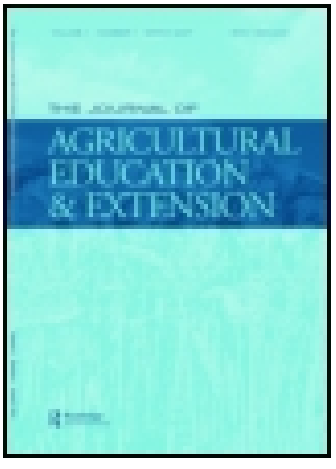

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Socio-economic Factors Affecting Adoption of Modern Information and Communication Technology by Farmers in India: Analysis Using Multivariate Probit Model

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Socio-economic Factors Affecting Adoption of Modern Information and Communication Technology by Farmers in India: Analysis Using Multivariate Probit Model

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ABSTRACT Purpose: *The paper analyzes factors that affect the likelihood of adoption of different agriculture-related information sources by farmers.*
Design/Methodology/Approach: *The paper links the theoretical understanding of the existing multiple sources of information that farmer use, with the empirical model to analyze the factors that affect the farmer's adoption of different agriculture-related information sources. The analysis is done using a multivariate probit model and primary survey data of 1,200 farmer households of five Indo-Gangetic states of India, covering 120 villages.*
Findings: *The results of the study highlight that farmer's age, education level and farm size influence farmer's behaviour in selecting different sources of information. The results show that farmers use multiple information sources, that may be complementary or substitutes to each other and this also implies that any single source does not satisfy all information needs of the farmer.*
Practical implication: *If we understand the likelihood of farmer's choice of source of information then direction can be provided and policies can be developed to provide information through those sources in targeted regions with the most effective impact.*
Originality/Value: *Information plays a key role in a farmer's life by enhancing their knowledge and strengthening their decision-making ability. Farmers use multiple sources of information as no one source is sufficient in itself.*

KEY WORDS: Mobile phones, Agricultural information, Indian farmers, Multivariate Probit model

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Introduction

Information plays a key role in strengthening a farmer's daily decision-making related to agricultural activities by enhancing their knowledge about new technology, inputs and markets. Each stage of the agriculture production requires a number of specific actions or decisions by the farmer (Mittal, Gandhi, and Tripathi 2010). Farmers need latest information on the inputs, technology, seed, pest and weed management, agronomic practices, prices, and also information on government run agricultural schemes or programmes. The importance of information in farming was realized long ago by many researchers (Williams and Williams 1971; Dervin 1976; Rogers 1995) and they documented its impact on increasing agriculture productivity and improving farmers' livelihood through adoption of new seed and non-seed technologies, diversifying cropping pattern, better market connectivity etc. The prevalence of diverse information sources has enabled farmers to access information more quickly, timely and has helped them to make more informed and better decisions (Aker 2011; Mittal, Gandhi, and Tripathi 2010; Mittal 2012).

The predominant source of information in most of the developing countries is public extension services which helps in disseminating knowledge regarding the technology, and cropping system relevant for specific geographical areas and by recommending the appropriate use of inputs, farm practices and market information. In India, the department of agriculture and extension receive new information from various research stations of the Indian Council for Agricultural Research and allied institutions and state agricultural universities. Despite the huge investment, Indian public sector extension services are usually criticized for their ineffective targeting, limited reach and the huge administrative cost of delivering information (Glendenning 2010; Mittal, Gandhi, and Tripathi 2010; Sulaiman and Holt 2002). Additionally, a shrinking natural resource base, changing consumption patterns, diversification in cropping patterns, increasing commercialization and climate change have all led to changes in farmers' information needs. Till the recent past farmers obtained information from their farmer neighbourhood, input dealers, produce buyers/middlemen and traditional media sources like television, radio and newspaper. These modes have successfully penetrated to even remote regions but were restricted as they provide generic information, and could not target specific issues of the farmer and also could not provide much scope for farmers to interact with the information provider. The use of sources of communication like television, radio and newspapers have limited effectiveness (Mittal, Gandhi, and Tripathi 2010; Aker 2011) and these are unable to meet the growing information needs of farmers, relating to crop and technology choice, processing, utilization, storage and marketing of their produce. The timing, quality, presentation and sources of information have been shown to be of vital importance in agricultural community (Aigbeakaen, Sanusi, and Ndagi 2007), and on such aspects these conventional sources have not performed very well. Experiences of the vulnerable communities in Asia, Africa, Latin America and the Caribbean point to the use of applications such as mobile phones, Internet and community radio in strengthening access of farmers to the relevant information, networking opportunities and increased awareness (Ospina and Heeks 2010).

