The Economic Impact of Seasonal Drought Forecast Information Service in Jamaica, 2014-15*

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Summary

Starting in 2014, Jamaica has been in one of the worst droughts recorded since the 1970s. The drought's effects on rural livelihood and the Jamaican economy have been devastating. According to widely published reports, the annual agricultural production declined by 30% in 2014 relative to 2013. This, along with brush fires, resulted in $1 billion loss for the economy. In response to the drought, the Jamaican Meteorological Service (JMS), in collaboration with the International Research Institute for Climate and Society (IRI) produced new seasonal drought-related forecast information. The information was provided to over 300 farmers during June 2014-June 2015 by JMS with the help of the Rural Agricultural Development Authority (RADA). The farmers received the information through farmer forums, phone text messages, extension agents, and by contacting the JMS. While anecdotal stories suggest that the losses in agricultural production might have been much greater if not for the provision of the information service by the JMS, they do not constitute robust evidence regarding the economic benefit of the information service. The goal of this study is to evaluate the economic impact of the service provided.

The following findings stand out. First, unlike many developing countries in Africa, Asia, and Latin America, the farmers in Jamaica have much higher educational attainments, which is an indication that they would be relatively more accessible to any information campaign, for example, the provision of climate information service and raising awareness about the climate change.

Second, the income and livelihood sources of the Jamaican farmers are not very diversified beyond agricultural-based activities. On average agriculture accounts for over 60% of the household income. Further, within agriculture, the on-farm activities are not very diversified.

These results suggest high economic vulnerability of the farmers to climate variability and change.

Third, lack of water, finances, and the uncertainty of water/rainfall/drought (uncertainty of WRD, henceforth) are the three most frequently reported challenges and constraints faced by the farmers. Limited access to finances is a concern for another reason: it may inhibit a farmer's ability to act upon new climate information.

Fourth, TV, radio, and the agricultural extension services provided by the RADA are the three most commonly reported sources of climate information for the farmers. They are also the three most reliable and trustworthy sources of climate information as identified by the farmers. Together, they suggest a relatively low level of awareness about the services that originate with the JMS. This is a potential obstacle to the utilization of climate information disseminated by the JMS.

Fifth, the impact of drought on agricultural production during June 2014 - June 2015 is substantial. The average reported percent loss in the volume of agricultural production relative to production in the preceding year is 57%, a figure much higher than the widely reported loss of 30%. The self-reported income status of Jamaican farmers was much worse in June 2015 relative to the income status in June 2014.

Sixth, the uncertainty of WRD has a substantial adverse effect on agricultural production. For the group of farmers faced with the uncertainty of WRD, the loss in the agricultural production was on average 25% larger relative to the mean loss of 57%. However, in the former group, the reported loss in agricultural production declines with the increasing degree of exposure to the information service. In other words, the losses in agricultural production for the

farmers faced with the constraint of WRD would have been much greater if not for the provision of the information service.

Seventh, not all of the components of the information service were effective. The information service provided through farmer forums and phone text messages were the most effective mechanisms of information dissemination.

Eight, the information service contributed to agricultural production by influencing the agricultural decisions and management of the farmers. It influenced the planting and sowing time, choice of crops, harvesting time, amount of land cultivated, mulching practices, chemical and fertilizer use, and irrigation.

Finally, there is strong demand for the future provision of similar climate information services. More importantly, the farmers would be willing to pay for timely, relevant, and accurate seasonal climate forecast information.

1. Introduction

Agriculture accounts for approximately 7% of Jamaica's GDP and employs one-fifth of the workforce. It is, therefore, a critical source of economic vitality of Jamaican livelihood, particularly of farming communities. However, agriculture is highly vulnerable to climate risks. Hurricanes, tropical storms, and drought are frequent and persistent causes of losses in agricultural productivity, income, wealth, and wellbeing. Starting in 2014, Jamaica has experienced one of its worst droughts in a decade and the fourth worst recorded since the 1970s.[1] Figure 1 shows monthly precipitation in Jamaica. With the exception of December 2014 and March 2015, the recorded monthly precipitation in Jamaica during June 2014 - June 2015 was significantly below the historical average of 1971-2000.

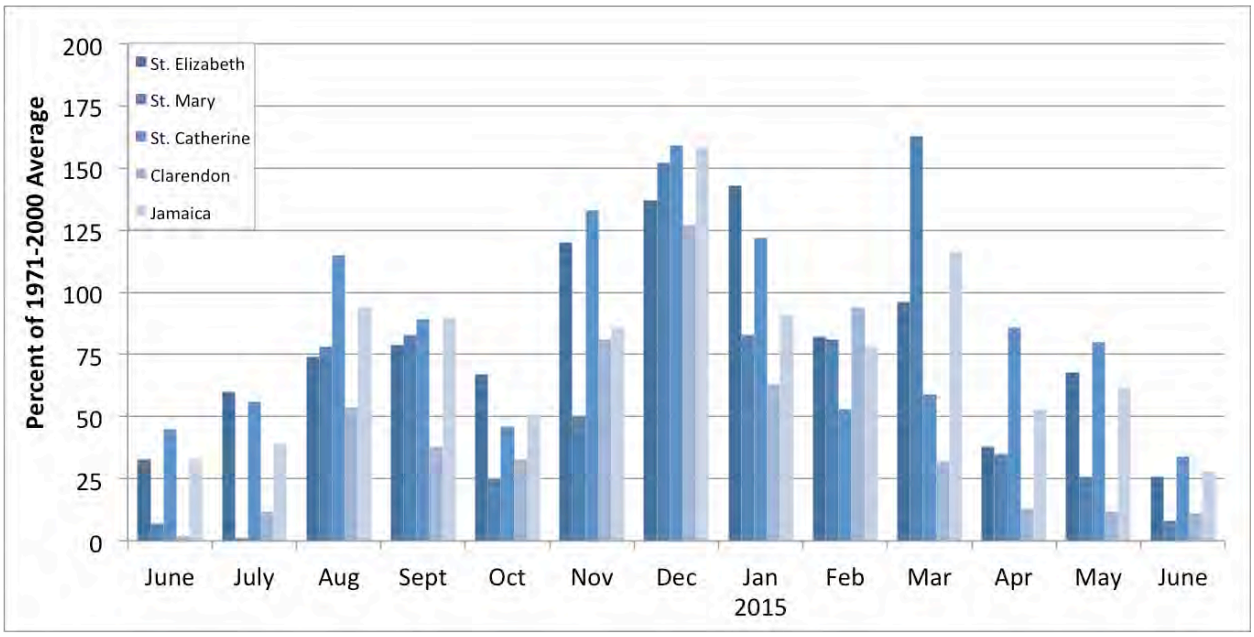

Figure 1. Monthly Precipitation in Jamaica. Data from the Jamaica Meteorological Service[2]

[1] http://www.usaid.gov/news-information/frontlines/science-technology-innovation-and-partnerships/innovative-weather-model

[2] http://jamaicaclimate.net/rainfall-summary.html

According to published reports, the drought caused a 30% decline in agricultural production in 2014 compared to 2013.[3] This, along with brush fires, resulted in an approximately $1 billion in loss for the economy. Personal stories from farming communities suggest that the losses in agricultural production might have been much greater if not for the provision of new seasonal drought forecast information produced by the JMS and the IRI, with support from the Climate Change Resilient Development project funded by USAID. The JMS produced the first seasonal drought forecast in November 2013 and the information was provided to more than 300 farmers through the mechanisms of farmers forums—day-long training events organized by ACDI-VOCA and RADA—and cell phone text messages; both the farmers forums and text message communications continued over the course of June 2014 - June 2015. The economic value of the drought information service would derive from the notion that the recipient farmers were able to make better farming decisions compared to non-recipient farmers, hence minimizing the adverse productivity impacts of the drought.[4] While these positive personal stories are encouraging, they are at best anecdotal evidence of the economic impact of the drought information service provided.

