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User Centric ICT Model for Supply Chain of Horticultural Crops in India§

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Abstract

Considering the immediate need to integrate the supply chain of horticultural crops by providing need-based information to different players mainly farmers, the paper has analyzed various aspects like information needs, sources of information and their reliability, factors responsible for willingness to pay for information and parameters of an ideal information dissemination system under the Indian conditions. The study is based on a sample of farmers from three districts of Madhya Pradesh and has revealed that farmers are the vital link in the supply chain of horticultural crops with a vast range of information requirements. This information may be delivered effectively using ICT, mainly mobile phones, which are being utilized by two-thirds of the farmers in the study area. Age, education level and irrigation have been found the factors defining the willingness of a farmer to pay for having access to information. To promote use of ICT for the effective and timely dissemination of information, a user-centric model has been envisaged which has suggested adoption of an integrated approach for information delivery to farmers. The study has also made some recommendations like increasing the reach of mobile phones, making ICT more farmer-friendly, and encouraging the corporate sector in having revenue model for information dissemination as majority of the farmers' are willing to pay.

Key words: Supply chain, horticultural products, information needs, information dissemination model, willingness to pay

JEL Classification: Q16, Q19, Q12

Introduction

Agriculture is a source of livelihood for a vast majority of poor, and holds the promise for reducing poverty. World wide, agricultural development has been two-to-four times more effective in reducing hunger and poverty in a country than any other sector (BMGF, 2011). The developments in agricultural sector were reported to be about four-times more effective in poverty reduction in China (Ravallion and Chen, 2007, World Bank, 2008a).

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Agriculture is an important sector of Indian economy and has achieved impressive growth in terms of increased production and marketable surplus of foodgrains and commercial crops (GoI, 2007). However, it is the diversification of Indian agriculture, in recent past, towards high-value horticultural crops, mainly fruits and vegetables, which has provided commercial dimensions to the Indian agriculture. Today, India stands second in production of fruits and vegetables in the world (NHB, 2011). With the concentrated efforts of Government of India through National Horticulture Mission, the pace of increase has been more in horticultural production than in foodgrains (Sharma, 2011; GoI, 2012).

The estimates of the marketed surplus from agri-commodities for the year 2011-12 indicate that the quantum of marketed surplus will be more for fruits and vegetables than for foodgrains and oilseeds (GoI, 2007). Only 2 per cent of horticultural produce is processed, 0.4 per cent is exported and 22 per cent is lost or wasted in the market chain (Singh, 2008). The efforts to increase horticultural production without giving much emphasis on developing adequate market infrastructure may have unfavorable implications for farmers.

There is a need for a new revolution to bring down the prices of agricultural produce for consumers through efficient supply chain management, and incentivize farmers to increase their production. The supply chain for horticultural products in India is highly fragmented and skewed away from producers for its inherent features like small landholding, illiteracy, poor access to organized finance, markets and information (World Bank, 2008b). A number of supply chains are operating in India for movement of commodities from farm gate to the ultimate consumer. The supply chain considered in this study mainly focuses on the flow of commodities from farmer to the consumer involving producers, traders and retailers. The challenges relating to supply chain in Indian agriculture are: non-availability of good quality seeds, lack of soil testing facilities and extension staff, poor access to credit, lack of information, huge post-harvest losses, lack of infrastructure like roads, cold storage, etc., poor market intelligence, high transportation cost, etc. (Kumar *et al*., 2004; Mittal, 2007).

Both public and private sector players have been trying to address the long-term and short-term challenges in agriculture, including reddresal of the abundant information needs of the sector. The task of information dissemination is quite challenging due to various factors like low literacy rate, poor availability of modern communication means, small landholdings and diversified crop cultivation that multiply the information needs. Hence, effective dissemination of the information using the existing technologies would be vital in enhancing efficiency of supply chain by integrating producers with the supply chain. Use of information and communication technology (ICT) could be one of the appropriate solutions in this regard. Since ICT includes anything ranging from radio to satellite imagery to mobile phones or electronic data transfers (Mcnamara *et al.*, 2011), it has the potential to strengthen the position of farmers by providing timely, accurate, reliable and demand-driven information in a user-friendly manner on various aspects. The impacts of ICT initiatives include increase in crop yield, profit and access to information, and decrease in the use of pesticides, fertilizers, input cost, and consumer price (Ramaraju *et al.,* 2011; Jensen, 2007).