In the last decade with the increasing penetration of mobile phones even in rural area, various mobile phone-based information delivery models for agricultural sector have developed. There has been promising beginnings in the extension services by the use of

modern information and communication technologies (ICTs) for agriculture. Several authors (Bhavnani et al. 2008; Ahmed and Elder 2009; Aker and Mbiti, 2010; Mittal and Tripathi, 2009; Mittal, Gandhi, and Tripathi 2010) describe the benefits of ICT transmitted information and knowledge on the lives of the poor, on farmer and fishermen's efficiency, on women's empowerment and on economic growth, but empirical evidence is still missing. These modern ICT models have been able to deliver customized and new information to farmers to enable them to make quicker and better decisions. Ogutu, Okello, and Otieno (2013) study finds that participation in the ICT-based market information service project has a positive and significant effect on the usage of purchased seed, fertilizer, labour productivity and land productivity, but has a negative and significant impact on the use of hired, family and total labour. Kirui's (2013) study specifically found that the largest proportion of money received (32%) via mobile was used on agricultural-related purposes (purchase of seed, fertilizer for planting and topdressing, farm equipment/implements, leasing of land for farming and paying farm workers). Famers have another advantage of mobile phones they do not go to market but directly communicate and ask the price of their production. In this context they save their money, time and energy (Muto and Yamano 2011; Lee and Bellemare 2013). Lee and Bellemare (2013) found that mobile phones appear to have a significant positive impact on prices, but only when the farmer or his spouse own the mobile phone.

However the provision of information is one component, and may require supporting environment for impact. For instance, in a recent experiment (Mitra et al. 2014), potato farmers in randomly chosen villages of two Indian districts were provided mobile phones, on which they received price information at which middlemen resold their output on a daily basis. However this information has no impact on middleman margins as farmers in the selected region has no direct access to outside market which supressed farmer's ability to bargain with traders and prevent information-based interventions from benefiting farmers. A number of empirical studies have analysed the relationship between personal characteristic of farmers and information sources (Adeogun, Olawoye, and Akinbile 2010; Aigbeakaen, Sanusi, and Ndagi 2007; Ofuoku, Emah, and Itedjere 2008; Okwu and Iorkaa 2011). The objective of this paper is to examine factors that affect the likelihood of adoption of different agriculture-related information sources by the farmers, considering the possibilities of adoption of different sources of information simultaneously. This may be due to the substitutable or complementary nature of various sources of information as well as farmers non-reliance on a single source. As the farmers receive information from different sources at the same time, the farmer's choice to adopt different information sources might be correlated. It is important to understand the farmer's perception in order to strengthen the functioning of available information sources as well as to develop targeted programmes and policies that can facilitate better delivery of information to farmers.

Data

For this study we used data collected in 2011 through a primary survey of 1,200 farming households in five Indo-Gangetic states of India namely,—Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal. Since these states form the major food bowl of India and are mainly affected by climate changes. They were chosen to understand how modern way of communication can disseminate information to enable farmers in managing risk.

Table 1. Grouping various information sources based on common characteristics

S. No.	Category	Type of sources included
1	Face-to-face	Krishi Vigyan Kendra's, Research stations, State Agricultural Universities, Krishi Mela (Farmers fair), State Department of Agriculture, non-governmental organizations (NGO), Cooperatives, Commission agents, middlemen, input dealers, private input companies, shops
2	Other farmers	Farmers or relatives in the same village or neighborhood
3	Traditional media	Television, Radio, Newspaper
4	Modern ICT	Landline phone, Mobile phones, Internet or Internet Kiosks

