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Mobile-based climate services impact on farmers risk management ability in India

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ABSTRACT

The climate service advisory was piloted in two states of India – Haryana and Bihar – covering 46 villages. Households were randomly selected in these villages to receive voice-based messages on individual farmers' mobile phones during the project period 2013–2015. The messages had content related to weather, seed varieties, climate-smart agricultural practices (CSAPs), efficient utilization of agricultural inputs, pests, and weed and nutrient management. In this context, this paper analyzes the listening rate of the messages by the individual farmers over the span of two years. The paper also analyzes and describes the process of change of farmers' ability to use the information in the messages to improve the awareness and then further convert the information into economic gains. The paper does so in the framework of a conceptual model that highlights the process of change – information use, if facilitated by enabling factors, has the potential to create outputs which can be measured as benefits (monetary and change in level of awareness). It is believed that mobile-phone enabled agro-advisory services have the potential to reduce information gaps and generate awareness about improved technologies which leads to improved adoption of technology. Through the pilot study, we show how climate services helped in enhancing farmers' awareness about the CSAPs.

1. Introduction

The mobile phone, one of the modern information and communication tools (ICT), has helped in providing several new opportunities not only to connect people, but also to improve service-delivery and reduce transaction costs (WDR, 2016; De Silva and Ratnadiwakara, 2008; Duncombe, 2016). The digital dividends for the agriculture sector from ICT is in terms of enhanced on-farm productivity by reducing the constraints of extension and information, facilitating market transparency, and improving logistics (Mittal and Tripathi, 2009; Mittal et al., 2010; WDR, 2016). In addition, as agriculture becomes knowledge-intensive due to the availability of new farming methods, technologies, and inputs, the need for the latest agriculture-related information has also increased. The realization for of the need for additional information increased with the observed changes in agriculture due to climate change. Climate changes poses an increased risk in agriculture due to climate variability (Mittal and Mehar 2015, 2012; FAO, 2015). To manage the risk of climate change, knowledge about climate-smart agricultural practices (CSAPs) is imperative. It is strongly believed and has been demonstrated that ICTs, primarily mobile phones, have the potential to reduce information asymmetry and can

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play a role in facilitating the adoption of technologies (Ali and Kumar, 2010; Mittal et al., 2010; Mittal, 2012; Mittal and Mehar, 2014; Bhatnagar, 2008; Anderson and Feder, 2007; Mittal and Kumar, 2000). This potential is further supported by strong mobile phone penetration in several developing countries of Africa and South Asia, such as India (Fischer et al., 2009; Mittal, 2012).

The process through which reduced information asymmetry leads to increased adoption of technology is not very well analyzed in the context of agriculture. The paper analyzes the 'listening rate'[2] of the agricultural information given to farmers through climate services over a span of two years during a pilot project in Haryana and Bihar; it also analyzes the process of change of farmers' ability to use this information in terms of 'increased awareness' and 'monetary gains'. The paper analyzes these within the context of a theoretical framework (Fig. 1) and a conceptual framework for a process of change to create outcomes (Fig. 2). The conceptual framework highlights the process of information use being facilitated by enabling factors that will create output measured as benefits. These two frameworks are interlinked, and the process of change represented in Fig. 2 will lead to impact and outcomes as presented in Fig. 1 of the paper.

India is leading in mobile network penetration and has among the highest number of mobile users (Mittal et al., 2010). It is believed that mobile phone-enabled agro-advisory services have the potential to reduce knowledge gaps and generate awareness of improved technologies. Through the data collected during the pilot study, we show how climate services enhance farmers' awareness about CSAPs (Mittal, 2016). However, enabling factors in the agricultural sector act constraints on utilization of information that is delivered in the form of agro-advisories. The paper also attempts to address this aspect.

This paper presents a conceptual framework of this process of change in Section 2 and tests it with the listening rate data in Section 4. The study demonstrates a strong relationship between usability of the information delivered and action taken by the farmers leading to improved awareness levels which, in turn, results in benefits via adoption of recommendations or technologies. Section 3 provides the details of the data and methodology used for the analysis. The main objective of the study is to demonstrate that there is change in awareness level of the farmers before and after the ICT intervention. The change in awareness level about the climate CSAPs is taken to be the first step towards managing climate risks, measured in terms of overall benefits to the farmers. The paper also demonstrates that the farmer-level data validates the theoretical conceptual framework presented in the paper. This is done by analyzing the data on frequency of listening rate of information delivered on mobile phones and its pattern of change over time. The conceptual framework on process of change is also validated using a correlation matrix across different attributes such as awareness, utilization, action taken, and benefits.

