Policy Paper 29

The Impact of Information on Returns from Farming

Pratap S. Birthal
Shiv Kumar
Digvijay S. Negi
Devesh Roy

भा.कृ.अ.प.– राष्ट्रीय कृषि आर्थिकी एवम् नीति अनुसंधान संस्थान
ICAR – NATIONAL INSTITUTE OF AGRICULTURAL ECONOMICS AND POLICY RESEARCH

NIAP Publication Committee

Pratap S. Birthal
S. S. Raju
N. P. Singh
Raka Saxena

NIAP was established by the Indian Council of Agricultural Research (ICAR) to strengthen agricultural economics and policy research in the National Agricultural Research System comprising network of ICAR institutions and State Agricultural Universities. The mandate of the Institute is:

- Policy-oriented research in network mode on (a) technology generation, diffusion and impact; (b) sustainable agricultural production systems; and (c) interaction between technology and other policy instruments like incentives, investments, institutions and trade, and (d) agricultural growth and development with focus on the role of technology.
- Strengthen capacity in agricultural economics and policy research in the national agricultural research system
- Enhance ICAR participation in agricultural policy decisions through policy-oriented research and professional interactions

NIAP has emerged as a think tank in the area of agricultural economics and policy research and it has considerably increased ICAR participation in policy making. Besides ICAR, the Institute regularly provides research based input to Planning Commission, various Ministries at Centre and States and to many other stakeholders for policy decisions in diverse areas related to agriculture.

Policy Paper 29

The Impact of Information on Returns from Farming

Pratap S. Birthal
Shiv Kumar
Digvijay S. Negi
Devesh Roy

ICAR – National Institute of Agricultural Economics and Policy Research
New Delhi - 110 012

The Impact of Information on Returns from Farming

Pratap S. Birthal
Shiv Kumar
Digvijay S. Negi
Devesh Roy

Published
October, 2015

Published by

Dr. P. S. Birthal
Acting Director
ICAR – National Institute of Agricultural Economics
and Policy Research
New Delhi - 110 012

The views expressed by the authors in this policy paper are personal and do not necessarily reflect the official policy or position of the organization they represent.

Printed at

National Printers, B-56, Naraina Industrial Area, Phase II, New Delhi-110028; Phone No.: 011-42138030, 09811220790

Preface

Information has considerable potential to influence agricultural outcomes, *i.e.*, agricultural productivity, farm incomes and ultimately farmers' welfare. It is vital input in agricultural production. Through its interaction with other factors of production, such as land, labour, capital and managerial ability, it improves production efficiency. The evidence presented in this study shows that information raises farm income by about 12%; the impact being bigger in the diversified cropping systems.

The need for information is more pronounced in smallholder-dominated agricultural systems as in India where farmers struggle to produce more to meet the growing demand for food, feed and fibre under resource constraints of land, water and energy that have already reached their extensive limits. Moreover, climate change is emerging as a big threat to agriculture. At the same time, demand for diverse, safe and quality food is becoming stronger in domestic as well in international markets. Future agriculture, thus, will become more information-intensive.

Agricultural research generates new technologies and agricultural practices that need to be disseminated to farmers and other stakeholders in right form and at right time. There are various means, such as public extension systems, mass media, social networks, and private agribusiness and marketing firms, through which the information can be disseminated. These information nodes, however, may differ in their outreach and efficiency. This study finds that formal information sources though are limited in their outreach; these have a larger impact on farm incomes. However, in a vast country, as India with considerable agro-ecological and social heterogeneity the need for a pluralistic information system cannot be undermined. The newer sources of information, such as mobiles and internet that are cost-effective and faster means of information dissemination, can fill the gap. The findings of this research will be useful in designing digital information system for Indian agriculture.

Pratap S Birthal
Acting Director

Acknowledgements

This study has benefitted from comments and suggestions from many peers and professionals. These include Prof. Ramesh Chand, former Director of NIAP and now Member, NITI AYOG, Government of India; Dr. P.K. Joshi, Director-South, Asia, International Food Policy Research Institute (IFPRI), New Delhi Office; Prof. Bharat Ramaswami, Indian Statistical Institute (ISI), New Delhi; Dr Srijit Mishra, Indira Gandhi Institute of Development Research (IGIDR), Mumbai and Dr Shalendra Kumar, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru. We thank all of them.

Authors

Contents

List of Tables and Figures

Tables

Figures

Executive Summary

Owing to several changes, such as shifts in food consumption away from staples towards high-value food products, growing stresses on natural resources, and climate change, Indian agriculture is becoming increasingly knowledge-intensive. Farmers need different types of information—ranging from weather forecasts and advisories, inputs, agronomic practices, pest management, markets and prices. The demand for information has amplified as farmers are tasked with not only enhancing agricultural productivity and conserving natural resources but also other requirements, such as complying with market preferences for diverse, safe and quality food. Adjusting to these changes requires a variety of information, the access to which can differentiate farm households, in terms of returns from farming.

While the role of information is becoming increasingly important in improving efficiency of agricultural production, there have been limited efforts towards a rigorous impact assessment of the access to and use of this vital input on the outcomes of farming. In this paper, using data from a nationally representative survey, conducted by the National Sample Survey Organisation (NSSO) of the Government of India, we examine farm households' access to and use of information, and its effects on farm income.

Approximately 40% of the farm households in India have access to information on fertilizer application, crop varieties, pest management, marketing, etc. However, only 75% of those who access information, use it in their farming decisions. The distribution of users of information by its source indicates that the government information sources including public extension workers, Krishi Vigyan Kendras (agriculture science centres), farm demonstrations, farmers' trainings and study tours organized by the government agencies, comprise a source of information for only 14% of the farm households. Farmers meet most of their information needs from other sources, including mass media, private sources and social networks. The social networks (progressive farmers, primary cooperative societies and village fairs) are utilized by 29% of the farm households, with progressive farmers being a prominent source. About 23% of the farm households depend on private sources, mainly on input dealers, for their information needs. Mass media sources, such as radio, television and newspaper are utilized by one-third of the farm households.

A number of socio-economic characteristics differentiate users of information from its non-users. The users of information have relatively

larger landholdings, higher endowment of labour and greater access to institutional credit. They are also more educated and better informed about the government policies. Further, the information use also differs by farm size and social status. About 41% of the large farmers (>4ha) use information compared to 20% of the sub-marginal farmers (<0.5ha). In rural areas, caste is an important indicator of social status, with scheduled caste and scheduled tribe being at the bottom of caste hierarchy. About 35% of the upper caste households use information as against 23% and 20% of the scheduled caste and scheduled tribe households, respectively. Further, smaller farmers and those at the bottom of social hierarchy (scheduled castes and scheduled tribes) use fewer information sources. Also, they are more dependent on informal information sources, *i.e.*, social networks and private sources. Larger farmers and those from upper castes use information from multiple sources, relatively more from mass media. These indicate toward a potential bias in access to information, which probably could be due to differences in observable (farm size, caste, age, education, etc.) and unobservable (skill, attitude towards risk, etc.) characteristics of the farm households that may simultaneously influence returns from farming.

The analysis of net income from cultivation by farm size and number of information sources used indicates that users of information (except sub-marginal farmers) realize significantly higher income per unit of land, and it increases with intensity of information use, *i.e.*, number of sources used. After controlling for the potential selection biases, the study finds that users of information realize 12% more income than the non-users. The impact is bigger in diversified cropping systems (cash crops along with foodgrains). The income effect of information sources also differs; the formal information sources, though their outreach is smaller, have a larger impact on farm income—almost twice of that of the informal sources possibly due to qualitative differences in information content and its delivery systems.

These findings are crucial for informed policy decisions regarding development of information delivery system. The agricultural extension policy should aim at developing information dissemination systems that are cost-effective, efficient in delivery and motivate farmers for a greater uptake of information on modern technologies and other practices irrespective of farm size and social status. Indian agriculture is diversifying towards higher-value crops; suggesting a need for developing information systems that cater to the needs of farmers growing these crops. Indeed, several government programs in India have relied on channels, such as radio, to implement large-scale agricultural programs without any scale or social bias. Our results suggest that returns on investment in extension services are quite attractive, and certainly there is a scope for improving outreach of such information sources for spread of agricultural technologies and practices in a heterogeneous rural society.

Investment on agricultural research and development has considerable potential for enhancing farm productivity and poverty reduction. A 12% higher net income for information users translates into an additional Rs 1140 per hectare of cropped area (at 2002-03 prices). This is much higher than the expenditure on public extension services (Rs 29 per hectare), and also on the research and education (Rs 157/ha). This indicates that investment in public extension services has not kept pace with the rising demand for information by the farmers, and implies that under-investment in public extension may limit realization of the potential gains in agricultural productivity from spending more on agricultural research.

Mobiles, internets and inter-linked arrangements, such as contract farming and producer organizations are emerging as alternatives to traditional extension systems, and these are claimed to be more efficient in information dissemination. The need is to collect and collate the context- and location-specific right information and disseminate it in right time and in a right form through such cost-effective channels. There is also a need to create awareness among farmers about the benefits of using information, to provide bundled services (technological, financial and non-financial), and to create effective linkages of service providers with research organizations, public extension systems, and market places.

Chapter 1

Introduction

Technological changes in agriculture and allied sectors, supported by investments in irrigation, infrastructure and institutions, have propelled India from a syndrome of food insecurity in the 1960s towards food self-sufficiency or even an occasional exporter of some food commodities. The growing population, however, keeps the challenge of producing more food as significant as in the past. Not only that, sustained income growth and a fast-growing urban population are causing changes in food consumption patterns, away from low-value staples towards high-value food commodities, implying that the agri-food production systems must change to address the growing food demand and changing consumer preferences for diversified and safe food.

Nonetheless, agri-food production systems are facing a number of biotic and abiotic pressures. Land, water and energy, the critical factors in agricultural production, have reached their extensive limits of exploitation. India's net cropped area has almost stagnated at around 140 million hectares, indicating little scope to bring additional area under cultivation. Groundwater resources have been over-exploited, especially in the intensively-cultivated north-western region comprising Punjab, Haryana and western Uttar Pradesh. Agriculture is also becoming energy-intensive. Not only that, the competition for these resources will intensify with their growing demands for residential and industrial purposes. Climate change is emerging as a big threat to sustainable development of agriculture. Future increases in agricultural production will, thus, crucially be determined by the technological breakthroughs, improvements in resource-use efficiency and innovations in service delivery systems.