Four districts are chosen in each state and in each district six villages and in each village ten households are randomly selected (ref to Appendix A). Thus each state has a randomly selected sample of 240 households. Data were collected using a structured questionnaire which gathered information on socio-economic characteristics of the households, their access to different types of information and the sources of information. A multivariate probit specification is used to examine how different socio-economic factors influenced the decision of farmers in adopting different sources of information for their agricultural activities. During the field survey farmers reported the use of 17 different sources of information for gathering the information on agricultural activities (Mittal and Mehar 2012). For the purpose of analysis, these different sources are grouped together in four categories (Table 1) based on common characteristics (ref to Appendix B). The four groups are: face-to-face interaction, other farmers, traditional media and modern ICT (Modern ICT in context of this paper means Landline phones, mobile phones, Internet and Internet Kiosk. The survey respondents did not had access to many other modern ICT's like video training, extension agents equipped with tablets, video training. Some new initiatives like SMS on mobile phones, tele-call centres were not separately recorded as only few farmers were using these facilities). The other farmers' category is kept separate from face-to-face information category because it is one of the major source of information (used by almost 90% farmers) and so if we would have clubbed the two categories together then the effects of other farmers category would have been dominant. Thus, to strengthen the internal validity of the analysis, we use it as a separate category. The direct cost of receiving information from any of these sources do not vary much as most of it is provided as part of the government programme or though free messaging services. Although there is difference in the establishment costs of different information sources like traditional media or modern ICT, the cost of receiving information is not considered as a factor influencing the decision of adoption of information source by farmer.

The independent variables that are likely to influence the farmer's behaviour in accessing information from different sources are defined as age of the farmer, education level, farm size, access to assets and geographical parameters represented by state dummies. Jenkins et al. (2011), Thompson (2012), Just et al. (2006) and Ali and Kumar (2010) have demonstrated in their studies that that age, education and income are important parameters that determine farmers decisions to select from different information sources.

Descriptive statistics of demographic and economic variables of the surveyed farmers of our study is also presented in Table 2.

Table 2. Descriptive statistics of demographic and economic characteristics of the surveyed farmers

Variable	Frequency	Percentage
Age (Years)		
less than 25	135	11.25
26–40	443	36.92
41–55	404	33.67
more than 55	217	18.08
Mean Age	42	–
Education level (Years)		
Illiterate	146	12.17
Primary schooling	235	19.58
Secondary and high level schooling	673	56.08
Graduate & above	146	12.17
Land-holdings[a]		
Marginal (less than 2.47 acres[b])	436	36.33
Small (2.47–4.94 acres)	361	30.08
Semi medium (4.94–9.88 acres)	237	19.75
Medium (9.88–24.7 acres)	135	11.25
Large(more than 24.7 acres)	31	2.58
Mean size of land holdings (acres)	5	–
Average no of plots[c]	3	–
Average plot size (acres)	1.75	–
Access to ICT gadgets[d]		
Radio	381	31.75
Television	948	79.00
Landline phone	79	6.58
Mobile phone	1188	99.00
Computer/Internet	56	4.67

Notes: Only 6 females (4 from UP and 2 from WB) were reported in survey of 1200 interviewed farmers. Sample covers 240 farmers from each state.
[a]This is the standardized distribution of land holding used by Agricultural Census of India and other Ministry of agriculture, Government of India publications.
[b]Conversion: 1hectare = 2.47 acres.
[c]Average plot size is calculated by dividing average farm size by no. of plots.
[d]Farmers have access to multiple assets.
Source: Own computation from CIMMYT survey 2011.

Age of the farmer (AGE): It is measured as respondent's age in number of years at the time of data collection. Usually older farmers are less likely to explore new sources of information and thus less likely to depend on multiple sources. It is hypothesized that the increase in age would have influence on access to different sources of information. The mean age of the sample is 40 years.

Education level: It is measured in terms of level of literacy and the codes given are: 0 = illiterate, 1 = primary schooling, 2 = secondary and high school, 3 = graduate and above. Education is one of the important factors that influence farmer's decision to bear the risks associated with new technologies and modern information sources. Farmers with better education are earlier adopters of modern technologies and apply modern inputs more efficiently throughout the adoption process (Feder, Just, and Zilberman 1985).

Farm size: This is proxy for farmer's economic status. It is measured in acres. It is expected to be positively associated with probability of using modern information

sources. The sample has more number of small and marginal farm holders and this matches the operational land holding statistics of agricultural census data by the government of India.

Access to household information assets: This is captured as farmer's ownership of mobile phone, land lines, radio and television. Almost all households own mobile phones.

State dummies: State dummies representing different states are included in the model to account for heterogeneity in the sample due to geographical disparity.