The primary objective of this study is to estimate the economic impact of the seasonal drought information service (information service, henceforth) received by more than 300 farmers during June 2014 - June 2015. However, the overarching goal is to provide a comprehensive evaluation of the information service: First, we estimate and identify the relative impacts of the various components of the information service; second, we investigate the utilization of the

[3] https://www.usaid.gov/news-information/frontlines/science-technology-innovation-and-partnerships/innovative-weather-model

[4]According to information theory, the value of information depends on three conditions: novelty, confidence, and ability and willingness to act on updated beliefs (Hirshleifer and Riley, 2002).

information service and its impacts on the agricultural production decisions; and thirdly we provide some insights into the demand for climate forecast information service in Jamaica.

The remainder is organized as follows. In section 2, we briefly describe the information service provided. Study design and data are discussed in section 3. The results are presented and discussed in Section 4. In Section 5, we assess the potential demand for similar climate information service in Jamaica. Finally, we conclude in Section 6.

2. Seasonal Drought Forecast Information Service, 2014-2015

In response to the drought, the JMS, in collaboration with the IRI produced seasonal drought forecast information, first, in November 2013. This information was provided to more than 300 farmers across Jamaica during 2014-2015. The provision of the information service was led by the JMS, with the support from RADA and ACDI-VOCA. It consisted of three components, which we can interpret as three related, but distinct, mediums of communicating drought-related information to farmers.[5]

The first component is "Farmer Forums," organized in 12 locations across different parishes. Seven of the forums were organized in 2014 and five in 2015 (from March to early July). Each forum aimed for the participation of approximately 50 farmers. St. Ann and St. Elizabeth parishes had the smallest number of participants. There was no well-defined procedure for determining the participants. The turnout was dependent on RADA's ability to mobilize the community, as they were charged with the responsibility of getting farmers to the forums. Bulletins about the scheduled forums were sent to RADA, who in turned distributed them to its regional offices and parishes. The forums had multiple purposes. First, they were meant to help

[5] Our understanding of the product, approach and procedures of the information service is entirely based on interviews with key individuals at the JMS, RADA, and ACDI-VOCA, the organizations responsible for the development and delivery of the information service.

farmers understand weather and climate terminologies used by the JMS. Second, they were aimed at educating farmers about JMS's products and services. Third, they were intended to be platforms that enabled the farmers' understanding and utilization of the climate information provided through phone text messages. Forum activities included a game of "Jeopardy" to aid farmers in understanding weather and climate information and presentations by the JMS of its product and climate services. Also the farmers were introduced to a drought forecast map to explain the significance of the different colors used in the maps. Moreover, a trial run was done with the text messages to identify who got them.

The second component of the information service was the provision of drought-related information to farmers via phone text messages. The majority of phone text recipients were the forum participants. Some of the text messages were sector-specific. Farmers were grouped according to their parishes, and messages were sent out accordingly. Depending on the region, text messages were sent either monthly or once every 3 months. Also JMS provided drought-related information via text messages to farmers and extension officers upon their request. For example, when no rain had fallen in a protracted period during the wet season, some farmers would inquire when it would rain. The text messages started in June 2014.

The third component of the information service was the role of RADA extension offices. Extension agents were also part of the farmer forums. They, in turn, were another medium of providing information to farmers.

For the purpose of this analysis, a farmer (or household) is counted as a member of the treatment (i.e., information service) group if she or he received information through one or more of the components of the information service, or by contacting the JMS directly to obtain information.

3. Study Design and Data

3.1. Design

A randomized controlled experiment (also known as a randomized controlled trial, RCT) is a more desirable sample design to study the impacts of an intervention (or program, or treatment), particularly in contexts where (a) comparison-treatment and control-groups can be well-defined and (b) the treatment is randomly assigned over the comparison groups. In such cases, it is relatively straightforward to identify and estimate the treatment effects. In absence of (a) and (b), researchers will generally employ widely used statistical methods of propensity score matching (PSM), regression discontinuity design (RDD), or identify natural experiments.

However, the information service considered here was not conceptualized as a randomized experiment and was not intended for rigorous impact evaluation. Therefore, we lack baseline data and "well-defined" comparison groups. While it is beyond the scope of this study to discuss the relative merits and applicability of PSM and RDD to impact evaluation of the information service, it must be noted that their application would necessitate the identification of a counterfactual group of farmers who did not receive or had no access to the seasonal drought forecast information.[6] Although only approximately 300 farmers were part of the treatment group, the drought-related information was available on the JMS website and hundreds of bulletins were circulated to farmers across Jamaica. Therefore, it is difficult to identify a comparable group of farmers who had no access to the seasonal forecast information, whose

[6] See Rahman and Buizer (2015) for further discussion on the evaluation of climate information services using survey and experimental data. Among many issues, they discuss the challenges of conducting impact evaluation of climate information services, the need for a theory of change, and the application and suitability of program evaluation methods for the evaluation of climate information services.

agricultural outcomes can be compared with the outcomes of 300 treated farmers for estimating the causal impact of the information service.

In light of the above limitations, we study the impact of the information service using data on a sample of farmers who directly or indirectly participated in the treatment. We estimate the economic impact of the information service by comparing the distribution of agricultural outcomes of sub-groups of the farmers. Here sub-groups of farmers, for example, refer to farmers who identified or did not identify uncertainty of WRD as one of the challenges and constraints to their agricultural decisions and management, among others.

3.2. Data

Data was collected on a sample of 453 farmers, distributed across 10 parishes. Our first target was to reach every farmer who attended a farmer forum, or received information through phone text messages. We were successful in reaching only 204 of the approximately 300 farmers in this group. Then we collected data from an additional group of 249 farmers who were not part of the preceding group, but may have received information through other mediums, e.g., radio and TV. Data was collected through phone interviews, primarily because detailed information about farmers' location, addresses, and availability was not readily available, and time did not permit seeking it out. Fortunately, we had their phone numbers, which farmers had provided to the JMS during the forums. For the additional group of farmers, RADA provided the phone numbers. Data was collected in August 2015.

Phone interview as a method for collecting data suffers from many limitations including low participation rate, lack of clear communication, and the difficulty of earning and keeping the trust of respondents, which are desirable for obtaining accurate information, among other reasons. Also it limits the ability of researchers to ask as many questions as they would like to

for detailed information. Because of these considerations, we incentivized the respondents for their time and participation. Each respondent was provided phone credit worth 1500 Jamaican dollars ($12.65 U.S.)

We collected information about households' demographic and socioeconomic characteristics, sources of income and livelihood, sources and utilization of climate information, participation in the information service, farming decisions and management practices before and after the information was received, reported agricultural output in the pre- and post - drought periods, attitude and perceptions about the information, and obstacles to utilization of the information, among others (see Appendix A). One of the key elements of our approach is the use of retrospective analysis.

3.3. Household Characteristics

Table 1 shows the distribution of the respondents by parishes. The majority of the respondents are from Clarendon, St. Thomas, St. Catherine, and St. Mary. This is not surprising given where farmer forums were convened.

Table 1. Distribution of Households by Parishes (n=453)

Parish	Number of Households	Percent
Clarendon	139	30.68%
Kingston	4	0.88%
Manchester	9	1.99%
Portland	33	7.28%
St. Andrew	12	2.65%
St. Ann	10	2.21%
St. Catherine	69	15.24%
St. Elizabeth	24	5.30%
St. Mary	62	13.69%
St. Thomas	91	20.08%

Approximately 70% of the respondents are male (Table 2). The average age of the

respondents is about 50 years, with a significant variation in age distribution reflected in a relatively high standard deviation (12.15). Average family size is 3.82. About 70% of the respondents owned agricultural land and 51% leased land. The average land ownership is approximately 9 acres. The distance to the nearest city indicates the remoteness of a farmer and his access to urban environments and markets. The average distance to the nearest city is 7 miles, suggesting relative remoteness of the households given the geographical size of Jamaica.