Owing to such changes in demand for agricultural products and growing stresses on natural resources, agriculture is becoming increasingly knowledge-intensive. Farmers face different types of information needs—ranging from weather forecasts and advisories, inputs, agronomic practices, pest management, markets and prices (Aker 2011). The demand for information has also amplified as farmers are tasked with not only improving agricultural productivity and conserving natural resources but also a host of other requirements, such as complying with market preferences for diverse, safe and quality food (Ferroni and Zhou 2012). To adjust to the changes farmers require information, the access to and use of

which can differentiate them, in terms of returns from farming. Information is vital input in agricultural production. Through its interaction with other factors of production, such as land, labour, capital and managerial ability it enhances production efficiency.

Historically, public or government extension system has been one of the important channels for information dissemination for farmers in India, especially during the green revolution period. Its outreach, however, has remained limited to only about 7% of the farm households (GoI 2005a). Thus, the government extension system alone cannot provide all the information that a farmer needs, and to all the farmers. Further, the public extension system in India has not been able to keep pace with the changes in global technological and economic environment (Birner and Anderson 2007). Feder and Slade (1986) conclude that free markets for agricultural services do not fully satisfy farmers' information needs, and the government support in provision of agricultural services is justified. Nevertheless, with upcoming of newer sources of information, such as radio, television, mobile and internet India's agricultural information dissemination system has become pluralistic over time.

The importance of information in agricultural performance is widely recognized, but there have been limited efforts towards a rigorous analysis of the impact of information on the outcomes from farming (Feder *et al.* 1999, Birkhaeuser *et al.* 1991, Godtland *et al.* 2004, Davis *et al.* 2010, Goyal 2010, Fafchamps and Minten 2012). In this paper, we empirically assess the impact of information on returns from farming. While analysing the linkages between information and agricultural performance we take into account several nuances of Indian agriculture. Indian agriculture is dominated by smallholders and also there is a significant social fragmentation along the lines of religion, caste and ethnicity. Since information search and acquisition usually involve fixed costs, smaller farmers are often disadvantaged in access to information. Further, social fragmentation can make some information sources exclusionary, *i.e.*, less accessible to the disadvantaged sections of the society and not to others. This indicates a need for multiple sources of information to make up for less accessible information channels.

The paper is structured as follows. Next chapter describes data used to examine linkages between information use and farm incomes. Chapter 3 describes the empirical approach followed to isolate the causal effect of information on farm income. Sources of information for different farm and social classes are discussed in chapter 4. In chapter 5, we present estimates of the impact of information on farm income. Conclusions and policy implications are discussed in the last chapter.

2 *Chapter*

Data

To examine outreach and impact of information on returns from farming we use data from a nationally representative survey conducted by the National Sample Survey Organisation (NSSO) in 2003 as a part of a larger survey that aimed at assessing the status of farmers and farming in India (GoI, 2005a, 2005b).[1] The survey contains information on social, economic, institutional and organizational aspects of farming from a sample of 51, 770 households spread over 6, 638 villages across the country. This data-set is comprehensive in terms of information sources including the subject on which information is sought from different sources. Subject to minimizing the biases, the nationally representative sample also mitigates the problem of potential lack of external validity.

Some salient features of this survey are as follows. First, the survey contains data on access to and use of information on modern agricultural technologies and practices, by its type and source. Second, data are available on the costs and returns in crop production that enables us to associate use of information with farm incomes. Third, besides providing data on various personal and household characteristics, the survey also contains information on some important policy and institutional dimensions of farming, such as farmers' association with institutional networks (for example, self-help groups), and their awareness regarding the government-determined minimum support prices of foodgrains and the agencies involved in their procurement.

This survey focuses on three main agricultural enterprises crop husbandry, animal husbandry and fisheries. In this paper, we assess the impact of information on returns from crop production only. The raw data were scrutinized for errors and outliers. We encountered two problems in the data-set. One, for some of the farm households, information on land, owned or leased-in, was missing. Another problem was of outliers as some farmers had reported unusually low or high income from crops in relation to the land they cultivated. In the analysis, we have dropped such observations that comprise less than 2% of the total sample.

[1]NSSO has used a mutli-stage stratified random sampling design for this survey, the details of which are available in GoI (2005a, 2005b).

Chapter 3

Empirical Strategy

Several factors, such as farm size, caste, education and cropping pattern simultaneously determine the use of information and its outcome, *i.e.*, net farm income. An empirical assessment of the effect of information on farm income, thus, might be prone to selection biases. Hence, our empirical strategy aims to overcome potential biases in estimation of the impact of information on farm income.

There are several challenges in identifying a causal relationship between use of information and farm outcomes. First, measuring outcome variables, such as net farm income is difficult and can introduce measurement errors. As Aker (2011) has argued 'while such errors may not introduce bias, these, however, can reduce precision, thereby making it more difficult to detect a statistically significant effect.' Feder *et al.* (1999) and Birkhaeuser *et al.* (1991) note that an ideal simulated experimental design is rarely available to evaluate the impact of information, and the second-best approaches are vulnerable to various biases emerging from targeting and self-selection.

More importantly, the observable and unobservable farmer and farm characteristics that are simultaneously correlated with the use of information and farm income can lead to selection biases. The first source of selection bias could be due to the significant differences in the observed characteristics of the users and non-users of information. These differences could be along several observed factors, such as farm size, age, education and social identity. These characteristics could be important in determining the farm income as well. With the differences in observed characteristics between users and non-users of information, part of the difference in farm income could be due to the differences in these characteristics and not due to the effect of the use of information. Second, the selection bias may also result from unobservable characteristics of farmers, community or location. It is possible, for example, that smarter farmers are also more gregarious and seek out information. The farm income that one realizes, then, could be a product of unobserved smartness rather than a result of information use *per se*.

Owing to possible selection issues we employ instrumental variable methods to isolate the effect of information on returns from farming. To

take into account the selection bias due to unobserved factors in the farm income regression we estimate the following instrumental variable (IV) regression:

$$\Pi_i=\alpha+\delta d_i+\gamma X_i+\varepsilon_i \qquad (1)$$

Where, Π_i denotes the net income per hectare of the i^{th} farmer; d_i is a dummy variable that takes a value of 1 if the farmer has used information, and zero otherwise; and X_i is a vector of farmer and farm characteristics. If X_i includes all the variables that influence use of information and if these variables are uncorrelated with the error term ε_i, then the OLS estimates of equation (1) will be consistent, and $\hat{\delta}$ can be treated as the true effect of information on farm income.

However, the OLS estimates can suffer from omitted variable bias. Unobserved ability or characteristics, like reputation or skill that cannot be controlled for, will lead to a bias, as $\hat{\delta}$ would capture the effect of such factors and not the effect of information. Suppose, for example, that farmers who use information have a poorer prospect without it, owing to their lower ability. In this case, $\hat{\delta}$ estimate would be affected by the omitted variables, leading to a downward bias. Similarly, it is possible that smarter farmers are also more gregarious and seek information that would lead to a higher productivity effect of information (a source of upward bias). For example, Evenson and Mwabu (2001) show a U-shaped pattern of the productivity effect of extension services across yield quintiles. Their finding suggests that for a given level of extension input (information), unobserved factors, for example farm management abilities, influence crop yields differently. Other examples of unobserved variables include farmers' risk preferences and social ties. For example, Liu (2013) finds that Chinese cotton farmers who are more risk averse adopt Bt variety later.

To correct for the selection bias, we need an ideal instrument such that it is correlated with use of information but not with farm income as measured. Here, in finding an appropriate instrument we appeal to the role of local networks in information transmission. A vast body of literature exists on the role of social networks in determining the farm outcomes (e.g., Bandierra and Rasul, 2006; Conley and Udry, 2010). The nature of the data at hand does not allow this analysis to account for all information sources embedded in the social networks (such as a network of less frequent interactions with friends and family located far away). In general, such factors as ability, reputation, social ties that affect the use of information and also the farm incomes can result in omitted variable bias, implying that d_i will be correlated with ε_i in (1).

Given the potential biases emanating from the observed and unobserved factors, this analysis uses instrumental variable (IV) techniques in estimating the impact of information on farm income. The ideal instrument, Z_i, is

such that it is correlated with the use of information and not correlated with the returns (net income profits from farming). For Z_i to qualify as an instrument, the following conditions should hold:

(i) Z_i is related to d_i, and

(ii) Z_i has no direct effect on Π_i. Z_i has an effect on Π_i only through d_i.

Since the instrument is correlated with treatment and is uncorrelated with outcome, an ideal instrument can effectively randomize subjects across treatment and, in effect, can achieve equal distribution of both the characteristics and the pre-treatment outcomes. The instrumental variable method is, thus, aimed at addressing both overt and unobserved biases in estimating the average treatment effect. The exclusion restriction is the conditional independence assumption, *i.e.*, the instrument is independent of the potential outcome. With instrumental variable regression, the IV estimator should capture only the effects on Π_i of shifts in d_i induced by Z_i, whereas the OLS estimator captures not only the direct effect of d_i on Π_i, but also the effect of the included measurement error and/or endogeneity.

In finding an appropriate instrument, this analysis appeals to the role of local networks in information transmission. The descriptive statistics, presented in the next chapter, shows a large number of farmers obtaining information from other farmers. It is not only the farmers who provide information to each other; social networks could also be useful in creating links with organizations which in turn could become a source of information. The idea is that if a higher proportion of farmers in the network is informed, the likelihood of that particular farmer being informed himself would be greater, *i.e.*, condition (i), above, is likely to be satisfied. Further, the proportion of informed farmers in the network should not have a direct effect on the operating profits of a particular farmer, *i.e.*, condition (ii) should hold. With these conditions in mind, consider the following equation that determines whether the farmer uses information or not.

$$d_i=\beta+\theta Z_i+u_i \qquad (2)$$

Combining (1) and (2) yields

$$\Pi_i=\vartheta+\gamma Z_i+\gamma X_i+\varepsilon_i \qquad (3)$$

Where $\vartheta=\alpha+\delta\beta$ and $\tau=\delta\theta$. Hence, the estimate $\hat{\delta}$ can be obtained as $\frac{\hat{\tau}}{\hat{\theta}}$. The instrumental variable estimator is an unbiased estimator of δ in large samples, *i.e.*, it is consistent.