Empirical Model—Multivariate Probit Model

The farmers reported that they access multiple sources of information. We thus assume that farmers are using these multiple sources of information simultaneously for similar information needs. The proposed methodology will derive insight on the farmer's socio-economic factors that lead to their adoption of different information sources. The null hypothesis of this research is that, there is no significant difference between the socio-economic characteristics of farmers and their access to information sources. This implies that farmers irrespective of their age, farm size and education will use a given source of information. The empirical specification of choice decision over the four groups of information sources can be modelled in two ways, by either multinomial or multivariate regression analysis. One of the underlying assumptions of multinomial models is the independence of irrelevant alternatives that is error terms of the choice equations are mutually exclusive (Greene 2003). However, the choices among the information sources are not mutually exclusive as farmers are accessing information from more than one source at the same time and therefore the random error components of the information sources may be correlated. Therefore, we consider using a multivariate model which allows for the possible contemporaneous correlation in the choice to access the four different sources simultaneously. Multivariate probit estimation has already been used in a number of studies that evaluate factors that affect adoption of agricultural technologies (see Gillespie, Davis, and Rahelizatovo 2004; Jenkins et al. 2011). Jenkins uses this approach to evaluate factors that affect cotton producers' adoption pattern of different information sources i.e. private, extension and media and Gillespie, Davis, and Rahelizatovo (2004) used this to estimate factors that affect adoption of four breeding technologies in hog production. They argue that modelling adoption decisions using a multivariate probit framework allows for increased efficiency in estimation in the case of simultaneity of adoption.

Empirically the model can be specified as follows:

$$\begin{aligned} Y_{i1} &= X'_{ij1}\beta 1 + \varepsilon_{i1} \\ Y_{i2} &= X'_{ij2}\beta 2 + \varepsilon_{i2} \\ Y_{i3} &= X'_{ij3}\beta 3 + \varepsilon_{i3} \\ Y_{i4} &= X'_{ij4}\beta 4 + \varepsilon_{i4} \end{aligned} \tag{1}$$

Where, i = farmer id, Y_{i1} = 1, if farmer access information from 'face-to-face' sources (0 otherwise), Y_{i2} = 1, if farmer access information from 'Other Farmers' (0 otherwise), Y_{i3} = 1, if farmer access information from 'Traditional Media' sources (0 otherwise), Y_{i4} = 1, if farmer access information from 'Modern ICT' sources (0 otherwise), X'_i = Vector of factors affecting access to the information source, β_j = Vector of unknown parameters (j = 1, 2, 3, 4), and ε = is the error term. The hypothesis can be tested by running four different independent binary probit or logit models by assuming that error terms are mutually exclusive. However, the decision to adopt different sources may be correlated, thus the elements of error terms might experience stochastic dependence. In this situation, a multivariate probit model of the following form is used to test the hypothesis

$$Y_{ij} = X'_{ij}\beta_j + \varepsilon_{ij} \tag{2}$$

Where *Yij* (j =1, … ,4) represent the four different information sources faced by the *ith* farmer (i = 1, … , 1,200), X'_{ij} is a $1 \times k$ vector of observed variables that affect the choice decision of farmer β_j is a $k \times 1$ vector of unknown parameters (to be estimated), and ε_{ij} is the unobserved error term. Assuming the error terms (across j = 1, … , m alternatives) are multivariate and are normally distributed with mean vector equal to zero, the unknown Ass parameters in Equation (2) are estimated using simulated maximum likelihood. The method uses Geweke-Hajivassiliour-Keane smooth recursive conditioning simulator procedure to evaluate the multivariate normal distribution. We estimate the model using in STATA (version 11) software.

Prior to the estimation of the model parameters, it is crucial to look into the problem of multicollinearity among the explanatory variables. A condition index was used to detect correlation (Belsley, Kuh, and Welsch 1980). The value of condition index is found to be less than 30. Therefore the data has no serious problem of multicollinearity. In this paper, pair-wise correlation of the error terms associated with farmer's adoption decision of information source is computed and its significance is tested to further justify the use of the multivariate probit model.

Discussion of Results

Selection Pattern of Information Sources by Farmers

Farmers reported that no single source provide them all the information that they want, thus, they rely on different sources for different types of information or even similar information. For example the information about inputs and prices is best available from input dealers while output market price information can be obtained from newspaper and middlemen in the village, but these sources lack information about specific choice of fertilizers or nutrients for their farm. Table. 3 presents the combinations of information sources that farmers use in the survey region. Only 9.5% of the farmers are using single source of information and mainly they depend on other farmers for their information needs.