Table 2. Household Characteristics

Variable	Mean	Standard Deviation	Min	Max
Male	0.70	0.455	0	1
Age	49.73	13.17	19	88
Household Size	3.82	1.97	1	15
Own Land	0.70	0.45	0	1
Land owned (acres)	8.6	14.24	1	120
Lease Land	0.51	0.50	0	1
Leased land (acres)	10.5	33.61	0	400
Distance to the nearest city (miles)	7.0	5.87	0	50

Approximately 47% of the respondents are currently married and 25% are unmarried and single (Table 3). Approximately 99% of the respondents have at least a primary school education, with 14% having attained university degrees. So unlike many developing countries in Asia, Africa, and Latin America, the farmers in Jamaica have a much higher educational attainment, which is an indication that they would be relatively more accessible to an

information program including the provision of the seasonal drought forecast and raising awareness about the climate change.

Table 3. Distribution of Respondents by Marital Status and Education

Marital Status	*Percent of Respondents*
Married	47%
Unmarried and Not single	19%
Unmarried and single	25%
Divorced	4%
Widowed	4%
Highest Level of Education Attained	
None	1%
Primary School	22%
Secondary School	39%
University	14%
Other Tertiary	16%
Other	8%

3.3.1. Income Diversification

Table 4 shows the distribution of the households by sources of income and livelihood. The respondents were asked to select whether given categories of income and livelihood applied to their households. This was done to capture the diversification of income and livelihood sources. While 96% of the households reported cultivation of land as one of their sources of

income, only 34% of the households reported salaried work as a source of income. On average, the households had 2.79 (out of 9) different sources of income and livelihood, suggesting a relatively low degree of diversification of income and livelihood.[7]

Table 4. Distribution of Households by Sources of Income and Livelihood

Source	Proportion of Households
Cultivation of Land	0.96
Agricultural casual wage labor	0.42
Non-agricultural casual wage labor	0.26
Raising of animals/livestock/poultry	0.40
Salaried work	0.34
Non-agricultural business	0.19
Remittances	0.09
Pension	0.08
Others	0.04

Income diversification can also be assessed using the share of agricultural income of the total household income. However, there are various measurement issues that need to be considered before using it as an indicator of the income diversification. First, it is difficult to estimate household income accurately using survey data, which suffers from the problems of under-reporting (or lack of reporting), and the fact that a significant share of agricultural production is for self-consumption. Second, given the unreliability of survey-based income information, it is difficult to accurately estimate the shares of different income sources, which

[7] It captures a household's different sources of income. It is a count variable.

could lead researchers to potentially misleading conclusions. Therefore, we attempted to assess the significance of agricultural income in the household income indirectly. Without asking about household income, the respondents were asked to provide a range estimate of the share of agricultural income of their total household income.[8] The idea was to arrive at a categorical indicator of the significance of agricultural income in the total household income, where the indicator takes the value of 1 if agricultural income accounted for less than 20% of the household income, 2 if it is 20-40%, 3 if 40-60%, 4 if 60-80%, and 5 if 80-100%. The summary result is presented in Table 5.

Table 5. Share of Agricultural Income in the Household Income

	Mean Share of Agricultural Income*
In one year before the drought of 2014	3.46 (1.22)
In one year during the drought of 2014-2015	3.16 (1.42)

* Standard deviation is in brackets.

From Table 5 the significance of agricultural income is pretty clear. On average, it accounts for over 60% of the household income.

Next we look at the variety of agricultural activities in which the farmers are involved, which serves as an indicator of the diversification of agricultural income. Table 6 contains a summary of our results. We observe that production of non-export (other) crops, export crops, goat/sheep farming, poultry farming, and pig farming are the top five reported agricultural activities of the farmers. At first glance, it may appear that only the production of export and

[8] The respondents were provided with the following alternatives: less than 20%, 20-40%, 40-60%, 60-80%, 80-100%.

non-exports crops are the agricultural activities that are sensitive to drought conditions, but a more careful analysis would suggest that the productivity of goat/sheep farming, poultry farming, and pig farming are equally, if not more, sensitive to drought conditions.

Table 6. Distribution of Households by Agricultural Activities

Agricultural Activity	Proportion of Households
Export Crops	0.36
Other Crops	0.97
Pig Farming	0.20
Beef Cattle Farming	0.13
Dairy Cattle Farming	0.02
Poultry Farming	0.28
Fish/Shrimp/Seafood	0.03
Goat/Sheep Farming	0.34
Bee Keeping	0.04
Horticulture	0.05

These results suggest that income and livelihood sources of Jamaican farmers are not diversified beyond agricultural-based activities. Further, within agriculture, on-farm activities are also not diversified. Together, they imply a high economic vulnerability of the farmers to climate variability and change.

3.3.2. Climate Information and Uncertainty of WRD as Obstacle to Farmers

Provision of climate information services, especially to farmers, is based on the assumption that it can lead to better agricultural decisions by reducing climate uncertainty, raising

awareness, and improving adaptation capacity. However, this will work only when there is demand for such information. Demand for climate information will exist if lack thereof is perceived by the farmer as an obstacle to better agricultural decisions and management, or if it can reduce climate uncertainty. Is the lack of climate information an obstacle to farmers in Jamaica? Is uncertainty of WRD a challenge or constraint to agricultural decisions and management in Jamaica? To answer these questions, we asked the households about the challenges and constraints to their agricultural decisions and management. The respondents were not provided options to choose from. Instead we asked it as an open ended question. They were allowed enough time think about the question before listing their challenges.

In Table 7, we summarize the responses. Only 3% of the farmers identified lack of climate-related information as one of their major challenges. Approximately 33% of the farmers reported

Table 7. Challenges and Constraints to Agriculture Decisions and Management

Challenges and Constraints	*Proportion of Households*
Lack of Finances	0.40
Increasing costs of inputs	0.14
Profitability of Farming	0.07
Lack of Equipment	0.17
Labor Shortage	0.11
Small scale of farming	0.06
Lack of climate-related information	0.03
Water	0.44
Uncertainty of WRD	0.33

uncertainty of WRD as one of their major challenges, highlighting the significance of the climate information services targeted at reducing climate uncertainty in Jamaica. Water availability and lack of finances are the two most frequently reported obstacles by the farmers. The lack of finance is a serious problem for another reason: it inhibits a farmer's ability to act upon new climate information.

3.3.3. Access to Climate Information

In Table 8, we present the sources of climate information identified by the households. TV (76%) and Radio (71%) are the two most common reported sources of climate information for the farmers, closely followed by Extension Agents/Offices (58%). Only 37% of the households identified the JMS as one of their sources. Table 9 reports types of climate information received by the households.

Table 8. Sources of Seasonal Climate Information

Source	Proportion of Households
Neighboring Farmers	0.39
Community Leaders	0.12
Farmers Groups	0.40
Extension Agent/Offices	0.58
JMS	0.37
Internet	0.25
Radio	0.71
TV	0.76

Table 9. Climate Information Received by Households

Types of Climate Information	Proportion of Households
Rainfall Forecast	0.92
Temperature Forecast	0.53
Drought Forecast	0.79
Storm Warning	0.59
Information about Climate Change	0.76

Interestingly, while the information service was delivered through phone text messages by JMS and Extension offices, TV, Radio and Extension Offices are identified as reliable and trustworthy sources of climate information by overwhelming majorities of the households (Table 10).

Table 10. Reliable and Trustworthy Sources (Reported by the Households) of Climate Information

Source	Proportion of Households
Neighboring Farmers	0.66
Community Leaders	0.36
Farmers Groups	0.70
Extension Agent/Offices	0.78
JMS	0.71
Internet	0.48
Radio	0.81
TV	0.85

3.3.3. Participation in the Information Service (Treatment Group)

Table 11 provides the households' extent of participation in the treatment group. We note that a household may receive information from the treatment sources as well as other sources (e.g., Radio and TV).

The first half of Table 11 shows households' extent of participation in the treatment group. Given our definition of the treatment group—farmers who received climate information from at least 1 of the 3 components noted in section 2—the most intensive participation (or treatment) is when a household a) attended a farmers forum, b) received information via text messages in 2014 and 2015, c) called and/or texted the JMS for information, and d) received information from RADA's extension offices.