Finally, a note about the network for each farmer based on which the instrument is constructed. In general, the definition of peer group or network is open-ended and is subject to the researcher's discretion. Broadly, the reference group for a person is defined by the individuals whose mean outcome and characteristics influence the individual's own outcome and characteristics. In the specific context of rural India, reference groups for

a farmer could comprise of farmers who may not be geographically most proximate but are socially nearest to the farmer by belonging to the same or a similar caste, religion or ethnic group. Hence, this analysis constitutes a reference group for each farmer, based on geographical proximity (same village) and social identity (similar caste).

This construction of social network is along the lines of Fontaine and Yamada (2011), who define reference groups in the Indian context based on education, age, geographical proximity and caste. For each farmer, the instrument (*i.e.*, the proportion of informed farmers in the network) is derived after excluding that individual farmer. Note that, the instrument can suffer from some measurement error, as the survey randomly selects some households in a village, and the actual proportion of households using information within a social group in a village may or may not equal the proportion estimated from the sample, *i.e.*, $Z_i=Z_i^*+v_i$. Since this will lead to attenuation bias in $\hat{\theta}$, this analysis will actually estimate a lower bound of θ. The estimated treatment effect will be unbiased, so long as the v_i is uncorrelated with d_i and ε_i.

Next, we assess whether the impact of an information source on net returns is heterogeneous. To do so we club various information sources into formal and informal categories based on the extent to which the information sources are registered or their dissemination activities conducted by the agents affiliated to a formal sector. Then, using instrumental variable strategy similar to the one discussed above we assess the impact of formal and informal sources of information on returns from farming.

A farmer may use information from both formal and informal sources simultaneously; hence, we deal with these in conjunction while estimating their impacts on farm outcomes. We employ additional instrumental variables where the use of information from formal sources and informal sources is predicted using instruments, viz. local social network for formal sources, and local social network for informal sources. Technically, it amounts to estimation of equation (4) below.

$$\Pi_i=\alpha+\delta^F d_i^F+\delta^I d_i^I+\gamma X_i+\varepsilon_i \qquad (4)$$

Where Π_i and X_i are defined as before. The main outcome equation has indicator variables for information through formal (d_i^F) as well as informal sources (d_i^I). Since both the treatment variables are endogenous, we need at least two instruments for identification. Using the same idea for constructing the instrument as before, we use (i) the proportion of farm households within a social group in the village utilizing information from formal sources, and (ii) the proportion of farm households within a social

group in the village utilizing information from informal sources, excluding the farmer in question.[2]

Imbens and Angrist (1994) show that with a dummy endogenous variable, instrumental variable (IV) method estimates causal effects for those whose behaviour would be changed by the instrument if it were assigned in a randomized trial. That is, the effect is estimated for subjects who take the treatment if assigned to the treatment group, but do not take the treatment otherwise. This parameter is known as local average treatment effect (LATE). If each subject in the population has the same response to a particular intervention or treatment, the distinction between LATE and other parameters does not matter. But with "heterogeneous treatment effects", the parameter identified by IV method may differ from the average treatment effect of interest. As there could be farm-level heterogeneity, the IV method measures the LATE and not the average treatment effect necessarily.

[2]These instruments are constructed following equation (3).

Chapter 4

Information Sources and Their Pattern of Use

4.1 Information sources and their outreach

Approximately 40% of the farm households in India have access to information on modern crop technologies and practices; and 75% of them (or 28% of the total farm households) use it in their agricultural decisions. Farmers use information from a number of sources representing the government, the mass media, the private sector and the social networks.

By aggregating across source categories[3], table 1 presents the distribution of farm households using information from different channels (table A. 1 in the appendix for details of information sources). The government

Table 1: Percent farm households using information from different sources

Source of information	Improved seeds	Fertilizer application	Plant Protection	Farm machinery	Harvesting/ marketing	Others	All
Mass Media	35.4 [3, 554]	31.6 [2, 571]	38.5 [1, 603]	36.7 [98]	28.9 [546]	27.0 [384]	33.8 [8, 756]
Government	15.6 [1, 570]	11.8 [958]	13.3 [551]	23.2 [62]	7.8 [148]	20.4 [290]	13.8 [3, 579]
Private	20.7 [2, 077]	28.1 [2, 289]	21.1 [877]	8.2 [22]	27.9 [526]	16.5 [235]	23.3 [6, 026]
Social networks	28.3 [2, 839]	28.5 [2, 322]	27.1 [1, 128]	31.8 [85]	35.4 [667]	36.1 [514]	29.2 [7, 555]
Total	100.0 [10, 040]	100.0 [8, 140]	100.0 [4, 159]	100.0 [267]	100.0 [1, 887]	100.0 [1, 423]	100.0 [25, 916]
Pearson $chi^2(15) = 490.2$							
Any source	38.7	31.4	16.0	1.0	7.3	5.5	27.6

Figures in parentheses are frequencies.

[3]Different information sources were categorised into (i) mass media, (ii) government, (iii) private, and (iv) social networks following Anderson and Feder (2007) and Aker (2011).

information sources comprise the government extension workers, Krishi Vigyan Kendras (agriculture science centres), credit agencies and farm demonstrations, trainings and study tours organized by the governments. Private information sources include input dealers, non-governmental organizations/private agency/para-technicians, and traders/processors. Radio, television and newspaper represent mass media. Primary cooperative societies, other progressive farmers, farmers' organizations and village fairs comprise social and institutional networks.

Mass media is the most important source of information as more than one-third of the farm households use information disseminated through radio, television and newspaper. Radio and television are utilized by 15% and 11% of the farm households, respectively (table A.1 in the appendix). Newspaper is an important information source for 8% households. Use of modern sources of information, such as telephones, mobiles and internet, however, is extremely limited[4]. The outreach of the government information sources is also not extensive as these are utilized only by 14% of the farm households. Notably, amongst government sources, the extension workers serve only about 7% of the farm households.

Farmers meet most of their information needs from other sources. Amongst these, farmer-to-farmer exchange of information is the most prominent with 23% of farm households using information from other progressive farmers. Feder and Slade (1986) have also reported a wider prevalence of farmer-to-farmer exchange of information in northern India. Using data from several surveys, Foster and Rosenzweig (1995) also found information from fellow farmers being as important as the information from public extension workers. The domineering role of progressive farmers in information provision has also been reported by Singh *et al*. (2003) and Bhagat *et al*. (2004). Since the list of providers of information used in this analysis is comprehensive, the effect of information can be ascertained in a way that is not likely to be driven by the "source effect".

The rural environment in India characterized by social fragmentation and dominance of smallholders, the prominent role of a progressive farmer in the neighbourhood as a source of information can be expected. When both the seekers and providers of information are from similar socio-cultural backgrounds, and information from these sources is locally available, it makes search and acquisition costs smaller. Input dealers emerge as the second most important source of information. About 18% farm households

[4]The use of information and communication technology (ICT) in agriculture has risen over time. The tele-density in India has increased more than ten-fold, from 7% in 2004-05 to 76% in 2011. The rural tele-densitystands at 36.8% (GoI 2011).

seek information from them (see table A1 in the appendix). This is expected, as the input suppliers have first-hand information on the availability of new crop varieties/seeds, fertilizers, pesticides and other inputs, and also they sell inputs on credit. From a survey in Tamil Nadu, Babu *et al.* (2011) find input dealers an important source of dissemination of agricultural information because a sizable proportion of farmers purchase their input requirements on credit. Information provided by the input dealers, as expected, largely pertains to the inputs, *i.e.*, seeds, fertilizers and pesticides they sell. However, with this link, the potential of bias in information cannot be ruled out. If it turns out to be so, the impact of information on farm income could be lower.

Information on markets and prices is obtained largely from traders and agro-processors and also from newspapers (see table A1 in the appendix). Overall, the commodity traders and agro-processors are a source of information for a small proportion of farm households. Note that, some of them procure raw materials from farmers through linked arrangements, such as contract farming. As part of this arrangement, they also provide information to farmers on various aspects of production and marketing of agricultural commodities.

Farmers' information needs are wide-ranging. They need information on technologies, inputs, prices, markets, and machinery for a variety of crops they grow and also on post-harvest management including on prices. The most sought information relates to seeds, followed by fertilizers, plant protection, harvesting/marketing and farm machinery. The relative importance of the information sources also varies by type of information the farmers demand. The mass media is the most important source of information on seeds, fertilizers and pest management. Information on markets and machinery are generally accessed through social networks.

4.2. Characteristics of users and non-users of information

Literature identifies a number of factors that influence access to and use of information by the farm households. The list of factors, that have been commonly identified, include age, education, experience, socio-economic status, landholding attributes, cropping pattern, risk-bearing capacity, and distance to an information source (Carter and Batte 1993, Solano *et al.* 2003, Alvarez and Nuthall 2005, Ali 2012, Babu *et al.* 2011; Okwu and Dauda 2011).

Table 2 compares key characteristics of users and non-users of information. Some of the characteristics are exogenous to whether the

Table 2: Comparison of selected characteristics of users and non-users of information

Characteristics	Users	No users	Difference in means/ proportions
Personal and household characteristics			
Operated area: hectares	1.6	1.1	-21.9***
Area irrigated: percent	64.5	51.2	-13.6***
Male headed households: percent	94.2	91.3	-10.1***
Average age of household head: years	48.6	47.2	-9.5***
Number of workers: aged 15-59	3.5	3.2	-14.6***
Family size: numbers	5.9	5.6	-10.9***
Educational attainment of the head of household: percent			
Illiterate	33.7	43.0	17.5***
Primary	30.5	29.3	-2.5**
Middle	16.0	14.2	-4.7***
Secondary	15.2	11.0	-11.8***
Graduate and above	4.7	2.6	-10.7***
Social structure by caste: percent			
Scheduled caste	11.4	19.4	19.7***
Scheduled tribes	14.2	15.5	3.4***
Other backward classes	37.5	37.5	0.1
General caste	36.9	27.6	-18.8***
Markets and policy awareness: percent			
Minimum support price	42.0	25.3	-33.7***
Procurement agency	29.5	15.4	-32.7***
Access to institutional credit	32.7	19.9	-27.8***
Seeds purchased	71.9	49.3	-42.2***
Organizational affiliation: percent			
Member of self-help groups	7.0	4.7	-9.1***
Member of registered farmer-organisations	4.1	2.0	-11.9***
Household type: percent			
Self-employed in non-agriculture	9.5	10.1	1.8
Agricultural labour	13.5	17.7	10.4***
Other labour	3.6	6.4	11.5***
Selfemployed in agriculture	66.6	59.2	-14.0***
Others	6.8	6.6	-0.8
No. of observations	12388	27903	

*** and ** denote significance at the 1% and 5% level, respectively.

farmer has access to information (for example, endowment of family labour), while others are possibly endogenous (for example, whether the land is irrigated). The users of information have larger landholdings and higher level of irrigation, compared to non-users. In terms of demographic differences, the users of information are relatively older, better educated, and have a greater endowment of family labour. It is assumed that education improves farmers' access to information. Our results show that the difference in education of the users and non-users of information becomes more pronounced towards higher end of schooling. There also appears to be a gender bias in access to information as the proportion of female-headed households is higher among the non-users. Further, for two-third of the farmers who use information agriculture is the main occupation, while amongst non-users this proportion is slightly on a lower side, possibly because of the opportunity cost of time in acquisition of information. Alternatively, the households primarily engaged in agriculture are likely to be more skilled in cultivation activities.

