Use of Seasonal Forecast Information in Farm Level Decision Making in Bundelkhand, India

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ABSTRACT

Improving agricultural outcomes is an important means of addressing global poverty. The uncertainty of climate variability has a large influence over agricultural productivity. It can produce extreme climatic events such as floods or droughts that can significantly damage crop yields resulting in loss of livelihood and food security for small-scale farmers around the world. Additionally, farmers make farming decisions that reduce the risk of negative impacts resulting from climatic extremes but at the expense of increased yields and profits in advantageous climatic conditions. Seasonal forecast information (SFI) is one tool that can be used to address this issue by reducing the uncertainty of future climatic conditions. Many small-scale farmers, however, do not fully utilize such information when it is available. Research suggests that the effective use of SFI exists in a knowledge-action system where deficiencies in its various components may inhibit forecast use. These components include forecast dissemination, demand, acceptance (including salience, credibility, and legitimacy), understanding, and action capacity. This study examines these components and how they relate to the use (or nonuse) of monsoon forecast information in Bundelkhand, India, through the use of a ground-level questionnaire. Overall, it finds significant associations between dissemination, salience, and action capacity with the use of monsoon forecast information. The findings suggest that these issues need to be addressed in order to increase forecast usage in the study area.

Keywords: *Climate Variability; Agricultural Productivity; Seasonal Forecast Information (SFI); Monsoon Forecast Information; Bundelkhand;*

Agricultural growth is recognized as being a primary avenue for addressing global poverty *(Bresciani & Valdés, 2007)*. Over 700 million people in India directly depend on climate-sensitive sectors like agriculture, forests, fisheries and natural resources such as water, fodder, and biodiversity for their livelihoods *(Satapathy et al. 2011)* and over 400 million of the world's poor (those subsisting on less than $1.25 USD per day) reside in the country—a population with a diminished capacity to adapt to climatic stressors (*Sumner, 2012*). For these agriculture producers and their families, any factor that contributes to a decrease in agricultural productivity can have significant detrimental effects on their well being. Even modest declines in productivity can have major negative impacts on food security, forced migration to urban areas in search of alternative income, or other negative repercussions. One of the biggest and uncontrollable factor that influences agricultural productivity (whether positively or negatively) is climate and its variability.

One tool for improving agricultural productivity that has been touted by the international research and development community is *seasonal forecast information* (SFI). This information makes medium-term, usually one to three seasons in advance, probabilistic predictions about average weather conditions such as rainfall or temperature for a meteorological season. If the prediction is skillful, it can reduce the uncertainty of future climatic variability potentially allowing farmers to reduce losses from poor climatic conditions and increase gains from beneficial climatic conditions *(Hansen et al. 2007)*. Evidence from Africa and South America has verified the benefits of SFI when it is disseminated and interpreted in an accurate manner *(Lansigan et al. 2007; Lemos et al. 2002; Patt, Suarez, & Gwata, 2005; Phillip et al. 2002)*.

However, as seasonal forecasting methods have developed, there has been limited uptake of the information by small-scale farmers in developing regions where they could benefit from such information (*Cash & Buizer, 2005; Cash et al., 2002; Meinke et al., 2006*). This study explores the barriers that may be impeding the use of monsoon forecast information (one form of SFI) in the Bundelkhand region of central India. The next section introduces a "knowledge-action" system developed from relevant literature that describes the different components comprising the pathway between the creation of forecast knowledge and its conversion into action at the farm level and that may be potential obstacles to the use of SFI. After that, the results of a survey conducted in three districts of Bundelkhand to identify potential barriers unique to the region are presented with accompanying discussion and conclusion.

The use of seasonal forecast information: The knowledge-action system in which SFI operates encompasses the creation of the knowledge, its dissemination, and its integration into farmers' decisions that can result in action. The system comprises both technical and social components. These components are separated into the following categories: dissemination, demand, acceptance, understanding, and action capacity. A description of each category follows.