Table 11. Treatment Group

Treatment Components	Proportion of Households
Farmers Forum	0.44
Phone Text Message from Met Service in 2014	0.20
Phone Text Message from Met Service in 2015	0.15
Called/Texted Met Service	0.10
Extension Agent/Offices	0.50
Non-Treatment	
Farmers Group	0.46
Internet	0.24
Radio	0.78
TV	0.82
Others	0.13

From Table 11, we observe that approximately 44% of the households in our sample attended farmers forums, 20% received information via text messages in 2014, and 15% did so in 2015. Also, 10% of the households contacted the JMS directly for information, while approximately 50% of the households received information from RADA extension offices.

The second part of Table 11 shows the households' non-treatment sources of seasonal drought forecast information. Approximately 82% of the households reported TV as one of their sources of information, closely followed by radio (78%), and farmers group (46%). From Table 11, the following three inferences are possible. *First*, if the treatment is defined as having received information from a) farmer forums, b) text messages, c) direct contact with the JMS, and/or d) RADA extension officers, farmers who received information *only* from any one of the "Non-Treatment" sources, listed in the second part of Table 11, can be considered as comprising the control group, as far as the medium of receiving information is concerned. However, strictly speaking, this is not a desirable control group for the purpose of studying the impacts of the information service. *Second*, since the forecast information was produced by the JMS, even if some farmers received this information from non-treatment sources, we can safely assume that it originated from the JMS. *Third*, given that the information was available to households through a variety of mediums, it is difficult to identify households that did not receive, or had no access to drought-related information from any source.

Given the above limitations, the following meaningful analyses are possible: first, we can study the impact of information service, as measured by the degree of exposure to the service, on agricultural outcomes; second, we can disaggregate the relative impacts of the different components of the information service; and thirdly, we can investigate whether the economic impacts of the information service vary across sub-groups of farmers, especially, for the farmers

who identify or don't identify uncertainty of WRD as a constraint to their agricultural decisions and management.

4. Results

4.1. The Impact of Drought on Agricultural Outcomes

We estimate the adverse impact of drought on agricultural output in three ways (see Table 12). First, we estimate the reported decline in the value of agricultural production during the drought. For this we compare the value of agricultural production in the year preceding the drought with the value of agricultural production in the year after the onset of the drought. Estimated decline in the mean value of agricultural production is given in row C, which stands at approximately 31%. The second measure is farmers' self-reported percent loss in the volume of agricultural production, in contrast with the value of agricultural production. This is reported in row D, which shows an estimate of approximately 57% loss in the volume of agricultural production, a figure much higher than other published estimates. The third measure of the economic impact of the drought is the relative income status of the households. We asked the respondents to compare their household income status in the year before the 2014 drought to their income status in August 2015. It is an ordinal ranking of the relative income status: 1 if worse than before, 2 if same as before, and 3 if better than before. The mean value is reported in row E, which is equal to 1.48, implying a comparatively worse income status in 2015.

Taken together, these estimates suggest a substantial adverse impact of drought on households' agricultural output and income status.

Table 12. Impact of Drought on Agricultural Production

Agricultural Production Adversely Affected: 92% of the Households

Outcome Variable	Mean (Jamaican $)	Stand Deviation
A. Value of Ag production in one year before the drought of 2014	1,362,598	3,598,914
B. Value of Ag production in one year during the drought of 2014-2015	939,635	2,737,946
C. Decline in Value of Ag Production (A - B)	-4,229,63 (31%)	2,232,974
D. Reported Loss in Ag production in 2014-2015 (%)	0.57 (57%)	0.25
E. Relative Income Status	1.48	0.72

This takes us to the primary question of this study: was the average loss in agricultural production of the farmers in the information service group statistically smaller than the average loss in agricultural production of the farmers who were not recipients of the information service?

4.2. The Impact of the Information Service

The main econometric problem in the estimation of treatment effects is selection bias, which may arise from the fact that treated households may differ from the non-treated for reasons other than treatment status per se. In such cases, it is difficult to isolate the contribution of the treatment from the contributions of other factors. It is quite possible that the households who participated in the information service were different from others, and therefore, we begin by comparing the households in the information service group with the comparison group to check if they were balanced along relevant observable factors. Table 13 presents the results, where we regress the participation in the information service (Treatment Group) on various household characteristics, including the reported uncertainty of WRD. In column 2, the results correspond

to the count measure of the extent of participation in the information service, while column 3 refers to the discrete (Yes/No) measure of the membership in the treatment group. It is very clear that the treatment and control groups are statistically comparable and similar. Therefore, there appears to be no selection bias.

Table 13. Membership in the Treatment Group+

	Information Service (Count)	Information Service (Discrete)
Age	-0.003 (0.005)	-0.0003 (0.001)
Male	-0.194 (0.141)	-0.019 (0.049)
Married	-0.090 (0.135)	-0.029 (0.048)
University Education	0.189 (0.187)	0.060 (0.063)
Household Size	0.007 (0.032)	0.0185 (0.011)
Own Land	0.065 (0.139)	0.036 (0.050)
Uncertainty of WRD	-0.163 (0.135)	-0.070 (0.048)
Constant	1.673*** (0.339)	0.642*** (0.114)
N	446	445
R-Square	0.015	0.018

+ Ordinary least square estimation. Robust standard errors are provided in brackets. *** Significant at 1%.

4.2.1. Aggregate Impact

Here we focus on the impact of the information service on reported loss in agricultural production.[9] We begin by estimating the following simple regression model:

[9] There are many reasons for focusing the analysis on reported loss in agricultural production, including the fact that the value of agricultural production also depends on market conditions. That is, the correlation between agricultural production and drought condition is more direct and obvious than the correlation between the value of agricultural production and drought condition.

*Percentage Loss in Agricultural Production = a0 + a1*Information Service + a2*Uncertainty of WRD + a3* (Information Service*Uncertainty of WRD) + a4*Age + a5*Gender + Stochastic Error* (1)

where the dependent variable is self-reported percent loss in agricultural production due to the drought during the period of June 2014 - June 2015.

Information Service refers to a farmer's degree of participation in the treatment. It is a count variable, which takes discrete values from 0 through 5. If a farmer was not a part of any of the components of the information service (farmer forums, phone text messages in 2014 or 2015, contact with extension officers or the Met service), the count variable is 0. Similarly, if a farmer participated in all of the components, the count variable is 5. It is essentially a measure of a farmer's degree of exposure to the information service. It is expected that with an increasing degree of exposure to the information service, the percentage loss in agricultural production will be decreasing, which is to say that *a1* is expected to be negative.

Uncertainty of WRD is a binary variable, which takes the value of 1 if a farmer identified it as one of the challenges and constraints to his agricultural decisions and management; otherwise, it takes the value of 0. We hypothesize that *a2* is positive, implying that a farmer faced with the uncertainty of WRD will experience a greater loss in agricultural production than a farmer without it. One explanation for this hypothesis is that a farmer is more likely to make poor agricultural decisions in the presence of this uncertainty.

The next variable, *Information Service*Uncertainty of WRD*, is the interaction between the two variables. This allows us to compare the agricultural losses of two sub-groups of farmers: the farmers who identified uncertainty of WRD as one of their challenges to agricultural decisions and management and were exposed to the information service, and the farmers who did

not identify the uncertainty of WRD as one of their challenges but were exposed to the information service. An information service for reducing the uncertainty of WRD is unlikely to be utilized by a farmer if the uncertainty of WRD does not constrain his/her agricultural decisions. In other words, providing information to a farmer can potentially improve his/her agricultural decisions, and thereby minimize loss in agricultural production, only if he/she needs the information. Hence, the expected sign of *a3* is negative. Gender is also a "dummy variable," taking the value of 1 if the respondent is male. Age is measured in years.