2. Conceptual framework

Although some evidences suggest ICTs contribute to general economic growth, there is little evidence to believe that economically-weak countries will be able to utilize ICT to its full potential with increasing efficiency (FAO, 2015; WDR, 2016). Although its application is evolving in the agriculture sector, ICT has demonstrated its ability to reach the farmer community (Bhatnagar, 2008; De Silva Harsha et al., 2008; Ali and Kumar, 2010). The effectiveness of the system plays a significant role in the magnitude of the impact of an ICT intervention in agriculture and the constraints of institutions and policies can be binding on the efficiency ICT systems (Mittal et al., 2010). Further, we expect that as the information gap reduces over time, the marginal benefits from information will also be reduced. Farmers will become more aware of the information and the utility of information they receive will decline unless the information is new in within in the context of climate change and cropping patterns (Mittal, 2012; Mehar et al., 2016). Fig. 1 illustrates a general framework for socio-economic impact pathways of ICT intervention in the agriculture sector. With an increase in the level of ICT penetration in a cluster or context after adoption of ICT, the immediate impact is realized in the form of efficiency in a farmer's ability to use inputs in an appropriate manner. Later, adoption of ICT impacts a farmer's ability to achieve gains indicated by an increase in yield, a reduction in production costs, and other social benefits. The framework also considers that, like any other normal goods, information also has a diminishing marginal utility (Laxminarayan and Macauley, 2012; Martin and Sell, 1980; Lionberger, 1968).

Behavioral change, awareness, and information about technology are crucial parameters of technology adoption (Dillon and Morris, 1996). Once farmers adopt technologies, impacts of the technologies result in major development changes at the macro-level such as reducing poverty level and increasing food and nutritional security. Such outcomes are always at the heart of intervention design, but their possibility of realization is related to the success of such interventions against challenges. The foremost challenge is to make farmers understand, believe, and trust the technologies offered to them (Mehar et al., 2016; Mittal and Mehar, 2015). ICTs play a significant role in providing this information and knowledge to farmers. Overall, ICT improves the reach, availability, and adoption of technology and improves access to input and output markets by bridging the information gap. These improvements help to facilitate institutional changes that can create desirable impacts through improved market efficiency (Mittal et al., 2010; De Silva et al., 2010; Anderson and Feder, 2007).

Under this conceptual framework, this paper focuses on two aspects, a) utilization of information and its usability over time and b) and test of the hypothesis that information usability may decline over time. It is also assumed that if the information is dynamic and adds value then its utility will not decline. Fig. 2 demonstrates the observed process of diffusion of information to create awareness that enables farmers to take action. This supports the theoretical framework presented in Fig. 1. The action taken in the present context is measured by the adoption of CSAPs that help farmers mitigate the risk of climate variability. The CSAPs are detailed in Annexure 1. In the process of diffusion, the enabling factors are the household and individual social and economic factors

[2] Listening rate is defined as the average time (in seconds) the farmer has listened to a message in a given region at a given point of time.