Several studies have pointed out towards the role of institutional networks, such as self-help groups, cooperatives and producer organizations, in dissemination of information (Putnam 2001, Glaeser *et al.* 2002). Through such networks farmers improve their contacts, interact and gather or share information and knowledge about modern agricultural technologies, inputs, marketing practices, government policies, etc. Further, a farmer's association with such networks reduces costs of search and acquisition of information due to scale economies, which otherwise could be higher for him or her (Babu *et al.* 2011). Our results indicate that only a small proportion of the farm households is associated with such institutional or formal networks. Their proportion, however, is higher among the users of information.

Farmers' awareness about public policy can act as catalyst in their search, acquisition and use information on modern technologies and practices. According to Ali (2012), farmers who are aware of the government-determined minimum support prices of agricultural commodities have a greater tendency to use information about other matters related to farming. We also find that farmers who are aware of the government policy of minimum support prices of foodgrains and their procurement agencies are better-informed about other aspects of farming. At the same time, farmers who have access to information are more likely to be informed about the support prices, so there is potential two-way causality. Users of information also have greater access to institutional farm credit enhancing

their capacity to purchase quality inputs and invest in farm infrastructure. Note that farmers who access to information and credit also use more of purchased seeds.

4.3 Farm size and information use

Table 3 presents information use differentiated by farm size. Evidently, use of information is positively associated with farm size. For example, 41% of the large farmers (>4.0ha) use information as compared to 20% of the sub-marginal farmers (<0.5ha). Farm size-wise differentiation of information use shows some interesting patterns. Smaller farmers rely more on social networks and private information sources for their information needs. For example, one-third of the sub-marginal farmers utilize social networks for their information needs as compared to 24% of the large farmers. On the other hand, larger farmers have a better access to mass media information sources, such as radio, television and newspaper and also to government information sources (for example, extension workers). In fact, the proportion of large farmers using information from government sources is almost twice that of the sub-marginal farmers. The chi-square statistic indicates that the difference in the proportions of different categories of farm households using information is significant. This differentiation in use of information sources could be due to

Table 3: Sources of information by farm type (percent)

Source of information	Sub-marginal (<0.5 ha)	Marginal (0.5–1 ha)	Small (1–2 ha)	Medium (2–4 ha)	Large (>4 ha)	All
Mass media	30.2 [2,389]	33.0 [1,669]	36.4 [2,068]	35.9 [1,413]	37.4 [1,108]	33.8 [8,647]
Government	10.0 [792]	13.2 [668]	14.3 [809]	16.6 [654]	19.2 [570]	13.7 [3,493]
Private	26.6 [2,108]	23.9 [1,209]	22.0 [1,251]	21.3 [837]	19.3 [572]	23.4 [5,977]
Social networks	33.2 [2,628]	30.0 [1,516]	27.3 [1,548]	26.2 [1,030]	24.1 [716]	29.1 [7,438]
All	31.0 [7,917]	19.8 [5,062]	22.2 [5,676]	15.4 [3,934]	11.6 [2,966]	100.0 [25,555]
Pearson $chi^2(12) = 390.9$						
Any source	20.0	29.5	35.3	38.3	40.6	27.6

Figures in parentheses are frequencies.

the differences in farmers' education levels, investment capacity, social status, etc.

4.4 Social status and information use

Apart from farm size, the access to and use of information can also be influenced by socio-cultural factors, such as caste, religion and ethnicity. Batte and Arnholt (2003) and Ali (2012) have shown that the early adoptors of technologies and innovations are usually those who belong to the upper strata of social hierarchy. In rural India, caste is an important indicator of social hierarchy with scheduled castes and tribes (SC/ST) being at the bottom, followed by other backward castes and upper castes. Hence, we also examine information use of farm households by their castes.

Table 4 shows use of information by caste. The proportion of information users is higher among the upper caste households – about 35% of the upper caste households use information compared to 23% of the scheduled caste (SC) and 20% of the scheduled tribe (ST) households. Further, relative to the upper caste households, the lower caste households, especially those from the scheduled castes, depend more on social networks for their information needs. Social networks are a source of information for about 35% of the scheduled caste households as compared to 26% of the upper caste households who use information from such networks. Incidentally, mass media sources (particularly television and newspaper) are utilized

Table 4: Sources of information by caste (percent)

Source of information	Scheduled tribes	Scheduled castes	Other backward castes	Upper castes	All
Mass media	31.5 [789]	24.9 [883]	33.2 [3,300]	38.4 [3, 675]	33.8 [8,647]
Government	17.8 [446]	11.7 [414]	14.2 [1,407]	12.8 [1, 226]	13.7 [3,493]
Private	20.9 [522]	28.7 [1,018]	22.5 [2,232]	23.0 [2, 205]	23.4 [5,977]
Social networks	29.8 [745]	34.6 [1,227]	30.2 [3,003]	25.7 [2, 463]	29.1 [7,438]
Pearson $chi^2(9) = 329.3$					
Any source	20.0	23.2	27.3	34.8	27.6

Figures in parentheses are frequencies.

more by the upper caste households for their information needs. This is expected because of the differences in the economic status and education levels of the social groups. For example, owning a television requires initial investment, and accessing information from print media depends on the level of literacy of a farmer. Notably, the government sources are relatively less biased against lower caste households, especially those belonging to the scheduled tribes.

4.5 Intensity of information use

Farmers need different types of information (seed, fertilizer, pesticides, weather, machines, etc.) that they may seek from a single or multiple sources; and access to multiple sources can potentially influence the returns from farming. Hence, we also examine the intensity of information use in terms of the number of information sources used by a farm household. Table 5 presents the frequency distribution of households by the number of information sources used, *i.e.*, low (one source), medium (two sources), and high (three or more). On average, more than 72% farm households have not used information. This proportion, however, declines with farm size. Fourteen percent households have used information from one source only (low users), 8% from two sources (medium users), and only 5% from three or more sources (high users). The intensity of information use increases with farm size. Only 2.6% of the sub-marginal and 4.8% of the marginal farmers have used information from three or more sources, compared to 12.5% of the large farmers. Thus, there is a definite pecking order in access to and use of information by farm households.

Table 5: Intensity of information use

(a) Distribution of households (%) by the number of information sources and farm type

Farm category	Non-users	One source	Two sources	Three or more sources
Sub-marginal	80.0	11.6	5.8	2.6
Marginal	70.5	16.0	8.8	4.8
Small	64.7	17.2	11.1	7.0
Medium	61.7	17.4	11.2	9.7
Large	59.4	15.9	12.3	12.5
Pearson $chi^2(12) = 356.3$				
Total	72.5	14.3	8.2	5.1

(b) Sources of information by intensity of use (%)

Source of information	One source	Two sources	Three or more sources	All
Mass media	24.1	34.4	38.2	33.8
Government	13.6	9.6	16.3	13.7
Private	22.9	27.1	21.2	23.4
Social networks	39.5	28.9	24.2	29.1
Overall	22.7	30.3	47.1	100.0
Pearson $chi^2(6) = 771.5$				
Total	14.3	8.2	5.1	27.6

Table 5b shows the distribution of farm households by the number of information sources used and the type of information source. It clearly brings out that the households using fewer number of information sources rely mostly on social networks, followed by private sources and mass media for their information needs. For medium information users, mass media comprise the most important source. The social networks and private sources are also important channels of information for them. For high information users also, the mass media are more important information channels, followed by social networks and private sources. Interestingly, the proportion of those availing information from the government sources is also higher among high information users.

Table 6 distinguishes important characteristics of the farmers by the number of information sources used. High users of information are generally older in age, more educated and skilled, and belong to the influential segments of the society. As expected, they are also asset-rich. The standardised bias in asset distribution, particularly land, between the two consecutive groups of users becomes stronger at higher-level of information intensity. On the other hand, gender bias in access to information, becomes smaller with intensity of information use. Further, farmers who get information from more than one source are more aware of the agricultural price policy and have better access to institutional credit. Note that the standardized bias for most of these variables between the two consecutive groups of information users is statistically significant at 5% or lower level.