In theory, when farmers are faced with the uncertainty of WRD, provision of information about WRD can potentially improve their decisions. However, there is no guarantee that the information will be utilized. If a farmer is faced with other constraints (e.g., financial), he may not be able to act upon the information and change his agricultural decisions. Therefore, in studying the impact of the information service, the roles of non-informational constraints must be accounted (or controlled) for, or otherwise the estimated result will either be biased or lead to incorrect inferences. Accordingly, we estimate the following regression model:

*Percentage Loss in Agricultural Production = a0 + a1*Information Service + a2*Uncertainty of WRD + a3* (Information Service*Uncertainty of WRD) + a4*Age + a5*Gender + a6*Lack of Finances + a7* Lack of Equipment + Stochastic Error* (2)

where *Lack of Finances* and *Lack of Equipment* are binary variables representing the financial and equipment constraints of the farmers, respectively. In addition to the uncertainty of WRD, lack of finances and equipment were the two most frequently reported constraints faced by the farmers. The estimated results of equations 1 and 2 are presented in columns 2 and 3, respectively, of Table 14.

Table 14. The Information Service and Percentage Loss in Agricultural Production+

	(2)	(3)
Information Service	0.018 (0.11)	0.019 (0.012)
Uncertainty of WRD	0.134*** (0.035)	0.130*** (0.035)
Information Service **X** Uncertainty of WRD	-0.042** (0.019)	-0.040** (0.019)
Lack of Finances		0.004 (0.028)
Lack of Equipment		0.018 (0.031)
Age	0.0006 (0.0009)	0.0007 (0.0009)
Gender	-0.039 (0.027)	-0.41 (0.027)
Constant	0.496*** (0.054)	0.489*** (0.055)
N	401	401
R-Square	0.038	0.039

+ OLS estimation. Robust standard errors in brackets. *** Significant at 1%; ** Significant at 5%; * significant at 10%.

From Table 14, we infer the following four results. First, information service, on average, does not have a significant impact on the reported loss in agricultural production. In other words, with increasing degree of exposure to the information service, the reported percentage loss in agricultural production does not decline. In fact, while the corresponding coefficient is positive, it is statistically insignificant. Second, the estimated coefficient of the uncertainty of WRD is significant at a 1% level of significance and has the expected positive sign. Its effect on

agricultural production is substantial: the farmers who indicate the uncertainty of WRD have a loss in agricultural production that is 0.13 (25%) larger on average relative to the mean of 53% loss.

Table 15. The Information Service and Percentage Loss in Agricultural Production: Controlling for Additional covariates

	(3)
Information Service	0.018 (0.012)
Uncertainty of WRD	0.133*** (0.035)
Information Service **X** Uncertainty of WRD	-0.039** (0.019)
Lack of Finances	0.002 (0.027)
Lack of Equipment	0.018 (0.031)
Age	0.001 (0.001)
Gender	-0.034 (0.027)
Married	-0.011 (0.028)
University Education	-0.032 (0.041)
Household Size	0.012** (0.006)
Constant	0.431 (0.065)
N	339
R-Square	0.052

+ Ordinary least square estimation. Robust standard errors are provided in brackets. *** Significant at 1%; ** Significant at 5%; * significant at 10%.

Third, the estimated coefficient of the interaction term (row 3, Table 15) is statistically significant at a 5% level of significance and has the expected sign (-0.042). This implies that farmers faced with the uncertainty of WRD experienced smaller losses in their agricultural

production with increasing exposure to the information service. Fourth, the preceding three results do not change even after controlling for the effects of *Lack of Finances* and *Lack of Equipment* (Column 3, Table 14), and additional controls for marital status, university education, and household size (Table 15). In sum, the losses in agricultural production for the farmers faced with the constraint of the uncertainty of WRD would have been much greater if not for the provision of the information service.

While the above results provide a robust sense of the aggregate impact of the information service on agricultural production, they are not very insightful for future programming of climate information services. In essence what these results suggest is that climate information services filling the existing information gaps of the farmers will positively affect agricultural production. They fall short of generating specific policy or program guidance for the future design of the climate information services in other contexts. For instance, further results on relative efficacies of the different components of the information service are very desirable. Was it the farmer forums or the information provided via the phone text messages that was the most effective? Was it the phone text messages in 2014 or 2015? Or, can we attribute the prevented loss in agricultural production to the role of the Extension Agents/Office? Or, might it be the case that the farmers who contacted the Met service for drought-related information had more success in minimizing their production losses because they knew what they were doing? In the next section, we attempt to answer these questions.

4.2.2. Disaggregating the Impact of the Information Service

For each sub-component of the information service, we estimate regression models 1 and 2. We start with the role of the farmers forums. We revise regression models 1 and 2 where the Information Service is replaced by *Information through Farmer Forum*, while keeping the rest of

the specifications intact. Similarly, we update the corresponding regression models for the other sub-components of the information service.

Table 16 presents the results on the role of the farmers forums. The results are consistent with the results from Table 14. However, they are more revealing. The interaction effect, *Information through Farmer Forum*Uncertainty of WRD,* is not only statistically significant at a 5% level of significance and has the expected negative sign, but the magnitudes (-0.110, -0.107)

Table 16. Information through Farmer Forum and Percentage Loss in Agricultural Production+

	(1)	(2)
Information through Farmer Forum	0.039 (0.032)	0.041 (0.033)
Uncertainty of WRD	0.123*** (0.33)	0.120*** (0.033)
Information through Farmer Forum **X** Uncertainty of WRD	-0.110** (0.052)	-0.107** (0.052)
Lack of Finances		0.006 (0.028)
Lack of Equipment		0.018 (0.031)
Age	0.0006 (0.0009)	.0006 (0.009)
Gender	-0.043 (0.027)	-0.043 (0.027)
Constant	0.509*** (0.052)	0.502*** (0.053)
N	401	401
R-Square	0.037	0.039

+ Ordinary least square estimation. Robust standard errors are provided in brackets. *** Significant at 1%; ** Significant at 5%; * significant at 10%.

are approximately three times bigger than the interaction effects in Table 14. This suggests that the farmer forums were the vital component of the information service. We find similar results on the role of the information through phone text messages in 2014 (Table 17), where the interaction effect is approximately four times bigger than the effect found in Table 16.

Table 17. Information through Phone Messages in 2014 and Percentage Loss in Agricultural Production+

	(1)	(2)
Information through Phone Messages in 2014	0.059 (0.039)	0.058 (0.040)
Uncertainty of WRD	0.111*** (0.028)	0.108*** (0.026)
Information through Phone Messages in 2014 **X** Uncertainty of WRD	-0.179*** (0.066)	-0.174*** (0.066)
Lack of Finances		0.047 (0.028)
Lack of Equipment		0.014 (0.031)
Age	0.0009 (0.0009)	0.0009 (0.0009)
Gender	-0.045* (0.0.27)	-0.046* (0.027)
Constant	0.505*** (0.053)	0.499*** (0.054)
N	401	401
R-Square	0.044	0.046

+ Ordinary least square estimation. Robust standard errors are provided in brackets. *** Significant at 1%; ** Significant at 5%; * significant at 10%.

However, the interaction effect corresponding to the information through phone text messages in 2015 is insignificant (Table 18).

Table 18. Information through Phone Messages in 2015 and Percent Loss in Agricultural Production+

	(1)	(2)
Information through Phone Messages in 2015	0.068 (0.043)	0.068 (0.043)
Uncertainty of WRD	0.093*** (0.027)	0.089*** (0.027)
Information through Phone Messages in 2015 **X** Uncertainty of WRD	-0.110 (0.079)	-0.104 (0.078)
Lack of Finances		0.005 (0.027)
Lack of Equipment		0.022 (0.031)
Age	0.0006 (0.0009)	0.0006 (0.0009)
Gender	-0.045* (0.027)	-0.047* (0.028)
Constant	0.519*** (0.051)	0.512*** (0.052)
N	401	401
R-Square	0.034	0.037

+ Ordinary least square estimation. Robust standard errors are provided in brackets. *** Significant at 1%; ** Significant at 5%; * significant at 10%.

There are at least three potential explanations of this result. First, utilization of climate information has a gestation period. That is, climate information is not instantaneously utilized. Farmers may need time to process and act upon any new information. Second, farmers may be reluctant to act upon any new information because they are doubtful of their accuracy and validity. Third, climate information may not be utilized because farmers are unwilling to update

their beliefs about climate and prefer to rely on their past experiences. That is, farming habits may potentially be a part of the explanation.