All the farmers who are using traditional media or modern ICT sources are also accessing information from other sources. By using modern ICT along with conventional information sources, these farmers may be benefiting by having better yields or reduced cost of production or better price realization (Jensen 2007; Abraham 2007; Mittal, Gandhi, and Tripathi 2010; Aker 2008). Almost one-third of the farmers are using

Table 3. Proportion of farmers using different combinations of information sources

Possible sources of information combination	Frequencies of farmers	% of farmers
Only 'Face-to-Face'	49	4.0
Only 'Other Farmers'	66	5.5
Only 'Traditional media'	0	–
Only 'Modern ICT'	0	–
'Face-to-Face' and 'Other Farmer'	213	17.8
'Face-to-Face' and 'Traditional media'	24	2.0
'Face-to-Face' and 'Modern ICT'	7	0.6
'Other Farmer' and 'Modern ICT'	25	2.1
'Other Farmer' and 'Traditional media'	80	6.7
'Modern ICT' and 'Traditional media'	9	0.8
'Face-to-Face', 'Other Farmer' and Traditional media	336	28.0
'Face-to-Face', 'Other Farmer' and Modern ICT	36	3.0
'Face-to-Face', 'Traditional media' and Modern ICT	13	1.1
'Other Farmer', 'Traditional media' and Modern ICT	81	6.7
All four	260	21.6
None of the four	1	0.1
Total	1200	100

Note: Four sources of information as categorized for the analysis are—face-to-face interaction, traditional media, modern ICT and other farmers.

combinations of three sources of information, whereas 21.6% of the farmers are using simultaneously all the four sources of information. Due to these wide variations in farmer's selection pattern across various combinations of information sources, there is a possibility that farmer's choice of any particular source is correlated with their choice of other sources of information. To test this, pair-wise correlation coefficients across the residuals of the multivariate probit model is calculated (Table 4). These coefficients measure the correlation between the different information sources, after controlling for the influence of the observed factors that has been accounted (Greene 2003).

Most of the pair-wise correlation coefficient of the residuals of information sources are significant, this supports our hypothesis that the error terms in selection decision equations are correlated and justify the use of multivariate probit instead of independent probit model. The positive signs of the correlation coefficients suggest that the decision to adopt one particular source may make it more likely that another associated source of

Table 4. Correlation coefficients between information-source-selection decisions

Information Source Selection	Correlation coefficient[a]	Standard error
'Face-to-Face' and 'Other Farmer'	−0.441*	0.079
'Face-to-Face' and 'Traditional media'	0.113	0.074
'Face-to-Face' and 'Modern ICT'	0.072	0.073
'Other Farmer' and 'Modern ICT'	−0.055	0.066
'Other Farmer' and 'Traditional media'	−0.026*	0.066
'Modern ICT' and 'Traditional media'	0.240*	0.053

[a]Correlation coefficients between the residuals from the multivariate probit equations.
*indicate statistical significance at the 1% level.

information will also be selected and thereby suggest that the two sources of information are complimentary to each other. Whereas negative signs suggest the substitutability between the two associated sources. In the present model, modern ICT and traditional media sources are the most significant complementary sources for farmers. As an explanation, it could be argued that farmer who adopts radio and/or television for information tends to be more likely to adopt mobile based information sources too. This also justifies our earlier assumption of farmer using multiple sources for accessing information. Another inference can also be drawn that farmers' adoption behaviour is in transition process because they might be switching from the conventional sources to the new sources of information. Therefore, even if farmers are accessing information from modern or traditional media sources of information, they are still relying on old sources.