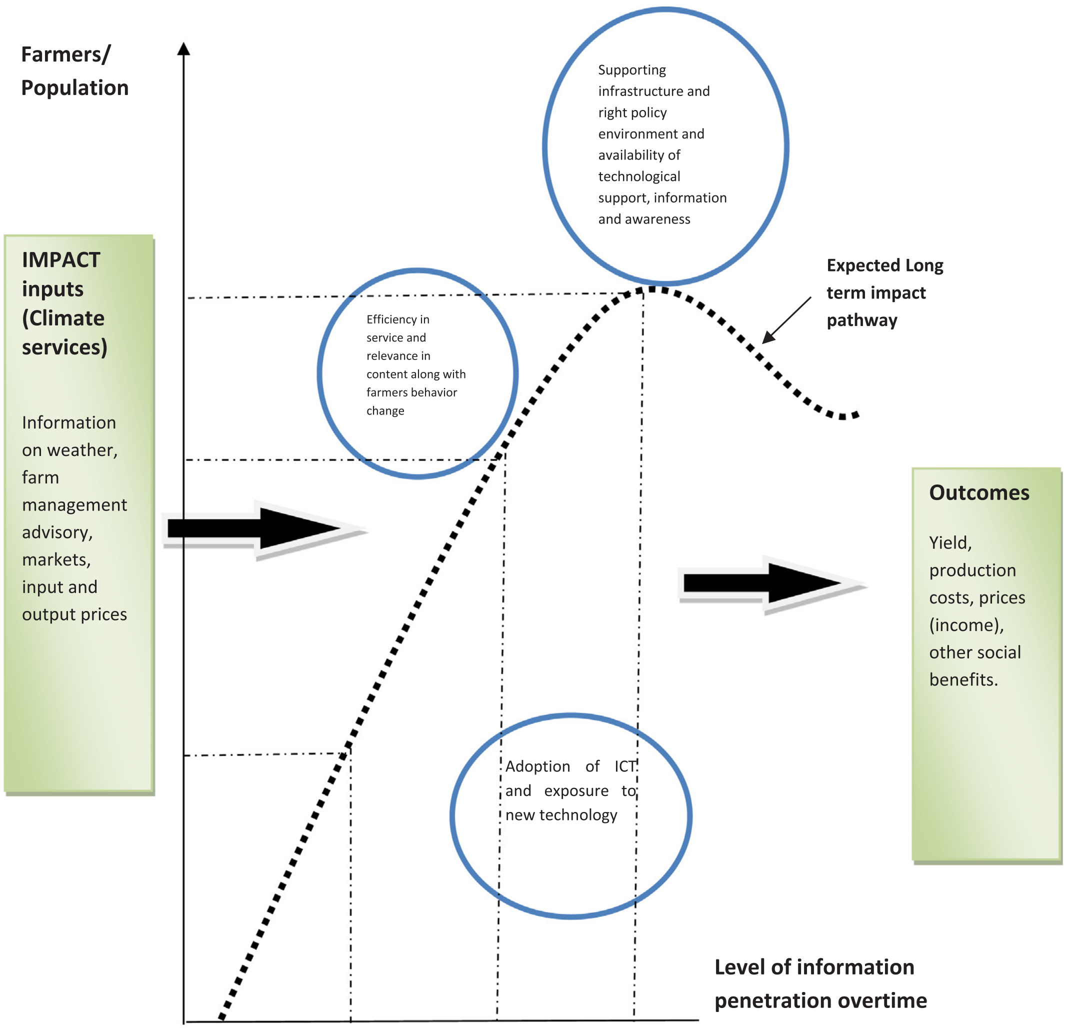

Fig. 1. Theoretical framework for factors impacting adaptability of information in the agriculture sector. *Source:* Conceived by first author.

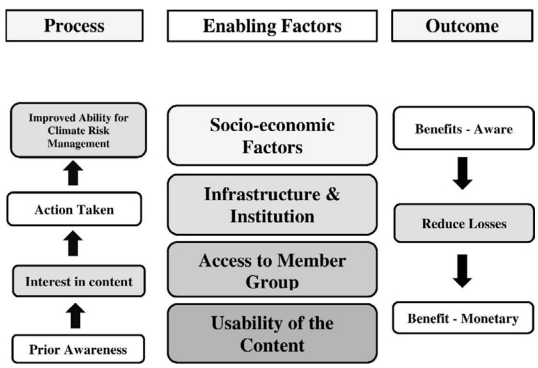

Fig 2. . Conceptual framework for process of change to create outcomes. *Source:* Adapted from Lionberger, H. F. (1968), modified by authors.

such as income, land size, gender, education level and age (Annexure 2). These factors are supported by existing supporting institutions and infrastructure such as the availability of machines, seed, markets to access inputs, and/or membership in a group. The content of the information is equally important to enable change. Thus, the analysis presents the results regarding the adoption of the information and benefits accrued from the climate services in two states of India.