Tables 17 and 18 reveal another interesting result: the role of gender. While the gender effect is significant only at 10%, the signs are negative, which suggest that the information via phone text messages to females in the households was more beneficial. It could also mean that information provided to women in the households are perhaps more likely to be used and acted upon than if the same information is provided to men in the households. While these are some of the possible explanations, we cannot directly infer them from the results in Tables 17 and 18.

In Tables 19 and 20, we present the corresponding results for the roles of Extension services and the information requested from the Met service. We find that neither of these two components of the information service has a significant impact on agricultural production.

Table 19. Information through Extension and Percentage Loss in Agricultural Production+

	(1)	(2)
Information through Extension	-0.017 (0.033)	-0.016 (0.033)
Uncertainty of WRD	0.064* (0.035)	0.061* (0.034)
Information through Extension **X** Uncertainty of WRD	0.042 (0.051)	0.025 (0.051)
Lack of Finances		0.005 (0.028)
Lack of Equipment		0.024 (0.030)
Age	0.0005 (0.0009)	0.0006 (0.0009)
Gender	-0.046* (0.027)	-0.047* (0.028)
Constant	0.540*** (0.056)	0.533*** (0.057)
N	400	400
R-Square	0.028	0.030

+ Ordinary least square estimation. Robust standard errors are provided in brackets. *** Significant at 1%; ** Significant at 5%; * significant at 10%

Table 20. Information Requested from the Met and Percentage Loss in Agricultural Production+

	(1)	(2)
Information Requested from the Met	0.063 (0.052)	0.065 (0.052)
Uncertainty of WRD	0.089*** (0.027)	0.087*** (0.027)
Information Requested from the Met **X** Uncertainty of WRD	-0.129 (0.089)	-0.126 (0.089)
Lack of Finances		0.005 (0.028)
Lack of Equipment		0.023 (0.030)
Age	0.0005 (0.0009)	0.0005 (0.0009)
Gender	-0.039 (0.027)	-0.040 (0.028)
Constant	0.521*** (0.051)	0.513*** (0.052)
N	401	401
R-Square	0.033	0.035

+ Ordinary least square estimation. Robust standard errors are provided in brackets. *** Significant at 1%; ** Significant at 5%; * significant at 10%.

4.3. The Impact of Information Service on Agricultural Production Decisions

Climate information to farmers is only as good as its influence on their agricultural decisions and management practices. The drought-related forecast information is not an exception. Approximately 79% of the farmers reported changing their agricultural production decisions in light of the seasonal drought-related information. Nevertheless, we test the influence of the information service on agricultural production decisions.

The result is presented in Table 21, where the dependent variable takes the value of 1 if a household's agricultural decisions were influenced or affected by the information service; otherwise it takes the value of 0. We note two important results.

Table 21. The Impact of Drought- related Information on Agricultural Production Decision+

	(1)	(2)
Information Service (Count)	0.075***	…
	(0.014)	
Information (Discrete)	…	0.214***
		(0.046)
Age	0.002	-0.002
	(0.002)	(0.002)
Male	0.078*	0.067
	(0.044)	(0.044)
Married	0.096**	0.095**
	(0.042)	(0.043)
University Education	0.036	0.038
	(0.052)	(0.054)
Household Size	0.018**	0.014*
	(0.008)	(0.009)
Years of Farming	-0.0002	0.0003
	(0.002)	(0.002)
Uncertainty of WRD	0.109***	0.111***
	(0.037)	(0.038)
Constant	0.551***	0.546***
	(0.100)	(0.102)
N	428	427
R-Square	0.094	0.092

+ Ordinary least square estimation. Robust standard errors are in brackets.
*** Significant at 1%, ** significant at 5%, and * significant at 10%.

First, irrespective of how the membership in the treatment group/information service is defined, it has a statistically significant and positive impact on households' agricultural decisions. That is, the households in the treatment group were more likely to change their agricultural decisions.

Second, the households who identified the uncertainty of WRD as one of their major challenges to production agriculture were more likely to change their agricultural decisions compared to other households.

Among other results, we find that the married respondents, and the households with bigger family size, were more likely to change their agricultural decisions.

Given the preceding findings, it is equally interesting to examine the kinds of agricultural decisions that were made in light of the drought-related information. In Table 22, we present the

Table 22. Households by Agricultural Decisions Affected by Seasonal Drought Information

Agricultural Decision	*Proportion of Households*
Change in planting/sowing time	0.71
Change in harvesting time	0.27
Change in types of crops	0.61
Reduction in amount of land cultivated	0.32
Change in fertilizer/chemical use	0.25
Change in mulching practices	0.27
Increased irrigation	0.19
Did not farm crops during the drought	0.10
Focused on raining livestock	0.12
Diversified to non-farm income	0.13

distribution of the households whose agricultural decisions were affected by drought-related information. Timely and relevant information can affect different aspects of farming decisions, ranging from a change in planting time to diversification to non-farm income sources. From

Table 22, we note that for farmers whose agricultural decisions were affected by the drought-related information, for a significant majority (71%) information affected planting time, closely followed by changes in crop types (61%), reduction in amount of land cultivated (32%), and changes in harvesting time (27%), respectively. And approximately 10% of the farmers decided to not plant crops altogether during the drought, and instead focused on off-farm and non-farm sources of income.

For approximately 21% farmers, the information had no impact on their agricultural production decisions and management. For this group of farmers, we wanted to learn why their decisions were not influenced by the information. Table 23 summarizes the reported reasons.

Table 23. Reasons for Not Utilizing Seasonal Drought-related Information

No influence on agricultural decision: 21% of the households

Reasons	*Proportion of households*
I could not understand the information	0.05
I did not trust the information	0.05
The information was not useful	0.14
Lack of recommendations	0.07
Received them too late	0.06
Decisions based on past experience	0.61
Others	0.49

From the above table we note that the common reason for not utilizing seasonal drought forecast information is farmers' reliance on past experience (61%).

5. Demand for Seasonal Climate Forecast Information

While the impact evaluation is the most rigorous way of testing the utility of a climate information service, it can also be inferred from the future demand for the service. The underlying rationale is that if a climate information service is helpful and has impacts on agricultural decisions, the farmers must be interested in receiving the service in the future and, ideally, willing to pay for the service. Given our finding that the information service did in fact have economic impacts, by influencing the agricultural decisions of the households, we next investigate the preference and willingness to pay for the service in the future.

From Table 24, we can clearly infer that there is very strong demand for the provision of this kind of information service in Jamaica, further reassuring the finding that the information service was useful to the farmers. More importantly, it suggests that the farmers would be willing to pay for timely, relevant, and accurate seasonal climate forecast information service.

Table 24. Market for Climate Forecast Information

	Percent of Households
Would like to receive timely and useful climate forecast information in the future	97%
Would sign up for climate information service if it is requires payment for the service	84%

Next we examine whether the demand for the service is concentrated in some sub-groups of the farmers. For this, we regressed the indicated preference for receiving the service, and the willingness to sign up for the service if it requires payment, on various household attributes. Table 25 presents the results.

Table 25. Correlates of the Demand for Climate Forecast Information Service

	Would like to receive climate forecast information in the future	*Would sign up to receive climate forecast information if it requires payment for the service*
Age	-0.0006 (0.0008)	-0.0043*** (0.014)
Male	-0.0148 (0.0139)	0.0463 (0.0408)
Married	0.0059 (0.0126)	-0.0133 (0.0397)
University Education	-0.0294 (0.0288)	-0.0639 (0.0574)
Household Size	0.0010 (0.0029)	0.0069 (0.0074)
Own Land	0.0034 (0.0157)	0.0594 (0.0417)
Uncertainty of WRD	-0.0003 (0.0174)	0.0292 (0.0377)
Constant	1.0111*** (0.0546)	0.9656 (0.0887)***
N	442	409
R-Square	0.0083	0.0388

++ Ordinary least square estimation. Robust standard errors are provided in brackets. *** Significant at 1%; ** Significant at 5%; * significant at 10%.

