all influenced the *Communication Mode*. The fact that cell coverage was widespread was one reason text messages were viable. Furthermore, the MSJ needed to disseminate the information in the text based on its mandate as the Jamaica's weather and climate authority. However, texts alone were insufficient to overcome the users' knowledge gaps. The CIS needed to combine active and passive *Communication Modes*. Moreover, because CLR is easily transported from one farm to another by wind and laborers harvesting the coffee, all farmers need to manage CLR. Thus, our *Project Design* was geared to reach as many farmers as possible, further emphasizing a need for an economically efficient *Communication Mode*. The aim was for *Goal Alignment* between the providers and the farmers: reduced coffee losses due to CLR.

The aphorism "Know the Context" has become ubiquitous within CIS because of the many dimensions that each influence the what, when, how, and outcome of an intervention. The context, however, is not static. The constant changes of each dimension require responsive, flexible CIS. We experienced this before our second set of workshops when the farmers began to directly experience the impact of a large fall in the farmgate price of coffee. Because the farmers principally earn their income from coffee, the

farmers' apprehension about the price replaced CLR as their *Main Concern*. Moreover, because many farmers struggle to purchase agricultural inputs even under profitable circumstances, the price decline rendered purchasing inputs nearly impossible. The farmers' *Characteristics* amplified by the charge in the price caused the *Goal* of our CIS—to inform input usage—to be unrealistic in the short term. Thus, we recalibrated expectations, while we also reframed and modified our activities within our *Communication Modes* to focus on mitigating the price decline. As a response, we therefore designed the third workshop with an economic module to show the value-added of continual plant maintenance under different scenarios of investment.

5.2. A model to Know the Context

The nine dimensions in Figure 4 serve as an analytical model. First, at a higher order, we find that the context is larger than that of the users. The context also encompasses providers and the intersection of both the users and providers. In this way, CIS providers are critically reflective of themselves and take seriously the notion of challenging their own assumptions and skills. Furthermore, while all CIS has a starting point, the constant flux of all the dimensions causes the context to be emergent. In fact, CIS implicitly attempt to change the context, and successful ones will. "Know the Context" is therefore a call for CIS to be flexible and responsive.

At the dimensional level, Figure 4 also shows that the audience characteristics dimension links to more dimensions than any other. Often, the focus in CIS is on the users' decisions (Dilling & Lemos, 2011; Goddard, 2016). The decisions, however, are a function of users' characteristics. Therefore, understanding the audience reveals why those decisions are made, when, and how, among other important details. In this way, there are certain dimensions that are more likely to change than others based on their number of connections and their position downstream of other dimensions. Communication modes, for example, is downstream of four dimensions spanning each category of the users, providers, and their union. Dimensions like communication modes are therefore apt to change frequently, requiring more constant monitoring and adjustments to remain fit for purpose. In reflecting upon each dimension and their totality, providers can thereby continually adjust their activities.

6. Conclusion

CIS are ways to reduce climate vulnerability and build resilience. To be most effective in these goals, scholars and practitioners suggest that CIS must fit the context in which they are used. As we have shown, the context is varied, dynamic, and complex. How, then, can one know the context?

From an analysis of our own CIS, we identified nine dimensions that shaped the design and implementation of our activities and assembled them into an analytical model that helps us understand the context. Taken together, we suggest that these nine dimensions constitute the context that can both be actively managed and serve as a guide in creating more effective CIS (Table 2). Instead of being faced with a plethora of diverse facts about a CIS intervention, the providers can use this model as a way to systematically identify the essential contextual dimensions, comprehend their interrelations, and adjust the project over time to accommodate change.

Our study offers several important insights about knowing the context. First, the context is dynamic and emergent. It is dynamic because each dimension links to others, and changes in one can have a rippling effect. It is emergent because the context is ever-changing. These properties argue for continued engagement so that the CIS can reflect on itself and be able to evolve as the context dictates.

Second, while it has been long recognized that each context is multi-dimensional and unique, analyses of the context typically focus on the end user. However, solely focusing on the users produces an incomplete analysis because users only exist in a context shared with the providers. The providers play important roles in project design and engagement, among others, that interact with the users. It is therefore important for CIS to emphasize reflection on the providers' context as much as the users'.

While CIS will be specific to a particular people and place, we suggest that our model also applies to many other situations in which climate information is brought to bear on local issues in a participatory way. While the relative importance of each dimension is context dependent—collaborations between state water agencies in the U.S. will be very different than working with Jamaican coffee farmers—in most cases, assessing the users, the providers, and their union will inform the design, implementation, and use of CIS. Indeed, these are the outcomes of knowing the context.