The outcome of the process can be seen as benefits, first in terms of increased awareness about CSAPs, which in the medium term is expected to lead to adoption of technologies, and second, further adoption of CSAPs that leads to reduced losses due to climate risk and further improve overall monetary benefits.

3. Data and methodology

'*Mobile Solutions*' are mobile phone-based voice agro-advisories introduced as part of the Climate Smart Village model under the International Maize and Wheat Improvement Center – Research Program on Climate Change, Agriculture and Food Security (CIMMYT-CCAFS) project (CIMMYT-CCAFS, 2014). This intervention was the result of the partnership between Kisan Sanchar as the disseminating partner and IFFCO Kisan Sanchar Limited (IKSL) as the content partner. The intervention aimed to improve awareness among farmers about climate risk management strategies and further lead to increased adoption of CSAPs and technologies. Under the pilot project, data was collected about farmers' information usability, improved awareness, and action taken by them, along with information on types of benefits farmers received by participating in the intervention. This project was piloted in two states of India-Haryana (western Indo Gangetic plains) and Bihar (eastern Indo Gangetic plains). Haryana and Bihar are the chosen locations under the CCAFS project to study the long-term impact of interventions to mitigate the risk of climate change as these two geographies are vulnerable to climate change. The two states are in different agro-ecological zones, have different cropping intensities, and represent different levels of development with respect to socio-economic factors such as per capita income and literacy level. These differences imply that the two states may have different enabling factors and conditions (Annexure 2).

Messages disseminated during the pilot phase included weather forecasts, recommended actions farmers should take given the forecasts, as well as information about pests and remedies, seed varieties, and climate-smart technologies such as the benefits of conservation agriculture. Additional messages provided information about climate change and its effects on agriculture. During the pilot project, farmers could call a helpline and ask questions. The helpline was set up as a toll-free number by one of the project partners and made use of a network of experts to respond to farmers' queries.

Two types of data were used for the analysis in this paper. The first data set is the electronically recorded information on the duration of messages farmers listened to. This listening data set represents the information collected from November 2013 to December 2015. The second data set consists of the socio-economic and baseline household information collected at the start of the intervention in August 2013 and feedback and impact of the intervention collected at the end of the project in January 2016. This data set aims to quantify the actions taken by the farmers based on the information they received and assesses the benefits that households could accrue. The socio-economic data set includes data collected from households in the villages of Karnal district of Haryana and Vaishali district of Bihar. A total of 1100 farmers participated in the project. Of these, 510 farmers were randomly selected and asked to give feedback on the usability and effectiveness of mobile-based agro-advisory services. Data from 493 farmers was usable for the analysis, of which 243 are from Haryana and 250 from Bihar.

The average listening rate is computed for different time intervals to compare the trends in information being delivered and heard by the farmers. This information is defined as the average time (in seconds) the farmer has listened to a message in a given region at a given point in time and was electronically recorded. The average listening rate measures the duration the farmers are listening to a message, although they had the option of disconnecting the phone (Mittal, 2016). This analysis uses the time spent by farmers listening to a message as an indicator of their interest in the information content of the message. It is assumed that if a farmer chooses to listen to a particular type of information or listens for a longer duration of time, then they are receiving valuable information and/or are interested in knowing about the information being disseminated.

Listening rates are categorized into 4 groups:

- Farmers who listened to 0–25% of the message time
- Farmers who listened to 26–50% of the message time
- Farmers who listened to 51–75% of the message time
- Farmers who listened to 76–100% of the message time

We assume that over time the greatest number of farmers listening will shift from the first category to the third or fourth category as their interest in the content grows.

More than 600 messages related to CSAPs were disseminated during the project period. The message lengths ranged from 45 to 110 s with an average message duration of 55 s.[3] This information is used to understand trends in listening. From the second set of data, we draw conclusions on how awareness has changed over time; that is, between the start and end of the intervention. Correlations were used to explore relationships between message usability, action taken, and benefits.