The ICT based interventions are using different technologies, but with a limited reach to the ultimate user due to various factors such as literacy level, understanding of ICT, extent of telecommunication infrastructure, awareness level and information needs of farmers, etc., leading to poor utilization of the information collected (Shalendra *et al.,* 2011). To enhance the efficiency of dissemination of information and to ensure its optimum utilization, it is important to find information needs of farmers. Under this back ground, this study was conducted with the following specific objectives: (i) to assess the information requirement of different actors in the supply chain, (ii) to evaluate the reliability of information obtained from various sources, (iii) to identify factors responsible for stakeholders adoption of ICT means and willingness to pay for information, and (iv) to suggest a suitable user-centric model for effective and efficient delivery of information.

Methodology

It is pertinent to know the information needs of the players in the supply chain, factors affecting adoption of means of information access, and willingness to pay for the information for suggesting an effective ICT model for dissemination of information. The state of Madhya Pradesh has taken a lead in acknowledging the importance of information and ICT application in bringing transparency and efficiency in various marketing functions and integrating different players of the supply chain. There are several public and private ICT initiatives in the state such as ITC e-choupal, Electronic networking of Mandies, AGMARKNET, etc. The paper is mainly based on the primary data collected using pre-tested schedule during the agricultural year 2010-11 from a sample of 105 farmers selected randomly from three districts of western Madhya Pradesh, viz. Ratlam, Ujjain and Mandsaur. The farmers were segregated into

two groups, adopters and non-adopters of ICT means for accessing information. The farmers utilizing one or more than one means out of phone (both mobile and landline), internet, radio and television were categorized as adopters, while the remaining were termed as non-adopters. The farmers' responses to various questions related to the use of ICT for accessing information were obtained and recorded. In addition to primary data, information from other published sources was also utilized. The statistical tools used in the study were descriptive statistics, logistics regression model and discriminant function analysis.

The logistic regression analysis is used to analyze the factors influencing the decision of adoption of ICT as a means for having access to information. The model utilized for the study is given in Equation (1):

$$Y_i^* = \alpha + \sum_{i=1}^{n} \beta_i X_i + \varepsilon_i \quad \ldots(1)$$

where, Y_i^*defines whether farmers access information from any source of ICT or not, X_i are independent variables influencing adoption of ICT means for information, β is a vector of unknown parameters, α is the intercept and ε_i is the error-term.

The model was specified and estimated to predict the likelihood or probability of the factors influencing adoption of ICT means (Ali, 2011) as follows:

$$\log(\text{ICT\_U}) = \alpha + \beta_1 \text{AGE} + \beta_2 \text{EDU} + \beta_3 \text{LAND} + \beta_4 \text{IRR\_L} + \beta_5 \text{INC} + \beta_6 \text{DIS\_MAR} + \beta_7 \text{GCA\_FV} + \varepsilon_i \quad \ldots(2)$$

The description of variables used in the model along with descriptive statistics and the expected directional effects of each independent variable are given in Table 1. The logit model is based on the cumulative probability function and is specified as per Equation (3):

$$P = F(Z) = \frac{1}{[1 + e^{-(\alpha + \beta_t X_i)}]} \quad \ldots(3)$$

where, *Z* determines a set of explanatory variables *X*; *F(Z)* is the cumulative logistic function; *e* represents the base of natural logarithms; and *P* is the probability of success when explanatory variable has the value *X*. Logit models are interpreted using Odds ratios. The odds ratio indicates the multiplicative impact in the odds for a unitary change in the explanatory variable, holding other variables constant. If the exponentiated coefficient is greater than unity, it explains that the odds are increasing. A negative value indicates that the odds are decreasing. Deviation of the exponentiated coefficient value from one indicates the magnitude of impact on the odds for a unit change in independent variable.