Forecast dissemination issues can limit SFI use through both a lack of awareness or a lack of a viable dissemination mechanism (*Sivakumar & Hansen, 2007; Ngugi et al. 2011*). If a potential SFI user does not know that the information exists due to the absence of any information regarding SFI, they will not be able to utilize SFI. If a potential SFI user is aware of the information, he or she may not have a viable way of accessing that information. This may be due to issues of physical access (e.g. the information is simply not communicated through any medium in the relevant area) or it may be due to economic issues (e.g. the information is broadcast via radio but the potential user cannot afford to purchase a radio).

Forecast demand issues can impede SFI use if a potential SFI user does not have agricultural values or goals or does not identify farm-related problems that are congruent with the benefits of SFI (*Fountas et al., 2006*). A farmer's values and goals drive the identification and definition of problems that can and need to be resolved from the viewpoint of the farmer. If these values and goals cannot be at least partially fulfilled with the benefits of SFI, then the use of SFI in farm-level decision making is less likely. Additionally, if values and goals *do* align but identified and defined problems emanating from these goals *do not*, the use of SFI is also less likely.

Forecast acceptance issues can arise from issues of saliency, credibility, and/or legitimacy (*Cash et al., 2002; Patt & Gwata, 2002)*. Saliency refers to the overall perceived usefulness of the information, which includes timely availability and spatial and temporal resolution (*Letson et al., 2001)*. Credibility is the perception of the information's quality or accuracy (*Hu et al., 2006; Patt & Gwata, 2002*). Legitimacy denotes perceptions regarding the quality and fairness of the information creation and dissemination process (*Cash & Buizer, 2005; Clark et al., 2002*). Perceived deficiencies in any of these qualities can inhibit the use of SFI.

Forecast understanding issues may occur if the potential SFI user cannot, or feels he or she cannot, adequately interpret and understand forecast information in the form that is available (*Hu et al., 2006*). Potential SFI users that do not feel they can understand the information correctly are less likely to use the information.

Table 1. Summary of farm level forecast knowledge-action system components

Component	Description
Dissemination	The potential forecast end-user is aware of the information and is able to access it.
Demand	The potential forecast end-user recognizes the problem uncertain climate variability may have on agricultural productivity.
Acceptance	The potential forecast end user believes the information is pertinent to their decision making process (salient), reasonably accurate (credible), and produced and disseminated through a fair process (legitimate).
Understanding	The potential forecast end user is confident in their ability to interpret the information.
Action Capacity	The potential forecast end user is able to alter their decisions based on the information.

Forecast action-capacity issues stem from real or perceived resource limitations that reduce the ability of a potential SFI user to integrate the information into the decision making process (*Ziervogel, 2004; Roncoli, 2006*). For example, if a farmer decides the addition of extra fertilizer than normal is warranted based on forecast information but cannot afford or access extra fertilizer, then the farmer is unable to integrate the information due to an issue of action-capacity.

Study background: The Bundelkhand region in central India, consisting of seven districts in the state of Uttar Pradesh and six districts in the state of Madhya Pradesh, exhibits the qualities that make India susceptible to climate variability to an even higher degree. It is a semi-arid region where over 80% of the region's population depends on the climate sensitive agricultural sector for their livelihoods and there is currently little scope for non-agrarian livelihoods such as industry or service—approximately 96% of regional farmers' income derives from agricultural activities (*Inter-Minsterial Central Team, 2008*). Further, the region is considered one of the least socioeconomically developed regions of not only the two states in which it reside but of India as a whole (*Inter-Minsterial Central Team, 2008)*. These factors increase the impacts of climate variability such as drought on the wellbeing of the region's inhabitants and depress overall agricultural outcomes—agricultural productivity is 40 per cent below other comparable areas in central India (*Inter-Minsterial Central Team, 2008)*.