Table 6: Selected characteristics of users and non-users of information by intensity of use

Characteristics	One source vs no use			Two sources vs one source			Three or more sources vs two sources		
	One source	Non-users	% difference	Two sources	One source	% difference	Three or more sources	Two sources	% difference
Personal and household characteristics									
Operated land: ha	1.4	1.3	1.3	1.6	1.4	7.5***	2.2	1.6	24.7***
Area irrigated: %	59.2	50.3	13.6***	64.6	59.2	6.0***	71.1	64.6	7.0**
Male headed households: (%)	94.2	91.8	9.8***	94.8	94.2	2.5	95.2	94.8	1.7
Average age of the household-head: years	48.0	47.4	4.1***	48.9	48	7.0***	50.3	48.9	10.2**
Number of workers: aged (15 to 59 years	3.4	3.2	8.2***	3.6	3.4	11.0***	3.7	3.6	5.5**
Family size	5.7	5.5	6.2***	6.0	5.7	10.7***	6.1	6.0	2.7
Educational attainment of the head of household: %									
Illiterate	39.8	43.8	-8.0***	35.3	39.8	-9.4***	24.3	35.3	-24.3***
Primary	28.8	27.5	2.8**	27.8	28.8	-2.2	26.5	27.8	-2.8
Middle	14.8	14.5	0.9	16.8	14.8	5.5***	19.1	16.8	6.1**
Secondary	13.2	11.5	5.1***	15.8	13.2	7.3***	21.3	15.8	14.3***
Graduate and above	3.5	2.8	3.9***	4.4	3.5	4.8***	8.8	4.4	17.8***
Social structure by caste: %									
Scheduled caste	15.6	15	1.6	13.2	15.6	-6.7***	11.2	13.2	-6.3**
Scheduled tribes	12.6	18.6	-16.6***	12.1	12.6	-1.6	7.9	12.1	-13.9***
Other backward classes	37.4	37.8	-0.8	36.8	37.4	-1.1	39.5	36.8	5.5**
General caste	34.4	28.6	12.6***	37.8	34.4	7.0***	41.3	37.8	7.2***

Table 6 Continued

Household type: %									
Self-employed in non-agriculture	9.5	10.4	-3.0**	11	9.5	4.8**	9.0	11	-6.7**
Agricultural labourer	15.7	17	-3.5**	12.1	15.7	-10.3***	8.3	12.1	-12.5***
Other labourer	4.9	7.2	-9.8***	3.6	4.9	-6.2***	2.2	3.6	-8.5***
Self-employed in agriculture	64.0	58.4	11.5***	66.6	64	5.5***	71.2	66.6	9.9***
Others	5.9	7.1	-4.5***	6.7	5.9	3.1	9.3	6.7	9.7***
Markets and policy awareness: %									
Minimum support price	35.4	26.9	18.6***	44.0	35.4	17.7***	63.8	44.0	40.4***
Procurement agency	23.0	16.7	15.9***	31.7	23	19.7***	49.2	31.7	36.3***
Access to institutional credit	30.3	21.0	21.4***	33.9	30.3	7.5***	42.8	33.9	18.5***
Seeds purchased	50.1	41.5	17.4***	51.4	50.1	2.5	57.7	51.4	12.8***
Organizational affiliation: %									
Member of self-help groups	6.6	4.9	7.2***	6.5	6.6	-0.3	10.4	6.5	14.3***
Member of registered farmer-organisations	3.0	2.2	4.9***	4.6	3.0	8.6***	7.6	4.6	12.5***

Note: ***, ** and ** denote significance at 1%, 5% and 10% level respectively.

Chapter 5

Impact of Information on Farm Income

Does information enhance farm income, and to what extent? Do smaller farmers benefit from information use? To analyse these relationships between information use and farm income, first we compare the average net returns per unit of cropped area for users and non-users of information by farm size and number of information sources used.

In calculating the returns from farming, gross returns from different crops are estimated as a product of their production levels per unit of land and prices. Net returns are arrived at by deducting variable and fixed expenses from the gross returns as described below.

Net returns per hectare (rupees) = (gross income – total expenses)/gross cropped area

Gross income = value of output + value of by-products

Total expenses =Expenses on seeds + pesticides + fertilisers + irrigation + repair and maintenance on machinery and farm equipment + interest + lease rent for land + labour (regular and casual) + other expenses

Table 7 shows net returns per unit of cultivated land for users and non-users of information by farm size and number of information sources used. Three important observations stand out from the summary comparison of farm income across users (with different levels of use) and non-users of information. One, there is a clear evidence that the use of information in agricultural decisions helps improve farm incomes or production efficiency. On average, the users of information realize higher income than do the non-users of information. Two, net farm income is positively associated with intensity of information use, *i.e.*, those who use information from multiple sources realize higher net returns from farming. For example, the marginal farmers who use information from three or more sources realize 22% higher net returns compared to those who use only one source of information. Three, the difference in net income of users and non-users of information increases with farm size; the larger difference (32%) being in the case of medium farmers, and closely followed by large farmers. The difference is statistically significant, except in the case of sub-marginal farmers where the non-users of information obtain higher net returns. This

Table 7: Net returns by farm size and number of information sources used (rupees per hectare)

Farm category	Non-users	One source	Two sources	Three or more sources	Any source
Sub-marginal	12, 197	11, 767 (0.759)	12, 036 (0.894)	10, 384 (0.411)	11, 680 (0.626)
Marginal	8, 119	8, 852 (0.087)	9, 497 (0.036)	10, 831 (0.000)	9, 352 (0.000)
Small	7, 192	7573 (0.339)	9, 150 (0.000)	9, 214 (0.028)	8, 382 (0.001)
Medium	6, 934	9, 329 (0.187)	8, 700 (0.002)	9, 326 (0.016)	9, 146 (0.019)
Large	5, 872	6, 616 (0.199)	8, 028 (0.032)	8, 380 (0.000)	7, 541 (0.001)
Overall	9, 399	9, 532 (0.820)	9, 950 (0.261)	9, 737 (0.600)	9, 692 (0.485)

Note: Figures in parentheses are p-values for the difference in means relative to non-users.

is expected, as the intensity of information use increases with farm size, and possibly also because of an inverse relationship between farm size and productivity. In the case of sub-marginal farmers, higher income to non-users of information could possibly due to their greater allocation of area to crops, such as vegetables and spices that generate higher returns compared to widely grown foodgrain crops.

Further, irrespective of the situation with regard to the use of information, a negative relationship exists between net income and farm size (Table 7 and Figure 1). Thus, smaller farmers (proportionately more from lower castes), on average, tend to have lower access to information yet they could have higher net income per unit of land because of an inverse size-productivity relationship. In other words, the users of information among the smaller/lower caste farmers tend to have higher net returns to land vis-à-vis the large farmers, even without use of information. The inverse relationship between net income and farm size can be attributed to a greater area allocation to high-value crops (Birthal *et al.* 2014), higher cropping intensity, and greater use of inputs, especially family labour on smaller farms (Chand *et al.* 2011).

Figure 2 plots kernel density of the landholding size and farm income for users and non-users of information. The density of the non-users of

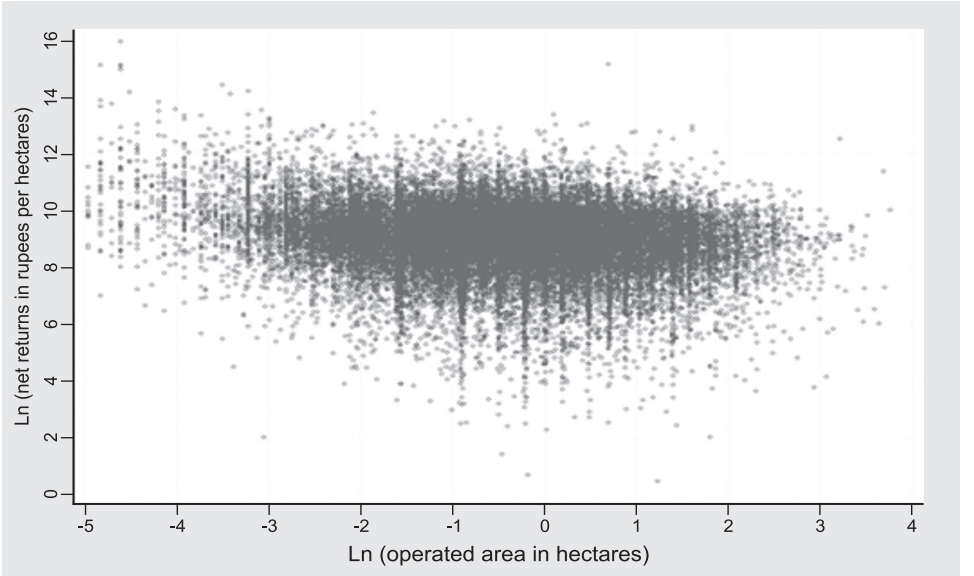

Figure 1. Relationship between farm size and net returns per hectare

information peaks at a smaller landholding size as compared to that of the users of information. Also towards tail of the land distribution, the density of information users lies above that of the non-users. This indicates existence of a scale bias in access to and use of information. Likewise, the density of the non-users of information peaks at a lower level of farm income as compared to that of the users. The difference, however, is not as stark, possibly due to the mitigation of the positive effect of information by inverse size-productivity relationship.

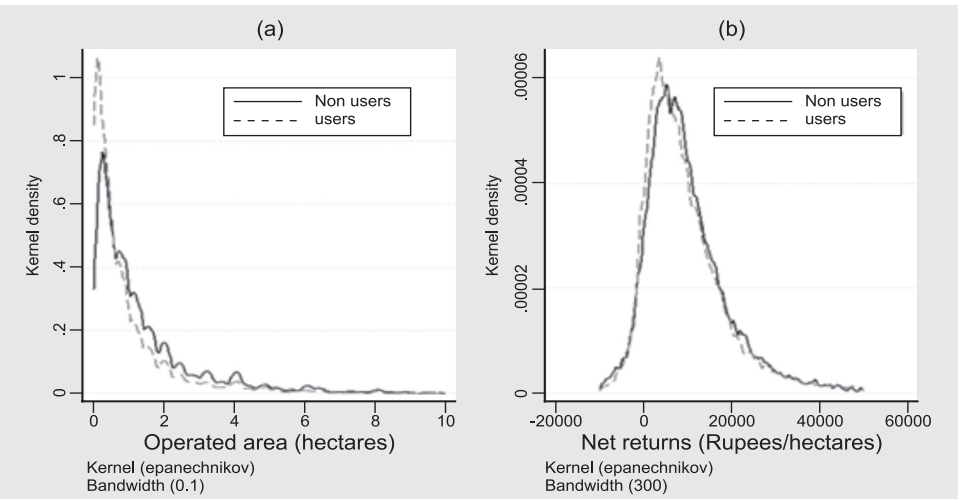

Figure 2. Kernel density of landholding size and net returns

As noticed earlier, smaller farmers tend to have less use of information. This means without accounting for the farm size differences, information seem to have smaller impacts, as sub-marginal farmers are observed to realize higher net returns per hectare than do the large farmers, even without use of information. Therefore, to account for the differences in farm income due to differences in farm size and social identity, we econometrically estimate the impact of information on farm income using instrumental variable technique as described in chapter 3.

We begin with the estimation of reduced form relationship between the impact variable and the instrument (*i.e.* net returns as a function of networks). Angrist and Krueger (1991) show that the reduced form is proportional to the causal effect of interest and argue that the likelihood of a causal effect is low if one does not find a causal relation of interest in the reduced form. Table 8 presents estimates of the reduced form equations, for the full sample and also for the sub-samples categorising farm households into growers of (a) foodgrain crops only, and (b) foodgrain crops along with other crops (diversified). Estimates from the sub-samples indicate the possible effect of cropping pattern on farm income.