To identify the variables that discriminate farmers into willing-to-pay (Group 1) and not-willing-to-pay (Group 0) groups, a linear discriminant function was used. A high value of Z corresponds to willingness to pay and a low value for not willing to pay. The magnitude of the coefficients is an indication of the relative importance. Variables with large coefficients are thought to contribute more to the overall

Table 1. Description of variables considered in logistics regress analysis

Variable	Description	Mean	Standard deviation	Expected sign
Dependent				
ICT_U	Use of ICT mode for agricultural information	0.72	0.45	
Independent				
AGE	Farmers' age (years)	38.4	11.54	-
EDU	Farmers' education level (No. of years)	9.32	4.06	+
LAND	Farmer's operational landholding (ha)	6.08	5.47	+
IRR_L	Proportion of irrigated land (%)	88.90	17.27	+
INC	Monthly household income (₹/month)	10940.55	10183.55	+
DIS_MAR	Distance to market (km)	13.88	8.51	-
GCA_FV	Proportion of gross cropped area put to horticultural crops (%)	34.49	16.53	+

Source: Authors' calculations based on survey

discriminant function. The percentage of cases classified correctly is an indicator of the effectiveness of the discriminant function. This tool has been extensively used in agricultural finance, especially in discriminating defaulters and non-defaulters of farm credit (Pandey and Muraleedharan, 1977). The variables were selected in such a manner that those related to demography, literacy, occupation, agriculture and information were included in the analysis.

The discriminant function used in the study could be mathematically represented by Equation (4)

$$Z = \sum_{i=1}^{n} L_i X_i \quad \ldots(4)$$

where, *Z* is the total discriminant score for farmers willing to pay and not willing to pay,

X_1 = Source of information (ICT source=1, otherwise=0),

X_2 = Age of farmers (years),

X_3 = Number of years of schooling,

X_4 = Total operational land (ha),

X_5 = Proportion of irrigated land (%),

X_6 = Gross cropped area under fruits and vegetables (%),

X_7 = Family income per month (₹),

X_8 = Distance to market (km),

X_9 = Reliability of information (reliable=1, otherwise=0),

X_{10} = Main occupation of farmer (agriculture=1, otherwise=0), and

Li (i =1,2....,10) are linear discriminant coefficients.

Information Requirement

Table 2 broadly describes the information requirements of different players in the supply chain. A strong need is felt of information dissemination among farmers throughout the value chain (Meera *et al.*, 2004; Meitei and Devi, 2009; Narula and Nainwal, 2010). Timely, accurate and representative market information is a powerful tool in the empowerment of farmers in a libralised marketing system (Tollens, 2006). Farmers need information at every stage, from sowing of seeds to marketing of produce. As per the findings of the study, information was required by them on various aspects of production like availability of inputs, new production technologies and scientific management of crops. They also needed information on various marketing related issues like proximity of markets, trends in prices and arrival of different commodities in various markets and price support policies of the government. General agricultural information such as crop insurance schemes, weather and agriculture related news was also sought by the farmers.

Another important player in the supply chain is 'trader', who plays an important role in the regulated markets, particularly in the process of price discovery for farmers' produce. The information requirement of a trader is less than of a farmer. The focus of trader is

Table 2. Information requirements of different players in the supply chain

Stage	Farmer-Producer	Trader	Retailer
Production	Inputs (prices & availability), soil testing, production technologies, good agricultural practices	Acreage under crops, production estimates	—
Post-harvest management	On-farm/ scientific storage, grading and sorting, packing, transportation	Storage facilities, grades and standards, transportation, packaging	Packaging
Marketing	Markets, price and arrivals, alternative buyers	Markets, price and arrivals, market and legal issues, international trade	Prices, arrivals, intra-mark-up prices, markets, transport
Others	Weather, credit	Weather, credit	Credit, festive-driven demand

Source: Narula and Nainwal (2010) and field discussions.