A variety of crops are grown in Madhya Pradesh (in which half of Bundelkhand resides) with the largest percentage by gross cropped area being soybean (26%), wheat (19%), and gram (14%). Majority of land holdings (67.67%) in the state are less than 2 hectares with only 1.61% being larger than 10 hectares. An average of 81.4 kg of fertilizer per hectare is applied to agricultural land in the state. Farm mechanization is primarily machine driven with an estimated 82.6 per cent of farm energy deriving from mechanical energy as opposed to animal energy. Approximately 50 per cent of the geographical area in Bundelkhand is estimated to be under cultivation for at least some periods during the year, and the majority of this land is rainfed as only 41.2 per cent of the total sown area is considered irrigated (*Inter-Minsterial Central Team, 2008; Ministry of Agriculture, 2008)*. Agriculture is performed for a mix of subsistence and commercial purposes with an estimated 96 per cent of farmer's income deriving from crop and livestock enterprises *(Inter-Minsterial Central Team, 2008)*.

Water scarcity is a major issue for agriculture in Bundelkhand. Even irrigated land is susceptible to water scarcity as the main sources of irrigation are wells and ponds, which rely on rainwater for replenishment. In past droughts, many wells relied upon for drinking and irrigation water have dried up. The average annual rainfall for the Uttar Pradesh and Madhya Pradesh sections of Bundelkhand ranges between approximately 876 to 991 mm with about 90 per cent occurring during the Southwest monsoon between mid-June and early September (*Inter-Minsterial Central Team, 2008)*. Accordingly, the region is highly sensitive to variations in climatic patterns, especially the Southwest monsoon, since many areas do not have access to alternative water sources in the case of even mild drought. This reality makes forecasting of monsoon onset and rains in Bundelkhand particularly salient due to the magnified importance of the monsoon to agriculture, livelihood, and food security in the region *(Sulochana Gadgil & Gadgil, 2006*).

METHODOLOGY

This study operated under the assumption that the use or nonuse of SFI information is a function of the knowledge-action system components previously described and as shown in equation 1. Deficiencies in any of these components can potentially hamper the use of this information by the intended end users. Accordingly, to understand the barriers to the use of SFI, one must have information pertaining to these different components. For this reason, a primary survey was conducted among farmers in three districts of the Bundelkhand region of India. Though there is a plethora of information available on SFI use barriers for different populations around the world, a specific examination of this area is warranted due to the spatially heterogeneous nature of these barriers—the barriers that impede use in one area do not necessarily correlate with the barriers in another area (*Orlove, Broad, & Petty, 2004*).

Equation 1. Function governing the use of SFI

SFI Use = f (dissemination, demand, acceptance, understanding, action capacity)

The questionnaire was pre-tested and administered between December 2012 and January 2013. Three districts (Datia, Tikamgarh, and Chhatarpur) were surveyed within the Madhya Pradesh portion of Bundelkhand. The districts were selected for their representativeness of the predominant semi-arid agroclimatic conditions of the Bundelkhand region as well as proximity to Development Alternatives' Bundelkhand field station. Within each district, two blocks were randomly selected and two villages were selected within each block based on accessibility and familiarity with Development Alternatives partner NGOs. Respondents were selected based on (1) if they were a farmer and (2) if they made decisions related to farming operations. In each village, 8 to 12 respondents were sought (depending on the amount of available farmers in the village) with a goal of reaching a total of 120 respondents. Respondents were read each question and offered to read along with the interviewer if they desired. Overall, 116 surveys were administered. However, due to suspected inaccurate survey administration and missing responses, 26 surveys were dropped from the analysis leaving a total of 90 completed surveys.

Table 2. Responses collected per district and block

District	Block	Surveys
Chhatarpur	A	11
	B	15
	Total	*26*
Tikamgarh	A	12
	B	13
	Total	*25*
Datia	A	21
	B	18
	Total	*39*

Survey instrument: The dependent variable of interest in this study, monsoon forecast use, was determined by reading respondents a description of such information, asking if they were aware of its existence, and then asking if they utilized that information for making decisions on their farm. Information regarding the independent variables (i.e. each knowledge-action system component listed in Table 1) was elicited through a variety of separate closed-ended questions. Most of the included questions were straightforward. For *dissemination*, respondents were asked questions regarding their access to various forms of media (i.e. radio, newspaper, television, etc.). For *demand*, respondents were asked questions regarding past experiences with climate variability and future expectations of climate variability as well as the importance of various factors to the selection of crop or seed type. For *acceptance*, respondents were asked about their opinions regarding the helpfulness, spatial range, temporal range, timely availability, accuracy, and fairness of monsoon information. For *understanding*, respondents were simply asked to rate their personal ability to interpret monsoon forecast information. Finally, for *action capacity*, respondents were asked about their ability to alter farming decisions if they felt they needed, due to monsoon forecast information.