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Figures

Figure 1. Map of the Blue Mountains coffee growing region and the workshop locations. Coffee produced within the Blue Mountain coffee region is protected under the Blue Mountain Coffee Brand (the boundary is approximate and was obtained from CIB).

Figure 2. Timeline of notable stresses and shocks affecting coffee production in the BMs. Data for the number of boxes produced (in thousands) in the BMs during each agricultural year (August 1 to July 31). Data is from the CIB. Each data point corresponds to the June year (e.g. data plotted in 2016 represents August 1, 2015 – July 31, 2016). One box of raw cherries weights about 27 kgs. The stresses and shocks were identified in consultation with CIB and from Author 2018. CLR refers to coffee leaf rust.

Figure 3. Different meanings ascribed to the SCF. Data is from the interviews we conducted with the randomly selected farmers. Sample size is 101; 3 farmers did not respond to this question.

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Figure 4. Model for developing an understanding of the context by monitoring and analyzing nine dimensions that pertain to the users, providers, and the intersection of the two. The more prominent links between the dimensions are noted, with the arrows depicting the directionality of influence.

Tables

Table 1. Agenda for the first workshops in June 2017.

20 mins	Introduction to Workshop Have an opening prayer, introduce project team, discuss project initiative and goals, and present the day's agenda.
60 mins	Develop Calendar of Climate and Weather Conditions & Coffee Management Activities Facilitate group discussion to develop a crop-climate-management calendar, focusing on the coffee plant lifecycle, the lifecycle of coffee leaf rust, how weather and climate conditions affect coffee and CLR, and how weather and climate influence coffee management practices.
60 mins	Discussion of Weather and Climate Forecasts Facilitate a discussion on the reasons why some people have and have not used weather and climate information, how weather and climate information are similar and different to each other, and some fundamental characteristics of weather and climate information.
60 mins	Lunch Have a lunch catered by a local business.
60 mins	Weather and Climate Scenarios Divide into small groups. Facilitate a discussion on how sample weather and climate forecasts could influence farm management activities.
30 min	Introduction to SMS system Discuss the text messaging and the information that it will contain, with an emphasis on its utility and limitations.
30 mins	Next Steps Summarize the day, solicit feedback on the workshop, discuss content of next workshop two months later, open the floor for comments, thank participants, and distribute a travel stipend to the farmers.

920 **Table 2.** The nine contextual dimensions of the context and their influence on the CIS.

Category	Dimension	Influence on the CIS
Users	Main concerns	The degree to which a CIS is seen as addressing salient concerns influences opportunities, trust, and use of the service. Main concerns, however, can change rapidly.
	Audience characteristics	Users are diverse. A person's experiences, perceptions, and knowledge, among others, shape his or her understanding and use of information. They also provide guidance for tailoring the service.
	User decisions	The decisions farmers make help define opportunities and barriers, while also providing direction for the form of the service provided.
	Meanings of information communicated	Technical language may be interpreted differently than intended, and can lead to misinterpretations and misapplications.
Providers	Resources	Human and financial resources constrain the types and forms of activities.
	Capacity to engage with users	The team composition, skillsets, and experiences influence the types and forms of activities as well as the relationships with the audience. Construct teams with the right skill sets and an openness to learn.
	Project design	The multidimensionality and dynamic nature of the entire context requires updating efforts based on new learning of the context. A flexible project design can lead to more favorable outcomes.
Union of Users and Providers	Communication modes	The mechanism by which information is communicated influences its accessibility, cost, and the content. There are advantages and disadvantages in each mode.
	Goal alignment	The primary benefits may ultimately be different than expected. Flexible goals may be more responsive to a wider set of outcomes.

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922 **Table 3.** Examples of audience characteristics that can influence a farmer's use of weather and climate
 923 information.

Element of difference	Influence on coffee and CIS use
Elevation of farm	Elevation influences coffee growth stages which, in turn, determines if cherries ripen during spring rains and CLR spreading. This timing influences if farmers can spray fungicides.
Knowledge of proper management techniques	Affects the efficacy of input usage. Information informing input timing will be effective only if inputs are applied effectively.
Previous use of technical weather and climate information	Can affect the trust in the information and the comprehension of probabilities.
Income and ownership of productive tools	Affects the ability to purchase inputs and tools like mechanical sprayers. A CIS targeting decisions to apply inputs will be useful only to those who can make these purchases.
Contact with extension officers	Affects access to farming information and weather and climate information as well as trust in the messenger of the information.
Importance of coffee to the livelihood	Affects how much a farmer is willing to invest in their farm, and therefore their willingness to use a CIS.

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