Table 3. Information requirements of producer-farmers

Information requirement	Most important	Important	Less important
Inputs – prices and availability	57	21	22
Cultivation practices	80	8	12
Plant protection	64	18	18
Weather information	69	22	9
Market price	74	16	10
Information on crop insurance	70	18	12
Scientific management	75	12	13
New production technology	76	11	13
Post harvest management	68	20	12
Markets available	63	25	12
Arrivals in different markets	60	24	16
Agricultural news	62	19	19
Food safety & quality	51	26	23

Source: Field Survey 2010-11

on market-related information, viz. on prices, arrivals, market availability, legal aspects, international markets and government policies. He also needs information on acreage under different crops to project quantum of arrivals in the markets. The retailers' information requirements are minimal in comparison to those of farmers and traders. They are largely concerned with information on prices and arrivals of different commodities in different markets in the vicinity.

The study has revealed that in crop production factors such as cultivation practices, plant protection and scientific management have been perceived as most important (Table 3). Though information on availability of markets and arrivals of commodities in various markets has not been perceived so important by the farmers, they do seek information on market prices to choose the market to which produce should be taken to get a better price. Other issues perceived important by farmers were crop insurance, weather, and post-harvest management. Food safety and quality were the least important issues in their menu of information. This suggests that farmers are either targeting domestic market only or they are not aware about the niche market which requires fulfillment of safety requirements. In the recent past, the Food Safety and Standards Act, 2006 has been promulgated in India and hence, it will be mandatory to follow certain safety requirements by the farmers as well as other players in the supply chain.

Sources of Information and their Reliability

The farmers had access to a number of information sources but they utilized mainly the traditional sources like fellow farmers, relatives, extension personnel and traders (Table 4). It was found that the farmers relied more on information received from traders and fellow farmers than from relatives and extension service providers.

The study has revealed that cellular phone was being used for seeking information by two-thirds of the farmers. Other reliable sources of information were newspaper-magazines, television, and radio. The farmers' access to information through such sources has been reported in other studies also (Mwakaje, 2010). Internet in-spite of various initiatives by the public and private sectors was not a popular means of information delivery in India. Thus, despite development of ICT as a source of information delivery, farmers rely more on traditional sources.

Factors Affecting Adoption of ICT Means

The results on parameter estimates of the logistics regression model on adoption of ICT as a means of access to information are presented in Table 5. It was found that factors like age, education, monthly family income, proportion of area under horticultural crops and distance from market had a significant influence on the farmers' decisions for adoption of ICT for

Table 4. Sources of information for Indian farmers and their reliability

Source	Sources of information for farmers		Reliability of information source (per cent farmers)		
	Number	Per cent	Highly reliable	Moderately reliable	Unreliable/ undecided
Fellow farmers	77	73.3	43.8	21.9	34.3
Relatives	64	61.0	27.6	26.7	45.7
Extension service providers	57	54.3	38.1	17.1	44.8
Private extension service providers	44	41.9	28.6	16.2	55.2
Traders	54	51.4	53.3	19.0	27.6
Television	47	44.8	51.4	25.7	22.9
Radio	33	31.4	42.9	22.9	34.3
News papers-magazines	66	62.9	40.0	16.2	43.8
Cellular phone	70	66.7	51.4	14.3	34.3
Internet	17	16.2	31.4	10.5	58.1

Source: Field Survey 2010-11

Table 5. Parameter estimates of logistics regression

Parameter	Description	β	Standard error	p-value	Exp (β)
Intercept		-5.117**	2.387	0.032	0.006
AGE	Farmers' age	-0.063***	0.160	0.095	0.939
EDU	Farmers' education	0.588*	0.160	0.000	1.801
LAND	Operational land holding	0.152	0.113	0.181	1.164
IRR_L	Proportion of irrigated land	0.011	0.020	0.576	1.011
INC	Monthly household income	0.000**	0.000	0.034	1.000
DIS_MAR	Distance to market	-0.065**	0.042	0.026	0.937
GCA_FV	% GCA horticultural crops	0.055**	0.024	0.032	1.056
log likelihood		56.768			
Chi-square		66.989*	df=7	0.000	
Correct prediction (%)		84.0			

Note: *, ** and *** denote significance at 1 per cent, 5 per cent and 10 per cent levels, respectively

accessing to information. The likelihood ratio test statistics indicated that explanatory variables used for predicting the decision of ICT-based information could explain a fairly good fit in the model. The coefficients of operational landholding and irrigation were found to be non-significant.