Analysis: Analysis of survey responses was conducted with two multivariate probit regression models-one describing the probability of being aware of SFI and the other describing the probability of using SFI if the respondent is aware of the information. Separate models were used instead of a single multinomial probit model due to the absence of responses regarding opinions on SFI for respondents that were not aware of the information. It was assumed unaware respondents would not be able to accurately answer questions regarding SFI.

SFI Awareness : A multivariate probit regression model was used to analyze the association between the awareness or non-awareness of SFI and socio-economic characteristics among survey respondents. The model is displayed in equation 2.

Equation 2. SFI awareness probit regression model

$$Pr\,(Awareness = 1) = \Phi\,(\beta_0 + \beta_1 Radio + \beta_2 TV + \beta_3 Newspaper + \beta_4 Age + \beta_5 Education + \beta_6 Agri\text{-}Income + \in$$

In this model, *Awareness* is a dichotomous variable indicating if the respondent reported being aware of SFI after being read a description of the information. *TV, Radio,* and *Newspaper* are dummy variables indicating access to the respective forms of media; *Age* is self-reported age; *Education* is self-reported education attainment ranging from illiterate to completion of post-graduate studies; and *Agri Income* is self-reported income from agricultural activities.

SFI Use : A multivariate probit regression model was used to analyze the association between the use or nonuse of SFI and responses to questions pertaining to the various knowledge-action system components of interest. The general model is displayed in equation 3.

Equation 3. Generalized SFI use probit regression model-

$$Pr\ (Use_i = 1) = \Phi(\beta_0 + \beta_1 (Dissemination)_i + \beta_2 (Demand)_i + \beta_3 (Acceptance)_i + \beta_4 (Understanding)_i + \beta_5 (Capacity)_i + \epsilon_i$$

In this model, *Use* is a dichotomous variable indicating if the respondent uses SFI when making farming related decisions as reported by the respondent. Dissemination, Demand, Acceptance, Understanding, and Capacity are vectors representing the five knowledge-action system components derived from the survey responses.

Due to the relatively small sample size, the inclusion of each question's response as a separate explanatory variable is not possible due to potentially overfitting the model[1]. To account for this problem, responses were aggregated into single vectors if the underlying information within the responses is expected to be the same (i.e. responses indicating the average availability of different farming resources are collapsed into one variable by taking the arithmetic mean of each response per individual). Additionally, many questions offered respondents the ability to answer with "I do not know". While few respondents answered this way per question, including these responses in the regression model would necessitate analyzing each response as a categorical variable as opposed to ordinal. While this method would be preferable since not knowing or have no opinion to a question related to one of the relevant components may influence SFI use, issues of separation preclude this approach, again, due to the relatively small sample size[2]. In an effort to avoid dropping observations where a respondent answered "I do not know" to one or more questions, thus decreasing the sample size further, such answers were assumed to indicate midpoint responses (i.e. a '3' response to a 1-5 Likert-type question).