4. Results and discussion

The average age of the farmers is 44 years. The percentage of farmers with a high level of education is higher than that of farmers with a low level of education. Only 11.2% of the farmers are females. The average land holding is less than 2 acres (Table 1). For the majority of the farmers, agriculture is their primary occupation and they largely depend upon non-government sources – such as

[3] The audio clips of this duration were made in collaboration with industry practitioners IKSL. Since the messages represent continuous engagement with the farmers, they had to be short and succinct. In fact, long messages are usually not acceptable. After testing the climate service model and holding focus group discussions, the message structure and duration were decided upon.

Table 1
. Data descriptive statistics.

Variables	Number	% of Farmers
Sample size	493	
Haryana	*243*	49.3
Bihar	*250*	50.7
Average age (In years)	43.9	
Female farmers		11.2
Average land size (in acres)	1.93	
Education Level		
Low		40.2
High		59.8
Access to ICT*		
Radio		22.9
Television		84.2
Landline phone		11.2
Agriculture as primary occupation		68.6
Primary source of information		
Government		18.5
Non-government		65.1
ICT		16.4
Member of any group		16.2

Note: *All farmers in the data have access to mobile phones.

friends and input dealers – for information.

4.1. Change in level of awareness

At the start and end of the intervention we asked farmers if they were aware about certain CSAPs. Information was sought regarding seven technologies and practices: 1) zero tillage (ZT), 2) land laser leveler (LLL), 3) direct seeding of rice, 4) happy seeder, 5) bed planting, 6) crop rotation, and 7) residue management. There is a rich literature (e.g., Jat et al., 2014, 2015; Sapkota et al., 2014; CIMMYT-CCAFS, 2014) on how the adoption of these CSAPs help improve climate risk management.

At the initiation of the intervention in Haryana, 24.3% of the farmers were not aware of any of the CSAPs while 45% of the farmers were aware of 2–3 such practices (Table 2). Similarly, in Bihar, almost 50% of the farmers did not know about CSAPs, while the rest only knew about the popular ones such as LLL and ZT. At end of the intervention these numbers were completely changed. In Haryana, 67.5% of the farmers knew about all of the CSAPs. In Bihar, 60% of the farmers said they knew about 3–5 of the practices and the number of farmers who said they were totally unaware was reduced to zero (Table 2).

4.2. Message listening rate over time

The listening rate data is presented as average listening rate in seconds divided into four categories: 1) 0–25% if famers listen to only the first 25% of the message time, 2) 26–50% if farmers listen to up to 50% of the message, 3) 51–75% if farmers listen to up to 75% of the message, and 4) 75–100% if farmers listen to almost the entire message.

Table 3 shows that at the initiation of the project, almost 62% of the farmers in Haryana were not listening to the messages and only 32% were listening to the messages in full. Although the percentage of farmers listening to full messages marginally increased to

Table 2
. Change in awareness level of CSAPs over the duration of the project. Unit: percentage of farmers.

Awareness level	Haryana (N = 243)		Bihar (N = 250)	
	Before	After	Before	After
0	24.3	0.4	50.8	0.0
1	14.4	0.8	14.0	4.8
2	23.5	0.8	23.6	12.0
3	22.6	0.4	9.6	22.8
4	9.1	1.6	2.0	31.6
5	3.7	7.8	0.0	14.8
6	0.8	20.6	0.0	10.4
7	1.6	67.5	0.0	3.6

Note: Each awareness level represents awareness about the number of CSAPs being considered in the study. For example, 0 means no awareness about any of the CSAPs while 7 means awareness about all of the practices.

Table 3
. Average listening rate of the information by the farmers.

State	Listening group	Average % of farmers listening to messages in the listening group				
		TP-I	TP-II	TP-III	TP-IV	TP-V
Haryana	0–25%	62.1	43.7	42.8	56.9	45.1
	26–50%	2.9	3.6	6.9	2.3	3.0
	51–75%	3.0	3.7	3.5	2.7	2.7
	75–100%	31.9	48.9	46.7	38.1	49.2
	Average Call Duration (seconds)	76.9	69.7	79.2	58.4	53.6
Bihar	0–25%	68.5	61.8	53.6	63.5	49.4
	26–50%	3.0	2.9	8.2	1.9	6.4
	51–75%	1.9	2.8	2.0	2.6	10.9
	75–100%	26.6	32.5	36.2	32.0	33.3
	Average Call Duration (seconds)	77.7	68.9	69.6	50.0	67.4

Note: TP corresponds with the time period of calls received by the farmers during November to December 2013 (TP-I), January to June 2014 (TP-II), July to December 2014 (TP-III), January to June 2015 (TP-IV), and July to December 2015 (TP-V).