Willingness to Pay for ICT-based Information

The provision of timely and accurate information involves cost, and therefore, it was pertinent to find users' willingness to pay for the services. It was found that more than 70 per cent of the farmers expressed their willingness to pay for ICT-based agricultural information delivery (Table 6). The willingness to pay was expressed for services such as voice message (77%), text message (81%), internet based (19%) and phone interactive (14%).

Farmers' willingness to pay for ICT-based information was not uniform across different sources of information. Identification of factors motivating farmers to pay for services will help in formulating strategies to commercialize and popularize use of ICT in agriculture. To identify the variables that categorize farmers into willing-to-pay (Group 1) and not-willing-

Table 6. Willingness to pay for ICT-based information

(in per cent)

Particulars	Yes	No	Undecided
WTP	70.5	19.0	10.5
If willing to pay, choice of services			
Phone voice SMS	77.0	—	—
Phone text SMS	81.1	—	—
Internet based	18.9	—	—
Phone interactive	4.1	—	—

Source: Field Survey 2010-11

to-pay (Group 0) groups, the linear discriminant function was used (Sulaiman and Sadamate, 2000).

The coefficients of discriminating variables for willingness to pay in the study area, given in Table 7, reveal that the variables such as the age of respondent (X_2), education level (X_3) and proportion of area under irrigation (X_5) were significant in the same order of sequence. When these three variables were included, the relevant discriminant function was of the following form:

$$Z= -0.790X_2 \quad 0.590X_3 \quad 0.494X_5$$

Z values are as follows:

For Group 0 = -0.805; for Group 1 = +0.420

The signs of X_is in the equation suggest that a farmer of younger age, higher education level and with higher level of irrigation are willing to pay more for agricultural information. Sulaiman and Sadamate (2000) have reported that variables like satisfaction level with primary source of information, higher income, higher proportion of gross cropped area under non-food crops and younger age to be the significant discriminators between those willing and not willing to pay for agricultural information.

User Centric ICT Model of Information Dissemination

Several models have been attempted by different players like government, private and cooperative institutions and NGOs to disseminate information on various aspects of production and marketing of agricultural commodities using different means of ICT (Shalendra *et al.,* 2011). The penetration of mobile phone is fast increasing and tele-density in rural India has been reported to have reached 38.53 per cent by the end of February 2012 (TRAI, 2012). Under such circumstances, mobile phones with reasonable penetration in the rural India and being used by two-third farmers in the study area may provide an effective platform for information dissemination. A user-centric ICT model for information dissemination has been envisaged (Figure 1) in this study also.

Another mode utilized successfully in some of the approaches to deliver information is introduction of a *Sanchalak* (facilitator), who is an educated and progressive farmer from the farming community. The initiatives like e-Chaupal have helped in the development of indigenous force in the form of

Table 7. Coefficients of discriminating variables for willingness to pay for information

Sl. No.	Discriminating characteristics	Discriminating function coefficient
1	Source of information (ICT source=1 otherwise=0)	NS
2	Age of farmers (years)	-0.790
3	Number of years of schooling	0.590
4	Total operational land (ha)	NS
5	Proportion of irrigated land (%)	0.494
6	Gross cropped area under fruits and vegetables (%)	NS
7	Family income per month (₹)	NS
8	Distance to market (km)	NS
9	Reliability of information (Reliable=1, otherwise=0)	NS
10	Main occupation of farmer (Agriculture=1, otherwise=0)	NS