Table 3. Probit regression model variable descriptions

Variable	Description
Use	Uses SFI for farming-related decisions (1=yes; 0=no)
TV	Has access to television (1=yes; 0=no)
Radio	Has access to radio (1=yes; 0=no)
Newspaper	Has access to newspaper (1=yes; 0=no)
Others	Knows others that use SFI for farming-related decisions (1=yes; 0=no)
AgriOutcome	Average importance of agricultural outcomes (range from 1, not important, to 3, important)
Past Perception	Average perception of late onset and deficient monsoon for past five years (0 out of 5 years…5 out of 5 years)
Importance	Average importance of SFI to achieving agricultural outcomes times overall importance of outcomes (range between 1, both not important, and 9, both important)
Availability	Frequency of SFI availability when it is needed (range from 1, never, to 5, always)
Range	SFI temporal range is adequate (1=yes, 2=no)
Regional	Similarity of home region's climate to nearby regions (range from 1, not at all similar, to 5, very similar)
Accuracy	Reliability of SFI for home district (range from 1, not at all reliable, to 5, very reliable)
Fairness Climate	SFI development and dissemination is fair/equitable (1=yes, 2=no)
Knowledgeable	Those responsible for developing SFI are knowledgeable about needs as a farmer (range from 1, not at all knowledgeable, to 5, very knowledgeable)
Traditional	Uses traditional forecasting techniques (1=yes; 0=no)
Education	Educational attainment ranging from illiterate to post-graduate
Understanding	Personal understanding of SFI (range from 1, poor, to 5, excellent)
AgriCapacity	Average ability to buy/obtain agricultural resources (range from 1, never, to 5, always)
Forecast Capacity	Ability to alter decisions based on SFI (range from 1, never, to 5, always)

1. *Over fitting occurs when a statistical model describes the idiosyncrasies of the sample data instead of the underlying relationships between variables. It often occurs when there are too many explanatory variables for too little observations (Babyak, 2004)*
2. *Separation may occur in probit or logistic regressions with small sample sizes in which one or more explanatory variables can perfectly predict one of the dichotomous dependent variable responses causing the corresponding parameter estimates to become infinity (Heinze & Schemper, 2002).*

This assumption was made based on bimodal response distributions from questions not used in the model where it seemed evident that many respondents selecting midpoint type responses did not actually have a strong opinion. Previous research also indicates that undecided or 'no opinion' type responses are often synonymous with neutral or midpoint Likert-type responses.

The final probit regression model is displayed in Equation 4. A listing and description of each explanatory variable is listed in Table 3.

Equation 4. Expanded SFI use probit regression model

$$Pr(Use=1) = \Phi(\beta_0 + \beta_1 Radio + \beta_2 TV + \beta_3 Newspaper + \beta_4 Others + \beta_5 Agri\ Outcome + \beta_6 Past\ Perception + \beta_7 Importance + \beta_8 Availability + \beta_9 Range + \beta_{10} Accuracy + \beta_{11} Regional\ Climate + \beta_{12} Fairness + \beta_{13} Knowledgable + \beta_{14} Traditional + \beta_{15} Education + \beta_{16} Understanding + \beta_{17} Agri\ Capacity + \beta_{18} Forcast\ Capacity + \in$$

RESULTS AND DISCUSSION

Respondent Profile: Of the 90 included survey respondents, 89 were male, signifying the male-dominated farm decision-making process in the study area, which corresponds to previous research regarding gender roles and agriculture around India (*Jewitt, 2000*). The average (self-reported) age was 43, with the youngest and oldest respondents being 20 and 75, respectively. There was a wide distribution of maximum educational attainment among the respondents. The average (self-reported) income resulting from farming activities was approximately 64,000 per year with a minimum and maximum of 3,000 and 500,000 per year, respectively. Average total income (including farming and non-farming activities) was approximately 74,000 per year with only 24 (26.7%) respondents reporting non-farming related income. Overall, approximately 88.6% of reported income was from farming related activities.

Table 4. Respondents educational attainment

Attainment level	No.	% of total
Illiterate	10	11.1
Literate	34	37.9
At least 10^{th} standard	24	26.7
At least 12^{th} standard	14	15.6
Graduate	6	6.7
Postgraduate	2	2.2