The net returns for those practicing diversified farming are significantly higher than those who grow only foodgrain crops (table A2 in the appendix). In the reduced form relationship, the instrument is statistically significant for the full sample as well as for the sub-sample of farmers practicing diversified agriculture. A negative and significant coefficient on the landholding size confirms our observation of the existence of a negative size-productivity relationship in agriculture. Similarly, a significant and negative coefficient on SC as well as ST households is an indication of the low level of productivity on farms cultivated by socially-disadvantaged farm households.

Following the estimation of the reduced form, OLS results in tables 9(a) and IV results in 9(b) establish that there is a significant positive effect of information on net returns from farming. As observed earlier, the negative effect of farm size on net income remains strong and statistically significant in both the OLS and IV specifications. Results from the first stage linear probability model also confirm the role of social identity in use of information, *i.e.*, statistically significant lower net income on the farms cultivated by socially-disadvantaged households.

Given that the impact of information differs across crop groups, tables 9(a) and 9(b) also provide separate estimates for the two sub-samples. The OLS estimates for the full sample suggest that use of information raises farm income by 9.6%.[5] In IV method, the first stage regressions show the validity of local social networks as an instrument for a farmer's

Table 8: Reduced form relationship between impact variable and the instrument

Dependent variable: Ln (net returns per hectare)	Full sample	Food grains and other crops	Food grains only
Personal and household characteristics			
Ln(operated land)	-0.1190***	-0.1585***	-0.1281***
	(0.0072)	(0.0093)	(0.0111)
Ln(operated land)2	0.0442***	0.0481***	0.0260***
	(0.0028)	(0.0032)	(0.0044)
Ln(age head)	0.0960	-0.2800	0.3957
	(0.3062)	(0.4223)	(0.4245)
Ln(age head)^2	0.0017	0.0526	-0.0429
	(0.0407)	(0.0560)	(0.0565)
Male head	0.0553***	0.0352	0.0625**
	(0.0195)	(0.0265)	(0.0264)
Ln(family size)	0.0943***	0.0902***	0.0655***
	(0.0107)	(0.0145)	(0.0144)
Educational attainment of the head of household			
Primary	0.0624***	0.0747***	0.0272
	(0.0128)	(0.0168)	(0.0179)
Middle	0.1105***	0.1097***	0.0652***
	(0.0160)	(0.0210)	(0.0231)
Secondary	0.1895***	0.2130***	0.1114***
	(0.0181)	(0.0240)	(0.0252)
Graduate	0.2062***	0.2236***	0.1307***
	(0.0290)	(0.0384)	(0.0424)
Social structure by caste			
ST	-0.0639***	-0.0115	-0.0810**
	(0.0239)	(0.0290)	(0.0344)
SC	-0.1145***	-0.0888***	-0.1034***
	(0.0191)	(0.0257)	(0.0256)
OBC	-0.0011	-0.0022	-0.0089
	(0.0152)	(0.0194)	(0.0218)
Household type			
Self-employed in non-agriculture	-0.0765***	-0.0665*	-0.0767**
	(0.0262)	(0.0351)	(0.0363)
Agricultural labour	-0.0987***	-0.0908***	-0.0893**
	(0.0259)	(0.0350)	(0.0357)
Other labour	-0.1297***	-0.0973**	-0.1850***
	(0.0307)	(0.0407)	(0.0431)
Self-employed in agriculture	0.1449***	0.1793***	0.0761**
	(0.0224)	(0.0288)	(0.0318)
Local networks (Instrument)	0.0615***	0.0809***	0.0061
	(0.0222)	(0.0281)	(0.0308)
Constant	8.1166***	8.9606***	7.5291***
	(0.5744)	(0.7936)	(0.7942)
No. of observations	40291	22399	17892
F	52.20	43.76	20.43
Adjusted R^2	0.3406	0.3540	0.3362

Notes: District dummies included. Figures in parentheses are village clustered standard errors.
***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

use of information. Moreover, the instrumental variable regressions that control for the unobserved farmer heterogeneity show higher impact of information on farm income (12.2%).

Disaggregating by farming system, the instrumental variable regressions indicate that the farmers who are cultivating more than just foodgrain crops or alternatively have a more diversified crop portfolio realize higher returns from use of information. The OLS estimates show 9.1% higher returns from the use of information in diversified cropping systems as compared to 5.2% for the foodgrain crops alone. Strikingly, after instrumenting, the effect of information in the case of diversified agriculture increases to 17%, but almost disappears or becomes negligible for the farmers who grow only foodgrain crops. This is expected, as farmers diversify their crop portfolio especially towards higher-value crops, such as vegetables and fruits that require more skills and care, their information needs also increase, and the use of information in agricultural decisions leads to higher income per hectare.

Further, we also assess the effect of information by its source, as the quality of the information (in terms of contents, appropriateness, cost-effectiveness, etc.) and its system of delivery may differ across information sources, giving rise to differential impacts of different sources on production efficiency. For sake of convenience, we classify various information sources into two broad groups-formal and informal based on the extent to which the information sources are registered or their dissemination activities are conducted by the agents affiliated to a formal sector. Accordingly, the government extension worker, Krishi Vigyan Kendra (KVK), television, radio, cooperative society, credit agency, and farm demonstration and training program organized by the government are clubbed together as formal sources; and the rest are classified as informal sources (village fair, input dealer, NGO, traders and food processor and other farmer). We hypothesize that formal system is qualitatively better than informal one, and has a larger impact on farm income.

Table 10 presents results on the effect of formal and informal information systems on net returns from farming. For determining the use of information from formal sources, the networks based on formal as well as informal sources are relevant, but the effect of formal sources is significantly larger. However, in the case of information from informal sources, it is only the networks based on informal sources that are relevant. The impact of formal information sources on returns from farming is estimated to be 12.5%, which is almost twice the impact of informal information sources. The impact is much larger in the case of diversified agriculture (15%). In fact, the impact of information from both formal and informal sources for those

[5]The treatment effect in the percentage terms is calculated as:$(e^{\hat{\delta}}-1)^* 100$, where $\hat{\delta}$ is the estimated coefficient.

Table 9 (a): Ordinary least squares estimates for the effect of use of information on net farm returns

	Full sample	Food grains and other crops	Food grains only
Dependent variable: Ln(net returns per hectare)			
Use of information	0.0917***	0.0870***	0.0511**
	(0.0146)	(0.0180)	(0.0219)
Personal and household characteristics			
Ln(operated land)	-0.1238***	-0.1631***	-0.1304***
	(0.0073)	(0.0094)	(0.0112)
Ln(operated land)^2	0.0438***	0.0479***	0.0258***
	(0.0028)	(0.0032)	(0.0044)
Ln(age head)	0.0804	-0.3004	0.3905
	(0.3062)	(0.4221)	(0.4240)
Ln(age head)^2	0.0034	0.0546	-0.0424
	(0.0407)	(0.0559)	(0.0564)
Male head	0.0530***	0.0327	0.0615**
	(0.0195)	(0.0265)	(0.0264)
Ln(family size)	0.0915***	0.0873***	0.0643***
	(0.0107)	(0.0145)	(0.0144)
Educational attainment of the head of household			
Primary	0.0590***	0.0710***	0.0252
	(0.0128)	(0.0167)	(0.0180)
Middle	0.1058***	0.1047***	0.0626***
	(0.0160)	(0.0210)	(0.0231)
Secondary	0.1813***	0.2030***	0.1078***
	(0.0181)	(0.0240)	(0.0252)
Graduate	0.1949***	0.2107***	0.1253***
	(0.0290)	(0.0384)	(0.0424)
Social structure by caste			
ST	-0.0657***	-0.0148	-0.0805**
	(0.0237)	(0.0287)	(0.0342)
SC	-0.1177***	-0.0938***	-0.1030***
	(0.0189)	(0.0255)	(0.0253)
OBC	-0.0015	-0.0030	-0.0087
	(0.0152)	(0.0194)	(0.0218)
Household type			
Self-employed in non-agriculture	-0.0761***	-0.0669*	-0.0763**
	(0.0262)	(0.0351)	(0.0363)
Agricultural labour	-0.0985***	-0.0914***	-0.0888**
	(0.0259)	(0.0350)	(0.0357)
Other labour	-0.1274***	-0.0959**	-0.1833***
	(0.0306)	(0.0407)	(0.0430)
Self-employed in agriculture	0.1430***	0.1762***	0.0763**
	(0.0224)	(0.0288)	(0.0317)
Constant	8.1504***	9.0152***	7.5312***
	(0.5744)	(0.7937)	(0.7933)
No. of observations	40291	22399	17892
F	53.15	44.13	20.51
Adjusted R^2	0.3414	0.3546	0.3365

Notes: District dummy included. Figures in parentheses are village clustered standard errors.
***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

(b) Instrumental variable regression for the effect of use of information on net farm returns

	Full sample	Food grains and other crops	Food grains only
First stage: Dependent variable: use of information=1, zero otherwise			
Personal and household characteristics			
Ln(operated land)	0.0515***	0.0506***	0.0453***
	(0.0027)	(0.0036)	(0.0041)
Ln(operated land)^2	0.0039***	0.0023**	0.0045***
	(0.0007)	(0.0010)	(0.0012)
Ln(age head)	0.1911	0.2657	0.0692
	(0.1200)	(0.1777)	(0.1581)
Ln(age head)^2	-0.0206	-0.0280	-0.0070
	(0.0160)	(0.0236)	(0.0212)
Male head	0.0257***	0.0306***	0.0191*
	(0.0073)	(0.0103)	(0.0099)
Ln(family size)	0.0294***	0.0313***	0.0257***
	(0.0042)	(0.0060)	(0.0057)
Educational attainment of the head of household			
Primary	0.0379***	0.0450***	0.0325***
	(0.0048)	(0.0069)	(0.0067)
Middle	0.0538***	0.0633***	0.0434***
	(0.0063)	(0.0087)	(0.0093)
Secondary	0.0912***	0.1159***	0.0635***
	(0.0072)	(0.0099)	(0.0104)
Graduate	0.1236***	0.1468***	0.0957***
	(0.0128)	(0.0174)	(0.0191)
Social structure by caste			
ST	0.0062	-0.0062	0.0230**
	(0.0062)	(0.0095)	(0.0091)
SC	0.0213***	0.0150*	0.0281***
	(0.0053)	(0.0085)	(0.0079)
OBC	-0.0005	-0.0077	0.0084
	(0.0044)	(0.0063)	(0.0071)
Household type			
Selfemployed in non-agriculture	-0.0039	0.0019	-0.0079
	(0.0101)	(0.0141)	(0.0147)
Agricultural labour	0.0002	0.0161	-0.0159
	(0.0097)	(0.0143)	(0.0137)
Other labour	-0.0250**	-0.0176	-0.0334**
	(0.0111)	(0.0157)	(0.0157)
Selfemployed in agriculture	0.0226***	0.0421***	-0.0023
	(0.0087)	(0.0117)	(0.0130)
Local networks (Instrument)	0.5316***	0.5168***	0.5294***
	(0.0098)	(0.0125)	(0.0142)
Constant	-0.3652	-0.5494*	-0.0888
	(0.2233)	(0.3330)	(0.2925)
No. of observations	40291	22399	17892
F	326.89	195.33	118.64
Adjusted R^2	0.3648	0.3425	0.4020
Second stage: Dependent variable: Ln(net returns per hectare)			
Use of information	0.1156***	0.1566***	0.0115
	(0.0413)	(0.0537)	(0.0573)
Includes all controls as in the first stage regression			
Constant	9.0001***	9.7308***	8.2584***
	(0.5729)	(0.7872)	(0.8021)
No. of observations	40291	22399	17892
Adjusted R2	0.3413	0.3539	0.3364