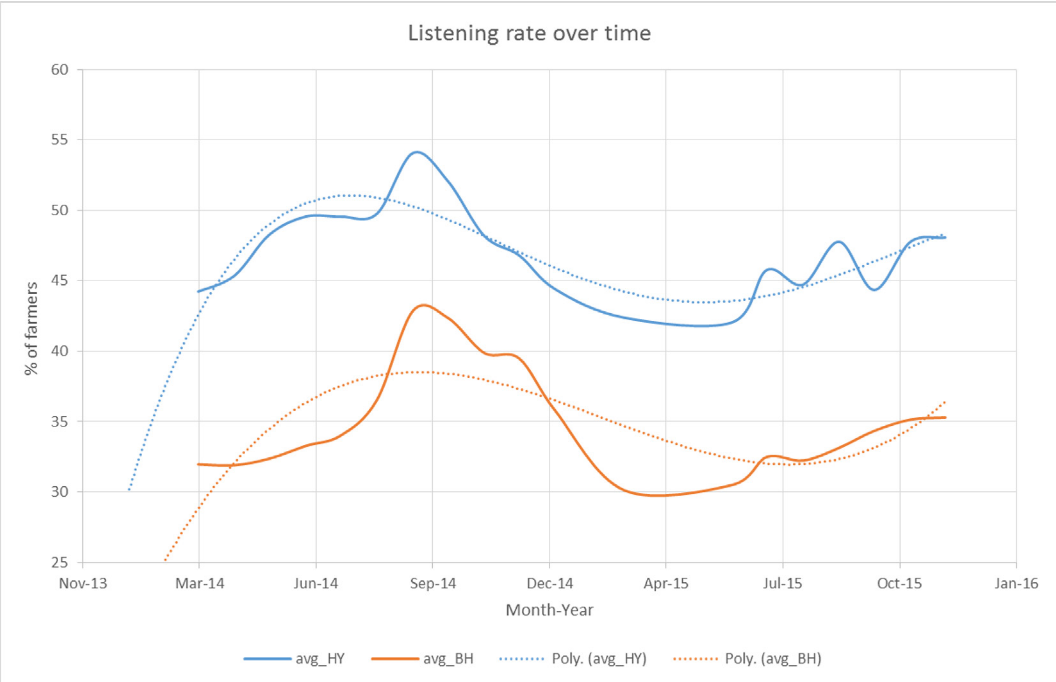

Fig 3. . Listening rate over time for Haryana (HY) and Bihar (BH) states, India.

nearly 50% by end of the project, the non-listeners declined to 45%. In Bihar, the percentage of non-listening farmers declined and there was an increase in farmers who were listening to the message for the complete duration.

When the percentage of farmers who were listening to the complete messages (75–100% category) is plotted over time on monthly basis, we observe a trend similar to the conceptual framework as in Fig. 1. The listening rate follows a parabolic path for both states, confirming the conceptual framework (Fig. 3).

4.3. Usefulness, actionability and benefit

Although the number of farmers listening to messages received on their mobile phones has increased substantially, ICT will not have a substantial effect on farmers' agricultural practices unless that information is of use to the farmer and is put to action (Mittal et al., 2010). A study[4] by a farm radio show demonstrated that by listening to the agricultural programs, 50% of farmers gained significant new knowledge about an agricultural innovation and one in five farmers would use this knowledge.

[4] http://www.farmradio.org/wp-content/uploads/Farm-Radio-Agriculture-Radio-That-Works.pdf.

Table 4
. Statistics on farmer's access and usability of agro-advisories and action taken (Unit: % of farmers).

		Haryana (N = 243)	Bihar (N = 250)
Access	No	2.9	4.4
	Yes	97.1	95.6
Usability	Low	2.9	8.0
	Medium	16.5	20.4
	High	80.7	71.6
Action taken	No	5.8	29.6
	Yes	94.2	70.4

Table 5
. Percent of farmers benefiting from information provided by voice messages.