Farming Profile : The average respondent reported that they had been farming for 18.9 years with a minimum and maximum reported length of 1.5 and 40 years, respectively. The average land on which the respondent farmed was approximately 3.5 hectares[3]. Most respondents indicated that the majority of their land was irrigated, which conflicts with official statistics of the Bundelkhand region indicating majority rainfed agriculture *(Inter-Minsterial Central Team, 2008)*. It is unclear if this is a result of an unclear question or sample selection. Other studies have found relatively high levels of reported irrigated land in the study area but note that the viability of the irrigation sources is strongly connected to monsoon rains. Since the survey was conducted during the dry season, farmers who have primarily rainfed fields may have temporarily migrated away from their village in search of an alternative income, thus reducing their representation in the sample. The vast majority of respondents (95.6%) reported owning the land on which they farmed with the remaining 4.4 per cent split evenly between those who farmed on rented land and those who reported farming on neither rented nor self-owned land. This result makes intuitive sense, as one would expect the owner of the land to be the one making farming related decisions.

Traditional forecast information : A slim majority (53.8%) of survey respondents reported using traditional forecasting techniques to predict the onset of the monsoon. A much smaller proportion (18.3%) reported using traditional forecasting techniques to predict the amount of rain the monsoon would bring. This discrepancy may reflect the relative importance of monsoon onset date compared to monsoon rainfall. While the total amount of rainfall the monsoon will bring is important for farmers, when the rains will begin may be more important to them.

The majority of respondents who use traditional forecasting techniques indicated that they believe the techniques are becoming less accurate than in the

3. *Many farmers reported land size in bighas, a unit of measurement sometimes used in India, Nepal, and Bangladesh. There is not a standard sized bigha across the geographical area in which it is used. In Madhya Pradesh, where this study was conducted, 1 bigha equals approximately 0.16 hectares. Reported land sizes were converted accordingly.*

past. 66.7 per cent believed the ability of their techniques to predict the onset of the monsoon is declining and 80 per cent believed the same of their techniques to predict total monsoon rainfall.

SFI awareness : After being read a description of SFI, 13 of 90 (14.4%) respondents indicated that they were not aware of the existence of the information. The estimated coefficients, average marginal effects, and corresponding p-values for the probit model displayed in equation 2 are presented in Table 5.

Table 5. SFI awareness probit regression model estimated coefficients, average marginal effects (AME), and corresponding p-values

Variable	Coefficient	p-value	AME	p-value
Access to radio	-0.90194	0.111	-0.10949	0.057
Access to TV	0.10702	0.844	0.01491	0.848
Access to newspaper	1.27155	0.032**	0.20896	0.033**
Age	-0.02332	0.205	-0.00318	0.186
Educational attainment	0.19193	0.444	0.02617	0.439
Agril. income (Rs.1,000/year)	0.48380	0.018**	0.00660	0.006*
Intercept	0.27788	0.750		

* p-value significant at 1% significance level

** p-value significant at 5% significance level

The Likelihood Ratio Chi-Squared test indicates that at least one coefficient in the estimated model is not zero with a p-value of 0.0002. Two of the explanatory variables, access to newspaper (*Newspaper*) and agricultural income (*AgriIncome*) are significant at the 5 per cent level.

The estimated coefficients indicate that access to newspaper and higher agricultural income increase the probability of being aware of SFI. The average marginal effect of access to newspaper signifies that having access to newspaper increases the probability of being aware of SFI by approximately 20.9%. Importantly, educational attainment is not significantly associated with SFI awareness, which suggests that the significance of newspaper access is not due to issues of literacy (i.e. illiterate respondents may consider newspaper inaccessible), but of physical access to the communication medium. The average marginal effect of agricultural income indicates that a Rs.1,000 increase

Table 6. SFI use probit regression model estimated coefficients, average marginal effects (AME), and corresponding p-values