Notes: District dummy included. Figures in parentheses are village clustered standard errors.
***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Table 10: Impact of formal and informal sources of information on returns from farming

	Full sample	Food grains and other crops	Food grains only
First stage 1: Dependent variable: use of information from formal sources=1, zero otherwise			
Formal local social network	0.4547***	0.4695***	0.4035***
	(0.0134)	(0.0168)	(0.0198)
Informal local social network	0.0222***	0.0378***	0.0002
	(0.0078)	(0.0116)	(0.0104)
Includes all the controls as in table 9(b)			
Constant	0.0896	0.0380	0.0655
	(0.1981)	(0.3064)	(0.2487)
No. of observations	40291	22399	17892
F	220.67	145.34	62.02
Adjusted R^2	0.2469	0.2497	0.2319
First stage 2: Dependent variable: use of information from formal sources=1, zero otherwise			
Formal local social network	-0.0109	0.0110	-0.0470***
	(0.0089)	(0.0114)	(0.0142)
Informal local social network	0.5587***	0.5236***	0.5818***
	(0.0116)	(0.0152)	(0.0159)
Includes all the controls as in table 9(b)			
Constant	-0.0357	0.0141	-0.0677
	(0.2056)	(0.3169)	(0.2549)
No. of observations	40291	22399	17892
F	214.84	117.72	93.99
Adjusted R^2	0.3871	0.3617	0.4339
Second stage: Dependent variable: Ln(net returns per hectare)			
Formal sources of information	0.1180*	0.1308*	-0.0243
	(0.0628)	(0.0760)	(0.1026)
Informal sources of information	0.0602	0.0899	0.0135
	(0.0478)	(0.0679)	(0.0592)
Includes all the controls as in table 9(b)			
Constant	8.9539***	9.6582***	8.2515***
	(0.5733)	(0.7869)	(0.8022)
No. of observations	40291	22399	17892
Adjusted R^2	0.3417	0.3544	0.3361

Notes: District dummy included. Figures in parentheses are village clustered standard errors.

***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

who grow only foodgrain crops is insignificant. The difference in impact of formal and informal sources estimated using IV method is also more pronounced as compared to the OLS estimates (table A3 in the appendix).

Alternatively, we also estimate the effect of formal and informal information sources separately. The endogenous variable is the use of information, which is instrumented by the formal and informal local social networks separately.The results (table A4 in the appendix) confirm that formal sources of information have a larger impact on returns from farming than the informal information sources.

The larger impact of formal information sources is expected. The formal sources of information are managed by the qualified and skilled professionals, for example, those who have degrees or diplomas in agriculture or allied sciences. Relatively, the quality of human resources in the informal information dissemination system is poor, and often the informal sources rely on formal sources for the intended information, which they share with farmers. In such cases, the loss of information in transmission can not be ruled out. For example, farmer to farmer exchange of information could be an easy means of spreading technologies and cropping practices, but because of inadequate knowledge on the characteristics and requirements of other farmers there is a high probability of information being lost or distorted during transmission. Similar could be the situation regarding private information sources, especially traders and input dealers who do not possess much knowledge of the technological and other requirements of different farming systems.

How do the estimated effects of information on farm outcomes in this paper compare with other estimates? Based on the available literature, it is clear that there are context specificities in the impact of information on farm outcomes. There are differences in the information sources, categories of information (regarding inputs, outputs or markets in general) and the nature of outcome measures (net returns or gross returns, per capita or per hectare of land). In other words, for comparison purposes, the effects of information in this paper can be assessed only qualitatively relative to those reported in other studies.

Owens *et al.* (2001) find that agricultural extension services in Zimbabwe could enhance the value of crop production (*i.e.*, gross returns per hectare) by about 15%. Davis *et al.* (2010) using data from three countries (Kenya, Tanzania and Uganda) find that farmers'per capita income to improve by 61% with participation in farmer field schools, one of the channels for information dissemination. Across countries, the estimated effect is 104% in Tanzania, 21% in Kenya and 18% in Uganda. Comparatively small effects of farmer field schools in Uganda are rationalized in terms of other information channels being in operation. In contrast with these studies, Comacho and Conover (2011) do not find any significant effect

of mobile phone based information on farm revenues.Few studies from India as well have analysed the impact of information and communication technology (ICT) on farm prices. Goyal (2010) finds soybean farmers in the state of Madhya Pradesh with improved access to market price information (through internet) realizing 1-5% higher prices. On the other hand, Fafchamps and Minten (2012) do not find any significant impact of information, through mobiles, either on the quality of farm produce or on prices in Maharashtra.

In relation to these studies, our study is different on three counts. First, we estimate effect of information on net returns normalized by size of landholding, *i.e.*, the net returns per hectare of cropped area. Second, we estimate effect of all possible sources of information together rather the effect of one node of information. The comprehensive data on sources of information used in this paper allows us to estimate the effect of information as such, *i.e.*, independent of the source. Third, our study has a larger geographic focus and has taken into consideration the role of context-specific factors, such as farm size and social identity in access to and use of information.

Clubbing different subjects and sources of information, we have shown that information has significant effect on farm income. It can raise returns from farming by 12%. The estimated impact is almost similar to that reported in a recent study on impact of information through mobiles on agricultural income in India by Vodafone Group (Anon. 2015). Our results also show that formal information sources, though have a limited outreach, their impact on farm outcomes is much stronger compared to that of the informal information dissemination channels.

Chapter 6

Conclusions and Policy Implications

In this paper, using data from a nationally representative large survey we have examined farm households' access to and use of information and its impact on net returns from farming. About 40% farm households in the country access information on modern agricultural technologies and farming practices, and 75% of them actually use it in their farming and other decisions related to it. Importantly, the outreach of the government extension workers is limited to only about 7% of the farm households. Most farmers rely on other information sources notably mass media (radio, television and newspaper) and social networks, such as other progressive farmers, and input dealers for their information needs.

We have also examined bias in the use of information by farm size and social identity, *i.e.* caste, and find that smaller farmers have access to relatively fewer information sources, and depend more on social networks for their information needs, while for larger farmers the mass media and government sources are relatively more important information sources. There is also some evidence of a bias against socially-disadvantaged farm households in access to and use of information. Interestingly, some of the government sources exhibit less social bias in information provision.

Overall, close-knit networks of farmers appear more effective in their outreach. Specifically, these connections comprise family and friends and are, in general, restrictive. In a socially-fragmented set up like the rural agrarian society of India, there are, however, limits to these social effects to translate into social multipliers. With considerable social heterogeneity, the large-scale programs of the government would require sources of information and services that are less exclusionary. We hypothesize that these nodes can be media and non-religious organizations, in particular, along with the government managed agricultural extension services. There is a case for investing in making government information more expansive and effective.

Our results show that information enhances net returns from farming by 12% on an average. The effect varies across cropping systems, being larger in the diversified farming systems. Further, the formal sources of information though are found to have smaller outreach; these have a larger effect on farm income compared to the informal information sources.

These findings are extremely crucial for policy decisions. The policy should aim at developing information delivery systems in a way such that there is a greater uptake of information by farmers irrespective of farm size and social class, and also create a larger impact on farm income. Further, Indian agriculture is diversifying towards higher-value crops; hence, there is a need for developing information systems that cater to the diversified needs of the farmers growing these crops. Indeed, several government programs in India have relied on mass media channels, such as radio and television to disseminate agricultural information to the masses without any biases. The bias in information use from these channels could perhaps be due to differences in the capacity of individuals to invest in the specific information channel, and human capital, *i.e.*, literacy.

The returns on investment in information systems seem to be quite attractive. There is certainly scope for increasing the outreach of the channels that are much more important for spread of agricultural technology in a heterogeneous society. The investment in public extension services, however, has not kept pace with the rising demand for information in agriculture. Note that, investment on agricultural research and development has been shown to have considerable potential for enhancing farm productivity and poverty reduction in India (Fan *et al.,* 2000; Fan *et al.,* 2007). Our results show that information raises net income per hectare by more than 12%, which in value terms translates to Rs 1140 per hectare of cropped area (at 2002-03 prices). This is much higher than the expenditure of Rs 29 per hectare on public extension services, and also on the research and education (Rs 157/ha). These findings suggest that underinvestment in public extension services may limit realization of the potential increases in agricultural productivity from spending more on agricultural research.

There are several constraints and also opportunities for improving the outcomes of information in the pluralistic extension system (Meena, *et al*. 2013). In order to enhance effects of informal sources of information, that at present comprise one of the important channels of information dissemination, the government should aim at linking them with government research and extension systems so as to improve upon their technological and management skills through formal trainings in agricultural extension management.

New business models of information dissemination, for example information and communication technology (ICT) and inter-linked arrangements, such as contract farming and producer organizations, are proving to be efficient in information dissemination (Mittal, *et al.* 2010, Tadesse and Bahiigwa 2015). Their outreach, however, is limited. For instance, the tele-density in rural India has improved a lot over time[7]; the

[7]See, footnote 4.

use of telephones and mobiles for search and acquisition of agricultural information has not been as significant perhaps due to lack of context-, and location-specific customized information. The need is to collect and collate the context- and location-specific right kind of information and disseminate it in right time and in a right form through the channels that are faster and cost-effective. Toward this, the study from Vodafone Group lists several recommendations like the provision of context-, and location-specific simple and straightforward messages, creation of awareness among farmers on the benefits of ICT services, provision of bundled services (technological, financial and non-financial), and creation of strong linkages of information providers with the research organizations, public extension systems and market places.