Categories	Awareness		Monetary gains	
	Haryana	Bihar	Haryana	Bihar
Not at all	1.2	8.0	2.9	12.0
Somewhat	–	9.2	6.2	14.0
Mildly	2.1	32.0	16.0	19.6
Adequate	6.6	36.8	14.4	32.8
Highly	90.1	14.0	60.5	21.6

Note: Haryana (N = 243); Bihar (N = 250).

Thus, we further analyzed the data to understand how many of the farmers who access the information over the phone found the information useful and how many of them have acted upon it. Information about usability and action were collected at the end of the project. Access is defined as farmers having received the messages and listening to them. This analysis uses the individual level listening data. In our study, 97% of the farmers in Haryana and 95.6% in Bihar listened to the messages (Table 4).

Usability is defined as a combination of attributes including being useful, timely, accurate, and trustworthy. During the study, farmers were asked if they found the voice messages useful, if the messages well relevant for their crop cycle, if they felt the information was accurate/correct, and if they trusted the information they received. The information is further categorized as low, medium and high with respect to usability (Table 4). Only a small percentage of farmers ranked the information as low in usability while 80% of the farmers in Haryana and 71.6% in Bihar found the information content usable.

The third aspect analyzed is action taken. If farmers put the information received in use at their farms, action taken was designated as 'Yes'. With respect to action taken, 94% of the farmers in Haryana and over 70% of the farmers in Bihar put the information to action. Usually the actions taken were following the advisories and adopting the CSAPs.

If the farmers utilized the information received via the advisories, then it is expected that the information will have an impact.[5] This impact can be in terms of improved awareness or monetary gains. The farmers were asked to list the types of benefits they experienced while participating in the project. The benefits are categorized as follows:

1. Improved awareness regarding farm practices, input use, CSAPs and technologies, and weather information;
2. Monetary benefits such as increased yields, reduced input costs, reduced losses, and increased income.

The percentage of farmers benefiting from the intervention of mobile-based voice messages are shown in Table 5 using a five-point Likert scale with categories from 'no benefit' to 'highly beneficial'. We have not quantified the benefits as they cannot be attributed solely to the inflow of information provided via the messages. Nearly 90% of the farmers in Haryana felt they highly benefited from the intervention with respect to an increased level of awareness while only 60.5% of the farmers felt they benefited monetarily. In Bihar, over 90% of farmers rated the benefits in awareness as 'mild', 'adequate', and 'high' while 60% reported monetary benefits if these three categories are considered together (Table 5). Overall, the two states differ in perceived benefits but largely farmers did realize benefits with respect to both level of awareness and monetary gains.

The correlation matrix in Table 6 shows the relationships between awareness, usability, action, and overall benefits. Awareness about CSAPs and message usability are each significantly correlated with action taken and benefits while action taken is only significantly correlated with benefits. The correlations support the framework for process of change associated with outcomes as

[5] The term 'impact' in this study is used to denote the benefits realized by farmers gain due to information utilization and action taken.

Table 6
Correlation.

		Awareness about CSAPs	Message usability	Action taken	Benefit total
Awareness about CSAPs	Pearson Correlation	1	0.004	0.092*	0.135**
	Sig. (two-tailed)		0.930	0.042	0.003
Message usability	Pearson Correlation		1	0.234**	0.319**
	Sig. (two-tailed)			0.000	0.000
Action taken	Pearson Correlation			1	0.238**
	Sig. (two-tailed)				0.000
Benefit total	Pearson Correlation				1
	Sig. (two-tailed)				

Note: *Correlation is significant at the 0.05 level (two-tailed); **correlation is significant at the 0.01 level (two-tailed); N = 493.

shown in Fig. 2. The parameters in the 'process of change' such as awareness about CSAPs and action taken by farmers are significantly correlated with the usability of the content 'enabling factor' which creates 'outcomes' (benefits) in the form of improved awareness and monetary gains. The significant correlation coefficients imply that strong relationships exist between enabling factors and outcomes.