Source: Authors calculations

Note: NS – Non-significant

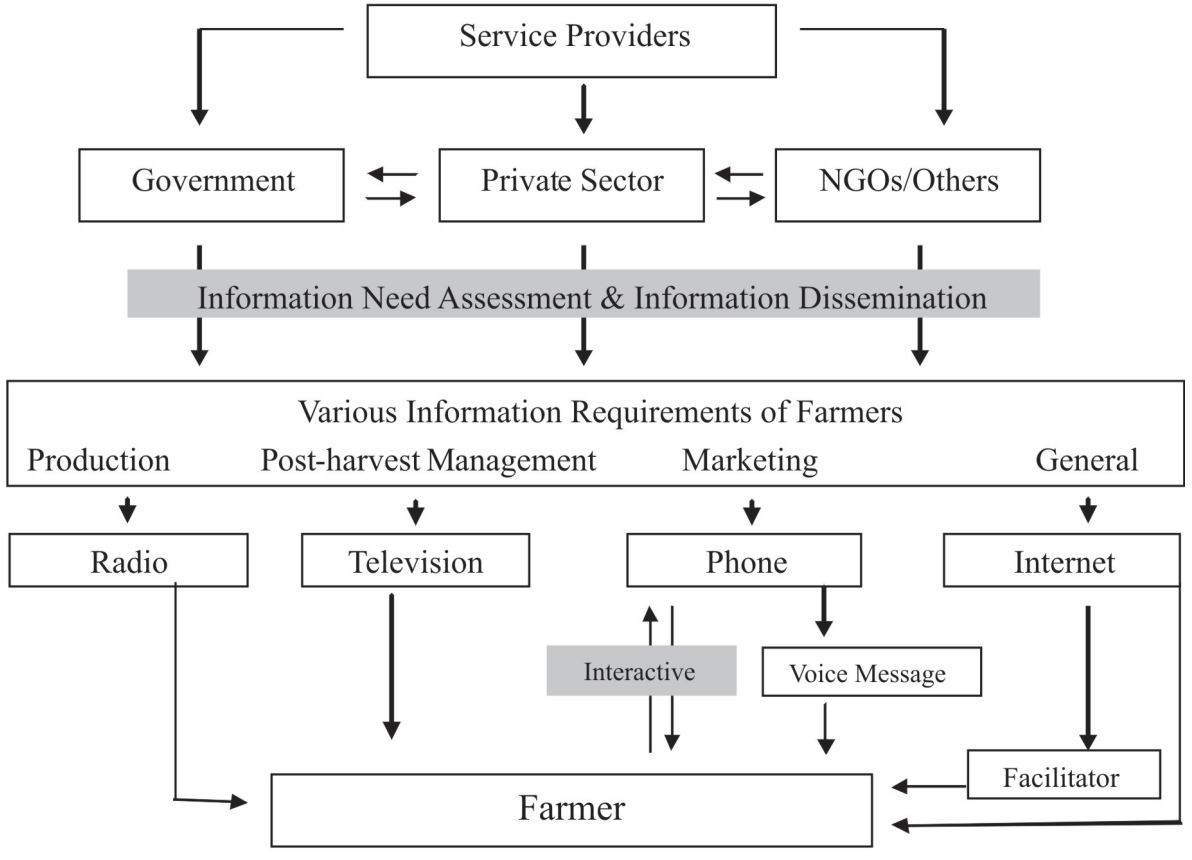

Figure 1. ICT-based user-centric information dissemination model

Sanchalaks that has ensured both local expertise and social acceptability (Ali, 2008). Such initiatives can effectively address problems like poor availability of internet facilities, low level of reliability on information, low level of literacy and lack of IT exposure to the farmers.

Another important dimension of an efficient information dissemination model is the delivery of need-based information. The content of information to be delivered to the farmers should be developed after a thorough assessment of the information needs of farmers and other stakeholders.

Also there are various agencies operating in isolation to serve the varying needs of farmers on the entire supply chain. The integration of such agencies will help in better dissemination of information and optimum utilization of resources. In addition to this, the dissemination of information may also be made effective through conglomeration of different ICTs like internet, text and voice messages, radio and television. The model also has proposed qualities like 'windows' for answering queries so that framers may interact with experts and receive customized information.

Recommendations

To enhance the efficiency of supply chain used for horticultural products using ICT, following recommendations have been made.

- Considering deep penetration of mobile phones into rural areas, its reach should be increased and facilities like voice SMS and text SMS may be utilized to disseminate information.
- Since factors like age and education have been found responsible for adoption of ICT, the higher proportion of youths and increasing literacy rate should be extensively utilized for information dissemination.
- Given the nature of cultivation and its lucrative returns, the supply chain of horticultural crops be made ICT-friendly.

- Encourage the private initiatives to provide need-based information to the farmers through a revenue-based model as most farmers are willing to pay for the service.
- As suggested by the model, an integrated approach envisaged in the study should be adopted for dissemination of information.

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