Two results are very striking. First, the future demand for the service is not correlated with any of the relevant, observable, household characteristics, which suggest the future demand for the information service is not concentrated in certain sub-groups of the farmers (Column 2, Table 25). Second, older farmers are less likely to sign up for the information service if it requires a payment for the service.

For the group of the farmers who were unwilling to sign up for the information service if it required payment (approximately 16% of the households), we wanted to investigate further and

understand the reasons behind this position. In Table 26, we summarize the findings, and they are self-explanatory.

Table 26. Reasons for Unwillingness to Pay for Climate Forecast Information Service

Reasons	*Percent of Respondents who reported unwillingness to pay for the service*
Climate forecast information are not accurate	19%
Can't afford to pay	28%
Government should be providing it	21%
Others	32%

6. Concluding Remarks

6.1. Main Findings

We studied the economic impact of the climate information service provided by the JMS, in collaboration with RADA and ACDI-VOCA, to approximately 300 farmers in Jamaica during 2014-2015. The information service was not rolled out as a randomized experiment and baseline data was not collected. Therefore, we lack well-defined comparison groups. Even though only about 300 farmers were the part of the information service, drought-related forecast information was widely available via other mediums (e.g., JMS website, distribution of bulletins, etc.). Hence, it is difficult to identify a "clean" control group of farmers whose agricultural outcomes can be compared with the outcomes of farmers in the information service group, for identifying and estimating the causal impact of the information service.

Given the above limitations, we estimated the impact of the information service by comparing the self-reported losses in agricultural production of 453 farmers by their degree of exposure to the information service, and by comparing the self-reported losses in agricultural

productions of sub-groups of the farmers, especially, the farmers with/without the uncertainty of WRD.

The main findings are as follows. Farmers in Jamaica are economically vulnerable, which makes their livelihood more susceptible to climate variability and change. The drought did in fact have devastating effects on economic outcomes. The average reported percentage loss in agricultural production (by volume) relative to agricultural production in the preceding year is 57%. Also, the relative income status of the farmers worsened in June 2015 relative to their income status in June 2014.

The uncertainty of WRD has a substantial adverse effect on agricultural production. For the group of farmers faced with the uncertainty of WRD, the loss in agricultural production is on average 25% larger relative to the mean loss of 57%.

Regarding the impact of the information service, on average it does not have a statistically significant impact on agricultural production, but it is very beneficial to the farms faced with the uncertainty of WRD. That is, for farms with the uncertainty of WRD, the loss in agricultural production declines with the increasing degree of exposure to the information service. In other words, the losses in agricultural production for the farms faced with the uncertainty of WRD would have been much greater if not for the provision of the information service. This suggests that the information service contributed to agricultural production by reducing the uncertainty of WRD, which is consistent with information theory. Among the different components of the information service, not all of the components are effective. The information service provided through farmers forums and phone text messages are the most effective mechanisms of information dissemination. In fact, farmers forums are the critical component of the information service.

The information service contributed to agricultural production by influencing farming and management decisions. We find that the service influenced planting and sowing time, choice of crops, harvesting time, amount of land cultivated, mulching practices, chemical and fertilizer use, and irrigation. Finally, there is strong demand for a seasonal forecast information service.

6.2. Limitations of Study

Our study is limited by at least four interrelated but distinct challenges. First, the information service, as discussed in Section 2, was not rolled out as a randomized experiment with the goal of studying its economic impacts. Consequently, it did not have a program structure, suitable for a straightforward impact evaluation study. Moreover, in the absence of baseline data and needs assessments, the information service was based on the assumption that drought-related information would be beneficial to all kinds of farmers. Some farmers received information from all of the components of the information service (farmers forums, phone text messages, extension agents, and by contacting the JMS), while others did not. Also, the information service did more than one thing: it educated the farmers about climate and the JMS's climate products during the farmers forums, and also provided drought-related forecast information through phone text messages and RADA. Thus, it is difficult to attribute the contribution of the information service to climate education and training or climate information, or both. More importantly, the drought-related forecast information was widely available, though not necessarily accessed, to everyone through JMS's website, bulletins, and RADA offices. So, it is almost impossible to identify a control group of farmers who did not have access to the information service, in particular, the drought-related forecast information. This motivated the empirical strategy adopted in this study, where we compared the distribution of the agricultural outcomes of the

farmers by their degree of exposure to the information service to estimate the impact of the service.

Second, we are unable to estimate the average treatment effect (ATE) of the information service. This is because the information service was provided to approximately 300 farmers, of which only 204 farmers are included in this study. We attempted to reach all 300 farmers, but we were able to interview only 204. This is potentially a problem if the farmers whom we were able to interview are systematically different from the remainder of the information service recipients.

Third, while we find that the information service contributed to agricultural production by influencing farming and management decisions, we are unable to provide a value-chain analysis or clear delineations of the possible causal mechanisms. There are many reasons for this including the fact that the farmers in the "comparison group" likely had access to the drought-related information from non-treatment sources. In addition, we don't have data on the frequency, accuracy, and timeliness of the specific drought-related forecast information provided by the JMS to the farmers in the information service, located in different parishes of Jamaica.

Finally, data was collected through phone interviews for reasons discussed in Section 3.2. Weaknesses and limitations of phone interviews as a method for collecting data are common knowledge. To us it also meant limiting our ability to ask some of the detailed questions which would have provided us additional information for more detailed and nuanced analyses.

6.3. Lessons for the Future Programming of the Climate Information Service

In light of the preceding limitations, while one should interpret the estimated magnitude of the impacts of the information service carefully, its beneficial role appears to be robust. This constitutes, to the best of our knowledge, the first rigorous impact evaluation of a climate information service.

From the findings, the following three lessons are clear for the future programming of climate information services. First, climate information services that meet the information needs of farmers will have desirable economic impacts.

Second, climate information services, especially to farmers, must be demand-driven, which requires baseline assessments for the identification of the needs, constraints, and effective mediums of information dissemination, among others. Most often climate information services are supply-driven, build on the assumption that climate information is always useful, which ignores the fact that the adoption and utilization of climate information is not automatic because of a host of non-informational constraints and barriers.

Third, climate information services usually do multiple things (e.g., capacity building, information dissemination), and have many ways of communicating information (e.g., JMS, RADA). These are not necessarily problems, but make the identification and estimation of the contributions of the respective components impossible, unless the impact evaluation is embedded in the program and the program has been designed accordingly.

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Appendix A

Seasonal Drought Information Service 2014-2015
Questionnaire

August 2015

Name of the Interviewer**:** _____ Date: _____ Time: _____

*[**Instruction for Interviewer**:* You will start the survey with a brief introduction. Note that you will be talking with a respondent for approximately 30 minutes, which is a lot of time for him/her. Therefore, it is important that you are polite and respectful. You want to make sure that the respondents are comfortable, particularly, because this is a phone interview. Otherwise, they will not be receptive to some of the questions].

Introduction

Good morning/afternoon/evening! We are a team of researchers from the University of the West Indies. We are studying the decision-making of farmers during the drought. So we would like to talk with the head of your household, or in his/her absence, an adult about various farming decisions of your household. We have selected 500 farmers all over Jamaica to participate in this interview. You are 1 of the 500 selected farmers. We will take approximately 30 minutes of your time. We know 30 minutes is a lot of time from your busy schedule. Therefore, as our gratitude for your participation, we will provide you with phone credit of $1500 Jamaican dollars. We will text you the numbers of the phone credit cards immediately after the interview.

[***Instruction for Interviewer*:** Please ask for an interview with the head of the household, or in his/her absence, a responsible adult. If no responsible adult is available, stop the interview and ask for a later convenient time at which the head of the household or other responsible adult will be available].

You may choose not to reply to any of the questions I ask. We will use the information only for the purpose of research. We want to understand farmers' decision-making during the drought. Would you like to help us by participating?