Results of Multivariate Probit Model

This section presents the estimation results on the factors affecting the information-source selection decision by farmers. The regression results of probit model are presented in Table 5. The explanatory variables of access to radio or television and access to mobile

Table 5. Estimated parameters of farmer's attributes on adoption of different sources of agriculture information: Multivariate Probit Model

	Face to face	Other farmers	Traditional media	Modern ICT
Age	−0.008	−0.001	−0.009*	0.001
	(−0.005)	(−0.005)	(−0.003)	(−0.003)
Educational level	−0.016	−0.151*	0.057	0.258*
	(−0.063)	(−0.051)	(−0.036)	(−0.035)
Farm size	0.082*	−0.001	0.023**	0.027*
	(−0.025)	(−0.013)	(−0.011)	(−0.007)
Access to Radio or television	0.035	−0.239	#	0.214
	(−0.188)	(−0.166)		(−0.138)
Access to Mobile phone	−0.598	0.367	0.299	#
	(−0.826)	(−0.546)	(−0.394)	
State dummies				
Bihar	−2.878*	1.024*	0.974*	0.942*
	(−0.194)	(−0.162)	(−0.124)	(−0.138)
Haryana	4.622	5.223	2.206*	1.311*
	(−294.34)	(−144.88)	(−0.193)	(−0.146)
Punjab	0.715*	1.133*	1.376*	0.157
	(−0.244)	(−0.182)	(−0.139)	−0.151)
Uttar Pradesh	0.978*	1.253*	0.301**	(0.534*
	(−0.231)	(−0.177)	(−0.119)	−0.138)
Constant	1.931**	0.756	−0.529	−1.940*
	(−0.888)	(−0.606)	(−0.431)	(−0.224)
Log Likelihood value				−1663.958
Wald test χ^2 (34)				964.680*
LR test of ρ_{ki}				48.438*
Number of Observations				1199

Note: West Bengal is used as a benchmark dummy, # Variable dropped in respective regression equation to avoid multi-colinearity; Figures in parenthesis are robust standard errors.
Likelihood Ratio Test H0: $\rho_{21} = \rho_{31} = \rho_{41} = \rho_{32} = \rho_{42} = \rho_{43} = 0$, $\chi^2_{(6)} = 69.4636$, p-value = 0.0000.
*, ** represent statistical significance at 1%, 5%.

phone have been removed from the last two columns respectively, due to their perfect collinearity with the respective dependent variable (The likelihood ratio test of ρ_{ki} (positive) reject the null hypothesis of error term correlation, justifying the use of multivariate probit model. Significant value of wald χ^2 test also allow us to reject the conjoint nullity of variable coefficients included in estimation).

The results suggest that farm size and state dummies significantly affect farmer's choice of information use from face-to-face sources. The coefficient for farm size is positive and significant coefficient of farm size suggests that farmers with large farmers are more likely to obtain information from a variety of sources, such as face-to-face interactions, traditional media and modern ICT. These farmers are more likely exploring new information and information sources which may be important to efficiently do farm risk management. Farm size as discussed before is also used as a proxy for farmer's economic status.

The negative and significant coefficient of Bihar dummy reflects a higher likelihood of not adopting face-to-face information sources whereas Uttar Pradesh and Punjab are positively and significantly influencing the decision of adopting information from this source. The positive and significant constant value also suggest that other things remain constant the surveyed farmers are more likely to prefer face-to-face interactions for agriculture information relative to other sources.

Though more than 90% of farmers are accessing information from 'other farmers' as shown in descriptive statistics in Table 2, the regression results suggest that farmers with relatively better education rely less on other farmers, and explore other information sources like modern ICTs for new information content. State-wise dummies show that farmers from all states except Haryana have a higher likelihood of obtaining information from other farmers relative to the reference state.

For the 'Traditional Media' information source equation, coefficients of age and farm size variable are significant. The coefficient for age is negative and this implies that elder farmers have extensive experience and knowledge about agriculture and thus they usually do not find much value from information that traditional media delivers. The coefficient for farm size is positive indicating that larger farmers will use traditional sources. However the coefficient of education level is not significant for use of traditional media but all the state dummies are positive and significant. With this we can generalize the fact that despite wide variation across socio-economic background of states, the general farmer tries to still use the traditional media for agriculture information.

The use of modern ICT information source comprised mainly of mobile phone-based information is positively and significantly associated with education level and farm size. This also means that resource rich farmer accesses information not only from the traditional media sources but also benefits from modern methods of information delivery like mobile phones. These results can be supported from some earlier studies which had shown that rich and large farmers are able to benefit more from the information delivered through mobile phones (Jensen 2007; Abraham 2007; Mittal, Gandhi, and Tripathi 2010). Access to ICT gadgets like radio and television is positively related to use of modern ICT although the coefficient is not significant, but this demonstrates complementarity in use of traditional media and modern ICT information sources. Bihar, Haryana and Uttar Pradesh are positively and significantly influencing farmer's adoption of modern ICT. The negative and significant constant value suggests that if other things remain same, surveyed farmers are less likely to only use modern ICT for information. This is in line

with our earlier inferences that farmers are motivated towards the use of modern information sources but only as a complementary to conventionally used information source.