5. Conclusion and way forward

This study presents a conceptual framework for evaluating the usability of information within the context of climate change and CSAPs as the information provided by the message service was intended to improve farmers' adaptive capacities and abilities to manage climate risk. The paper also supports the assertion that climate services can play an important role in both managing the risk of and adaptating to climate change. The paper clearly demonstrates that climate information delivered using mobile phones is useful to farmers and that there are benefits realized by acting on (e.g., implementing CSAPs and adopting technologies) the information.

The results from the present analysis suggest that information delivered through mobile phones can help improve farmers' awareness about CSAPs. This is believed to be the first step towards adoption. With reduced information asymmetry and improved awareness, we observed improvement in action taken and that farmers associated benefits realized with the actions taken. However, the gap between the number of farmers demonstrating an improved level of awareness and the number of farmers who have actually adopted CSAPs is still quite large. This difference between awareness and adoption may be due to the following reasons:

1. In a short span of time, such as that of the pilot study, we can expect only a slight change in perception and behavior. Thus, actions may be taken over the medium or long term as perceptions and behavior change to a greater extent.
2. Realizing the full potential of information to benefit farmers may require additional resources such as supporting infrastructure (e.g., machinery and irrigation systems), extension services and trainings, and experimental and demonstration fields and can benefit from an enabling policy environment that incentivizes the adoption of CSAPs. Thus, access to resources and enabling factors can play and important role in translating awareness into action.

Overall, climate services can play a significant role in strengthening the adoption of CSAPs by improving awareness about weather, climate, technologies, and practices and providing information that is actionable. Additional research exploring the relationships between information delivery, information usability, awareness of CSAPs, and adoption of CSAPs will be helpful in informing interventions designed to support farmers in managing the risks of climate change and climate variability. Further, research is needed that examines what constitutes an enabling environment and the enabling factors required for farmers to adopt CSAPs as a means of successfully adapting to and managing the risks of climate change.

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Conflict of interest

Authors declare there is no conflict of interest.

Annexures

See Annexures 1 and 2.

Annexure 1
Climate smart agriculture practices (CSAPs).

Climate Smart Category	Climate Smart Interventions
Water-smart	Direct seeded rice (DSR), maize-based systems, raised beds, precision land leveling, bunding, micro-irrigation, irrigation, scheduling, crop varieties, residue mulching, cropping system optimization
Nutrient-smart	Site-Specific Nutrient Management (SSNM), Nutrient Expert Decision Support tool for maize and wheat, Green Seeker, legume integration, leaf color chart (LCC)
Carbon-smart	No-tillage, residue management, agroforestry
Energy-smart	No-tillage, residue management, direct seeded rice (DSR), cropping system optimization, eliminate puddling in rice
Weather-smart	Weather forecast, index-based insurance, Seeds for Needs, crop diversification
Knowledge-smart	ICT-based agro-services, gender empowerment, capacity building

Source: Climate Smart Villages in Haryana, India; CIMMYT-CCAFS (2014).

Annexure
2. Comparison of Socio-economic and ecological factors between study sites.

Characteristic	Bihar	Haryana
Geographical location	Eastern India	North-western India
Topography	Alluvial plain	Alluvial plain
Agro-climatic zone	Middle-gangetic plain	Tran-gangetic plain
Soil	Piedmont swamp soil and Terai soil	Alluvial medium textured soil
Population		
Male (%)	52.14	53.23
Female (%)	47.85	46.76
Poverty level (%)	33.74	11.16
Sex ratio (number of female/1000 male)	916	877
Literacy		
Male (%)	73.39	85.38
Female (%)	53.33	66.77
Per capita income (INR per year)	19,205	94,798
Cropping intensity (%)	136	185
Human development index	0.367	0.552
Average annual rainfall (mm)	1200	300–1100
Main crops	Rice, wheat, maize, arhar, potato	Rice, wheat, cotton, potato, maize, bajra, jowar, barley, rapeseed, mustard, groundnut, sugarcane
Horticultural crops	Litchi, mango, makhana	
Important cropping systems	Rice-wheat, maize-wheat	Rice-wheat
Farming system	Crop-livestock	Crop-livestock
Status of farm mechanization	Average	Excellent
Access to market	Good	Excellent
Access to credit	Average	Average
Access to farm inputs and other services	Average	Good
Access to information	Average	Good

Date source: Bihar and Haryana ministry reports.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.crm.2018.08.003.

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