Variable	Coefficient	p-value	AME	p-value
Access to radio	1.88063	0.015**	0.28973	0.005*
Access to TV	-1.25098	0.266	-0.13591	0.215
Access to newspaper	0.51135	0.652	0.06832	0.660
Knows of others using SFI	2.21406	0.003*	0.37892	0.001*
Agricultural outcome importance	0.29659	0.936	0.04372	0.926
Perception of past climate variability	0.69083	0.107	0.08710	0.084
SFI importance	0.10561	0.606	0.01326	0.608
SFI availability	0.98884	0.004*	0.12486	0.001*
SFI temporal range	1.05413	0.161	0.13414	0.134
SFI accuracy	-0.12953	0.740	-0.01584	0.751
Regional climate similarity	-0.32233	0.430	-0.04185	0.420
SFI process is fair	-0.78794	0.400	-0.09730	0.367
SFI producers are knowledgeable	0.07046	0.848	0.00879	0.850
Uses traditional forecast techniques	-0.31950	0.624	-0.03957	0.617
Educational attainment	0.17209	0.561	0.02143	0.564
Personal understanding of SFI	0.48583	0.174	0.06148	0.157
Agricultural resource attainment capacity	0.87508	0.019**	0.11091	0.005*
Ability to incorporate SFI into decisions	-0.34159	0.277	-0.04356	0.266
Intercept	-11.51464	0.294		

* p-value significant at 1% significance level ** p-value significant at 5% significance level

in annual income increases the probability of awareness by approximately 0.6 per cent. This result supports other findings that contend that SFI may benefit wealthier farmers more than poorer farmers.

SFI use : After being read a description of SFI, 77 of 90 (85.6%) respondents indicated that they were aware of the existence of such information. Only respondents indicating awareness of SFI were asked questions pertaining directly to the forecast information as it was assumed that unaware respondents would not be able to answer these questions. Accordingly, only respondents that indicated awareness are included in the probit regression model. The estimated coefficients, average marginal effects, and associated p-values are presented in *Table 6*.

The Likelihood Ratio Chi-Squared test indicates that at least one coefficient in the estimated model is not zero with a p-value of less than 0.0001. Four of the explanatory variables—access to radio (*Radio*), knowing others that use SFI (*Others*), SFI availability (*Availability*), and agricultural resource attainment capacity (*AgriCapacity*)—are significant at the 5% level. The statistical significance of these variables suggests that issues of dissemination, saliency, and action capacity constrain the use of SFI among the study population.

Dissemination : Owning or having access to a radio is significantly associated with the use of SFI. Having access to radio increased the probability of using SFI by approximately 29 per cent. This result suggests that non-users of SFI may be hindered by information access via radio. Of respondents who were aware of SFI, approximately 75 per cent of them indicated that they could or believed they could access such information via radio, which is the second most indicated mechanism for accessing SFI (*Table 7*). Additionally, approximately 50% of respondents without access to radio *did* indicate that they were aware the information could be obtained via radio. These data give credence to the contention that SFI use is not hindered by a lack of knowledge of where to find SFI but by physical access to the dissemination mechanism.

Table 7. SFI access methods among SFI aware respondents

Mechanism	Yes		No	
	No.	%	No.	%
TV	71	92.2	6	7.8
Radio	57	74.0	20	26.0
Newspaper	54	70.1	23	29.9
Mobile	4	5.2	73	94.8
Internet	2	2.6	75	97.4
KVK	36	46.8	41	53.2
Other farmers	50	64.9	27	35.1
Other	11	14.3	66	85.7

The model's result contrasts with the significant relationship between access to newspaper and SFI awareness and the corresponding non-significance of access to radio and SFI awareness. This seemingly contradictory result may be indicative of noise in the data or reveal possible farmer preferences for receiving SFI. While reading about SFI in the newspaper may increase awareness of its existence, it may not necessarily lead to its use in the decision making process. On the other hand, SFI transmitted via radio may be received by farmers in a way that induces them to use it. This study does not illuminate the reasons for this difference, if a difference truly exists, but reasons could include a more trust in radio than newspaper among farmers or the information is transmitted in a more farmer-friendly way via radio than newspaper such as including specific agricultural advisories with SFI.

Those who reported knowing other farmers that used SFI are also more likely to use SFI themselves. Knowing someone else that uses SFI increased the probability of using SFI by approximately 38%. This may be indicative of social pressures influencing the use of SFI, but may also relate to the tendency of farmers to share information between each other *(Meinke et al., 2006)*. Indeed, a majority (64.9%) of respondents aware of SFI indicated that they could access the information through other farmers if they wanted. Additionally, knowing others who use SFI and being able to access SFI through other farmers are positively and significantly correlated (two-sample 't' test, $p<0.0001$), further supporting the assertion that the association between knowing others and using SFI is due to knowledge sharing.