Overall the regression results reject the null hypothesis that the socio-economic characters do not influence the adoption of different sources of information. The results suggest that as education level increases farmers tend to move from gathering information from other farmers' to modern ICT sources. Large farmers are positively and significantly associated with almost all categories of information sources. This may be because large farmers are more resourceful and have larger market surplus and are more aware and connected with all the available source of information unlike most of the small farmers who mainly produce to meet their subsistence needs. The coefficient for education level is positive and significant for modern ICT which on one hand implies that with increase in education, awareness increases and need to access different information sources arises. But it may also be that as modern ICT information dissemination in India is mainly through text messages, literacy is a constraint that excludes low educated farmers to use this source of information. The state dummy variables capture the variability in infrastructure, policy and state level constraints. Empirically these results are also shown by Jenkins 2009, Jenkins et al. 2011, Thompson 2012 and Ali and Kumar (2010).

Conclusion

In the dynamic and changing agricultural scenario, agricultural information plays a decisive role for the overall development of agriculture as well as improving the livelihoods of farmers. Agriculture information requirements are changing constantly which are primarily due to changing needs of agricultural activities and also farmers increasing awareness. Farmers need a wide variety of information on various issues such as availability of new inputs, technology or seed variety; disease outbreak or weather forecasts, market information and price information of both input and output for crop production and management, availability of agricultural support services or government schemes related to agriculture. Farmers access agriculture information from different sources and also as per the needs and demand of farmer.

This paper has investigated the factors that may influence farmer's adoption of different information sources. Taking into account the potential correlation among alternative information sources, multivariate probit model is used and the results showed that socio-economic characteristics of farmers like age, level of education and farm size are significantly related to farmer's use of different sources of agricultural information. These results can be used further to design programmes specific to farmer's profile. More simply, using these results, information providers can better anticipate which types of farmers would use their information in combination with other information sources. These results show the complementarity in the use of different sources of information and role of education in getting farmers connected to new sources of information. Also the inferences drawn in this paper need further exploration with farmers through experimental research. Overall, the farmers rely on multiple sources of information, but they still continue to extensively use other farmers and face-to-face interactions. We also do not deny the fact that successful use of information as a resource for agriculture development depends largely on the accessibility and adequacy of the information source, farmers preference for a particular information source and farmer's ability to use information.

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Appendix A: List of areas covered

State	Districts			
Bihar	Samstipur	East Champaran	Nawada	Bengusarai
Haryana	Sonepat	Kurkshetra	Karnal	Yamuna Nagar
Punjab	Amritsar	Bhatinda	Ludhiana	Sangrur
Uttar Pradesh	Barabanki	Deoria	Maharaj ganj	Meerut
West Bengal	Murshidabad	Nadia	North Dinajpur	South Dinajpur

Appendix B: Differences in different mode of information for agriculture services

	Various categories of information delivery		
	Face to face	Traditional media	Modern mode
Source of Information	• KVK/Research • Station • SAUs • Krishi Mela • State Dept. of Agriculture • NGO/ Cooperatives • Commission agent/ Mandi • Input dealers, private companies, shops	• Television • Radio • Newspaper	• Landline (Tele-centre) • Mobile Phone • Kiosk/Internet
Type of service provider	Government	Mostly Government	Mostly private
Scale of Information Dissemination	One person at one time	Many person	Unlimited number of person can be covered in some cases, e.g. sending information via SMS
Content of information	Generic information	Generic information	Customized information and individual solutions
Adequacy of information	Information not updated, not available on time	Not timely though reliable	Timely and reliable
Distance	Distance Restriction	In case of television distance restriction	No distance restriction
Literacy	No issue	Literacy for newspaper is an issue	Basic literacy for reading SMS, proper education for internet
Problems	Availability of Extension officer	Electricity problem in case of television	Local content of SMS, farmers lack awareness and technical know-how to use. Infrastructure of kiosks a limitation

Note: Category of other farmers is not included in this comparison since this category includes informal interactions with friends and relatives.
Source: Author's own compilation from CIMMYT survey, 2011