Section 1. Household Identification

101. Name of Parish: _____

102. Name of Community: _____

103. Name of District: _____

104. How far is the nearest city/town from your Community?

    a. Miles? _____

b. Minutes? _____

105. Name of Respondent:_____

106. Gender of the Respondent: MALE FEMALE

107. Age of the Respondent (in Years)? _____

108. Marital Status of the Respondent: (Circle one)

Married Unmarried & Single Unmarried & Not Single Divorced Widowed

109. How many people are in your household? _____

110. What is the highest level of education that you have attained?

1. None
2. Primary
3. Secondary
4. University
5. Other Tertiary

99. Other (Specify): _____

88. Not Stated

[**Interviewer to Respondent**: Now I am going to ask some questions about your household, not just about you. Therefore, while answering the next questions, please keep in mind that you are answering on the behalf your household.]

111. What are the <u>different</u> sources of income/livelihood for your household? (Check all that apply)

1. Cultivation of land
2. Agricultural casual wage labor
3. Non-agricultural casual wage labor
4. Raising of animals/livestock/poultry
5. Salaried work
6. Non-agricultural business
7. Remittances
8. Pension

99. Others (Specify):_____

112. Does your household own any agricultural land? YES NO

113. (**If YES in 112**) How many acres of land does your household own? _____

114. Does your household lease any agricultural land from others? YES NO

115. (**If YES in 114**) How many acres of agricultural land does your household lease from others? ____

116. How many acres of your total agricultural land (leased or owned) is irrigated? _____

Section 2. Uses and Sources of Seasonal Climate information

201. Do you generally obtain or receive seasonal climate information **before** making your farming decisions? YES NO

202. Do you find the following sources of weather and climate information reliable and trustworthy?

1. Neighboring farmers	YES	NO	Others
2. Community leaders	YES	NO	Others
3. Farmers group	YES	NO	Others
4. Extension Agent/Offices	YES	NO	Others
5. Met Service	YES	NO	Others
6. Internet	YES	NO	Others
7. Radio	YES	NO	Others
8. Television	YE	NO	Others

203. What are your sources of seasonal climate information? (Check all that apply)

1. Neighboring farmers
2. Community Leaders
3. Farmers groups
4. Extension Agent/Offices
5. Met Service
6. Internet
7. Radio
8. Television
99. Others (Specify): _____

203. What kind of seasonal climate information do you get? (Check all that apply)

1. Rainfall forecast
2. Temperature forecast
3. Drought forecast
4. Storm warning
5. Information about climate change
99. Others (Specify):_____

Section 3. Drought Information Service and Utilization

301. Did you or anyone in your household attend any farmers' forum between June 2014 to June 2015, where the organizers of the forum talked about weather and climate information and services?

YES NO DON'T KNOW/DON'T REMEMBER/NOT SURE

302. (**If YES in 301**) When? 2014 2015 BOTH

303. Did you or anyone in your household receive drought related information via text/phone messages from the Met Service in 2014?

YES NO Not Sure/Don't Remember

304. Did you or anyone in your household receive drought related information via text/phone messages from the Met Service in 2015?

YES NO Not Sure/Don't Remember

305. Did you or anyone in your household call or text the Met Service to ask for drought related information between June 2014 and June 2015?

YES NO

306. Did you or anyone in your household receive or obtain drought related information from any of the following other sources during June 2014 to June 2015?

1. Extension Agent/Offices?	YES	NO
2. Farmers group?	YES	NO
3. Internet?	YES	NO
4. Radio?	YES	NO
5. Television?	YES	NO
6. Others (Specify)? _____		

307. Did the drought related information change or affect your agricultural production decisions in any way?

YES NO Others

308. (**If YES in 307**) How did drought related information change or affect your agriculture production decisions? (**Check all that apply**)

1. Change in planting/sowing time
2. Change in harvesting time
3. Change in types of crops
4. Reduction in amount of land cultivated
5. Change in fertilizer/chemical/ use
6. Change in mulching practices
7. Increased irrigation
8. Did not farm crops during the drought period
9. Focused more on raising livestock than crops

10. Diversified to non-farm incomes
99. Others (Specify): _____

309. (**If NO in 307**) Why did drought related information not change or affect your agricultural decisions? (**Check all that Apply**)

1. I could not understand the information
2. I did not trust the information
3. The information was not useful
4. The information did not provide recommendations on what to do
5. I received them too late
6. I make my agricultural decisions based on my past experience
7. Others (Specify):_____

310. What are the challenges and constraints to your agricultural decisions and management? (**Don't read the options. Just ask the question, give the respondent enough time to think. According to his/her answer, you pick the appropriate categories**):

1. Lack of Finances
2. Increasing cost of inputs
3. Profitability of Farming
4. Lack of Equipment
5. Labor shortage
6. Small size/scale of my farming operation/Limited Land
7. Lack of Climate-related information
8. Water
9. Uncertainty of water/rainfall/drought
10. Others (Specify): _____

Section 4. Economics of Drought Information Service

401. For how many years have you been doing farming? _____

402. What is the main purpose of your farming?

1. Home Consumption
2. Sale
3. Both home consumption and sale
99. Not Stated

403. Which of the following is/are your agricultural activity/activities? (**Choose all that apply**)

1. Export crops
2. Other crops
3. Pig farming
4. Beef cattle farming

5. Dairy cattle farming
6. Poultry farming
7. Fish/Shrimp/farming/Seafood
8. Goat/Sheep Farming
9. Bee Keeping
10. Horticulture

99. Other (Specify):_____
88. Not Stated

404. Was your actual amount of agricultural output/production affected by drought during the period of June, 2014 to June, 2015?

YES NO

405. Value of Agriculture Production

405.1. In your estimation, what was the value of your Agricultural Production (both self-consumption and sale), including livestock, in one year period **before** the drought of 2014 (in Dollars)? _____

405.2. The above accounted for what percentage/share of your total household income in that year? (**Read them all options, let them select one**)

1. Less than 20%
2. 20 to 40 %
3. 40 to 60 %
4. 60 to 80%
5. 80 to 100%

405.3. In your estimation, what was the value of your Agricultural Production (both self-consumption and sale), including livestock, in one year period **after** the drought in June 2014 (in Dollars)? _____

405.4. The above accounted for what percentage/share of your total household income in the year? (**Read them all options, let them select one**)

1. Less than 20%
2. 20 to 40 %
3. 40 to 60 %
4. 60 to 80%
5. 80 to 100%

406. During June 2014- June 2015, drought impacted farmers' agricultural production in

Jamaica. In your estimation, what was your loss in agricultural production due to drought in this period?

a. Percent loss compared to the year before the drought? _____
b. Total Loss (in dollar)? _____

407. Please compare the income status of your household in the year before the drought in June 2014 to the income status now. Would you say, you are (Choose one):

1. Worse than before
2. Same as before
3. Better than before

Section 5. Demand for Climate Information

We are almost done. You have been very helpful. Now I would like to ask your opinion about the future provision of climate forecast information. Therefore, please carefully think about my questions.

501. Would you like to receive timely and useful climate forecast information in the future for your agricultural decisions?

YES NO DON'T KNOW/ CAN'T SAY

502. Would you sign up for this kind of climate information service if it requires you to pay for the service?

YES NO DON'T KNOW/ CAN'T SAY

503. (If NO in 502) What are the reasons? (**Check all that apply**)

1. The climate forecast information are not accurate.
2. I can't afford to pay
3. It is unfair to expect me to pay for the climate forecast information. Govt. should be providing it.
99. Other reasons (Specify): _____

600. So we can text you the right phone credit, what phone company do you use?

DIGICEL LIME

This completes our interview. Thank you so much for your participation. Please check your text message in few minutes for phone credits from me.

*****ONLY FOR THE USE OF INTERVIEWER*****

1. How easy was it to understand the respondent?

    1. Very easy
    2. Easy
    3. Difficult
    4. Very difficult

2. Did you have to speak in Patois? YES NO

3. Was the respondent forthcoming? YES NO

4. Was the respondent having difficulty in understanding the questions? YES NO

5. Did you have to take an appointment to interview this respondent? YES NO

About the Authors

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