Saliency : Respondents indicating that SFI is not available at the times they needed it are significantly less likely to utilize the information. This result suggests an issue with saliency if respondents are not utilizing SFI because it is or they believe it is not available at times useful to them. It is not clear if the underlying cause of this relationship is due to a perceived problem with timely availability when the information *is* available when it is most useful, or if the information truly is not available when it is most useful. Both the possibilities are considered.

First, SFI may not be physically available in time for farmers to adequately incorporate it into their decision making process. Farmers in other areas of the world have indicated that a lead time of one to two months before planting (which usually occurs at the beginning of the rainy season) is needed for SFI to be useful *(Ingram et al. 2002)*. The normal onset date of the Southwest monsoon in Bundelkhand is June 15th and the preliminary monsoon forecast from IMD is released in mid-April, giving approximately two months of lead time *(IMD, 2012)*. One thing to consider, however, is that the preliminary forecast may not receive as much media attention than the updated forecast released in mid-June, during or after the usual onset of the monsoon, potentially making it less likely that a farmer will hear about the forecast until it is too late. Additionally, farmers may value the updated forecast in June more than the preliminary April forecast and thus do not consider the early forecast.

On the other hand, nearly half (47.8%) of those who use SFI indicated that it was 'often' or 'always' available at the times when they needed it. This suggests that there is an issue with perceived SFI availability. Recalling that 14.4 per cent of the sample population is not aware of the existence of information, it is reasonable to conclude that an overall low awareness of details relating to the information may exist including when the forecast is generally available before each monsoon season. Potential users may believe that the information is simply not available when they need it and thus do not attempt to seek it out.

Action capacity: Respondents' perceptions regarding their ability to obtain or access various agricultural resources are significantly and positively associated with the use of SFI, suggesting an issue of action capacity. Farmers who feel that they are not always able to purchase the best seed or adequate amounts of fertilizer, for example, are less likely to use SFI. Since the model relies on self-reported information by the farmers, it is not possible to discern definitively whether the association is between *real* action capacity limitations or simply *perceived* ones. However, in an unreported iteration of the SFI use probit regression model that includes farmer income as an independent variable, farmer income was not significantly associated with SFI use[4]. The non-significance of farmer income suggests that perceived action capacity could be the real issue, as one would expect income to be associated with SFI use if real resource constraints exist.

CONCLUSION

The significant associations between SFI use and dissemination, saliency, and action capacity indicators suggest that there are systemic issues affecting the use of SFI in the study area. First, those without access to radio or knowledge of other farmers that use SFI are significantly less likely to use the information. Second, those who indicate that SFI is not available when it is needed are less likely to use the information. Also, those who indicate that they cannot always access agricultural resources such as seeds or fertilizer are less likely to use the information. Finally, the significant association between SFI awareness and newspaper access as well as income suggests there are issues that preclude some potential SFI users from even knowing that the information exists.

Future efforts by either the Indian government or agricultural and development NGOs to promote the use of SFI in Bundelkhand should take these factors into consideration. Other issues, such as credibility or understanding, should not be ignored however. Due to the relatively small sample size and other constraints, the likelihood that this study does not capture all issues pertaining to the use of SFI is high. Additional research is needed to further illuminate barriers to the use of forecast information. The imperative for increased focus on SFI in this region is evident from the survey, however, as a majority of the respondents indicate that traditional techniques are becoming less useful and many respondents do not use such techniques at all.

4. *Farmer income is excluded from the reported model for two reasons. First, income information is missing for several observations and its inclusion in the model would necessitate the omission of additional observations from the already relatively small number of 77. Second, when the probit model is estimated with farmer income and a smaller amount of observations, the four significant variables in the reported model remain significant with no additional significant variables. Since the income variable does not impact the other reported variables, it was excluded to retain additional observations in the model.*

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