References

Aker, J. C., 2011. Dial "A" for agriculture: A review of information and communication technologies for agricultural extension in developing countries. Agricultural Economics 42(6), 631-647.

Ali, J., 2012. Factors affecting the adoption of information and communication technologies (ICTs) for farming decisions. Journal of Agricultural & Food Information 13(1), 78-96.

Alvarez, J., Nuthall, P., 2006. Adoption of computer based information systems: The case of dairy farmers in Canterbury, NZ, and Florida, Uruguay. Computers and Electronics in Agriculture50, 48-60.

Anderson, J.R., Feder, G., 2007.Agricultural extension (pp. 2343–2378). In: Evenson, R., Pingali, P. (Eds.). Handbook of agricultural economics, Vol 3, Agricultural development: Farmers, farm production and farm markets, Elsevier, Amsterdam.

Angrist, J. D., Kruegar, A. B., 1991. Does compulsory schooling attendance affect schooling and earnings? Quarterly Journal of Economics 106, 976-1014.

Anon.2015. Connected farming in India: How mobile can support farmers' livelihoods? Vodafone Group, Newbury, Berkshire, UK.

Babu, S. C., Glendenning, C. J., Asenso-Okyere, K., Govindarajan, S. K., 2011. Farmers' information needs and search behaviours: Case study in Tamil Nadu, India. Discussion Paper 1165. International Food Policy Research Institute, Washington DC.

Bandierra O., Rasul, I., 2006. Social networks and technology adoption in northern Mozambique. Economic Journal 116 (514), 869–902.

Batte, M. T., Arnholt, M. W., 2003. Precision farming adoption and use in Ohio: Case studies of six leading-edge adopters. Computers and Electronics in Agriculture 38, 125–139.

Bhagat, G. R., Nain, M. S., Narda, R., 2004. Information sources for agricultural technology. Indian Journal of Extension Education 40, 109-110.

Birkhaeuser, D., Evenson, R. E., Feder, G., 1991. The economic impact of agricultural extension: A review. Economic Development and Cultural Change 39(3), 607-650.

Birner, R., Anderson, J., 2007. How to make agricultural extension demand driven? The case of India's agricultural extension policy. Discussion Paper, No. 00729, International Food Policy Research Institute, Washington DC.

Birthal, P.S., Joshi, P.K., Negi, D.S., Agarwal, S. 2014. Changing sources of growth in Indian agriculture: Implications for regional priorities for accelerating agricultural growth. Discussion paper 01325. International Food Policy Research Institute, Washington DC, USA.

Carter, B. R., Batte, M. T., 1993. Identifying needs and audiences in farm management outreach education. Review of Agricultural Economics15(3), 403-415.

Chand, R., Prasanna, P. A. L., Singh, A., 2011. Farm size and productivity: Understanding the strengths of smallholders and their livelihoods. Economic and Political Weekly 46 (26/27), 5–11.

Conley, T. G., Udry, C. R., 2010. Learning about a new technology: Pineapple in Ghana. American Economic Review 100(1), 35–69.

Davis, K., Nkoynya, E., Kato, E., Mekonnen, D. A., Odendo, M., Miiro R., Nkuba, J., 2010. Impact of farmer field schools on agricultural productivity and poverty in east Africa. Discussion Paper. 00992. International Food Policy Research Institute, Washington DC.

Evenson, R., Mwabu, G., 2001. The effect of agricultural extension on farm yields in Kenya. African Development Review 13(1), 1–23.

Fafchamps, M., Minten, B., 2012. Impact of SMS-based agricultural information on Indian farmers. World Bank Economic Review 26(3), 383-414.

Fan, S., Gulati, A., Thorat, S., 2007. Investment, subsidies and pro-poor growth in rural India.Discussion Paper 00716. International Food Policy Research Institute, Washington DC.

Fan, S., Hazell, P., Thorat, S., 2000. Government spending, growth, and poverty in rural India. American Journal of Agricultural Economics 82 (4), 1038-1051.

Feder, G., Slade, R., 1986. A comparative analysis of some aspects of the training and visit system of agricultural extension in India. Journal of Development Studies 22 (3), 407–28.

Feder, G., Willet, A., Zijp, W., 1999. Agricultural extension: Generic challenges and some ingredients for solutions. World Bank Policy Research Working Paper 2129, Washington DC.

Ferroni, M., Zhou, Y., 2012. Achievements and challenges in agricultural extension in India. Global Journal of Emerging Market Economies 4 (3), 319-346.

Fontaine, X., Yamada, K., 2011. Envy and hope: Relevant others' consumption and subjective well-being in urban India. GCOE Discussion Paper 212. Osaka University.

Foster, A., Rosenzweig, M., 1995. Learning by doing and learning from others: Human capital and technical change in agriculture. Journal of Political Economy103(6), 1176–1209.

Glaeser, E. L., Laibson, D., Sacerdote, B., 2002. An economic approach to social capital. The Economic Journal, November, F347-F458.

Godtland, E. M., Sadoulet, E., Murgai, R., Ortiz, O., 2004. The impact of farmer field schools on knowledge and productivity: A study of potato farmers in the Peruvian Andes. Economic Development and Cultural Change 53(1), 63-92.

GoI (Government of India)., 2005a. Situation assessment survey of farmers: Access to modern technology for farming. 59th Round, Report No. 499(59/33/2), National Sample Survey Organization, Ministry of Statistics and Programme Implementation, Government of India, New Delhi.

GoI., 2005b. Situation assessment survey of farmers: Some aspects of farming. 59th Round, Report No. 496(59/33/3), National Sample Survey Organization, Ministry of Statistics and Programme Implementation, Government of India, New Delhi.

GoI., 2011. Indian telecom sector growth: An international success story. Press Information Bureau, Ministry of Communications and Information Technology, Government of India, New Delhi, (http://pib.nic.in/newsite/erelease.aspx?relid=79183).

Goyal, A., 2010.Information, direct access to farmers, and rural market performance in central India. American Economic Journal: Applied Economics 2(3) 22-45.

Imbens, G. W., Angrist, J. D., 1994. Identification and estimation of local average treatment effects. Econometrica 62(2), 467-475.

Liu, E. M., 2013. Time to change what to sow: Risk preferences and technology adoption decisions of cotton farmers in China. The Review of Economics and Statistics 95(4), 1386–1403.

Meena, M. S., Singh, K. M., Swanson, B. E., 2013. Pluralistic agricultural extension system in India: Innovations and constraints. MPRA Working Paper, No. 48324.

Mittal, S., Gandhi, S., Tripathi, G., 2010. Socio-economic impact of mobile phones on Indian agriculture. Working paper 246. Indian Council for Research on International Economic Relations, New Delhi.

Okwu, O. J., Dauda, S., 2011. Extension communication channels' usage and preference by farmers in Benue state, Nigeria. Journal of Agricultural Extension and Rural Development 3(5), 88-94.

Owens, T., Hoddinott, J., Kinsey, B., 2003. The impact of agricultural extension on farm production in resettlement areas of Zimbabwe. Economic

Development and Cultural Change 51(2),337-57.

Putnam, R. D., 2001. Bowling alone: The collapse and revival of American community. New York: Simon and Schuster.

Singh, B., Narwal, R. S., Malik, J. S., 2003. Communication sources used by extension personnel and farmers. Indian Journal of Extension Education 39, 26-30.

Solano, C., Leon, H., Perez, E., Herrero, M., 2003. The role of personal information sources on the decision-making process of Costa Rican dairy farmers. Agricultural Systems 76, 3-18.

Tadesse, G., Bahiigwa, G. 2015. Mobile phones and farmers' marketing decisions in Ethiopia. World Development 68, 296–307.

Appendices

Table A1: Percentage of households reporting use of information from different sources

(a) By farm size

Source of information	Category	Sub-marginal	Marginal	Small	Medium	Large	Total
Other progressive farmers	Social networks	28.0	23.4	20.9	19.3	16.0	22.8
Input dealer	Private	21.8	18.4	17.6	15.7	14.2	18.4
Radio	Mass media	14.8	15.5	17.2	13.3	10.5	14.7
Television	Mass media	8.5	10.0	10.8	13.4	15.2	10.8
Newspaper	Mass media	6.8	7.4	8.5	9.3	11.7	8.3
Extension worker	Government	4.7	6.6	6.8	8.5	9.8	6.7
Primary cooperative society	Social networks	2.9	4.4	4.1	5.3	6.6	4.3
Government demonstration	Government	2.1	2.8	3.2	2.6	3.2	2.7
Output buyers/ food processors	Private	2.3	3.1	2.3	3.2	3.0	2.7
Village fair	Social networks	2.3	2.1	2.3	1.6	1.6	2.1
Telephone, mobile, and Internet	Private	2.0	1.8	1.5	1.8	1.4	1.8
Credit agency	Government	1.2	1.3	1.3	2.1	2.0	1.5
Participation in training program	Government	0.9	1.1	1.7	2.0	2.2	1.4
KrishiVigyan Kendra	Government	0.9	1.1	1.0	1.0	1.5	1.1
Para-technician/ private agency/ NGO	Private	0.5	0.6	0.7	0.6	0.7	0.6
Farmers' study tour	Government	0.2	0.3	0.3	0.4	0.6	0.3
Any source		20.0	29.5	35.3	38.3	40.6	27.6

(b) By caste

Source of information	Category	Scheduled tribes	Scheduled castes	Other backward castes	Upper castes	All
Other progressive farmers	Social networks	23.5	29.1	23.6	19.4	22.8
Input dealer	Private	16.0	23.7	17.2	18.2	18.4
Radio	Mass media	16.8	12.5	14.5	15.3	14.7
Television	Mass media	7.6	7.3	10.5	13.3	10.8
Newspaper	Mass media	7.2	5.1	8.2	9.8	8.3
Extension worker	Government	10.8	5.3	7.2	5.7	6.7
Primary cooperative society	Social networks	3.6	3.3	4.9	4.1	4.3
Government demonstration	Government	4.3	2.9	2.7	2.2	2.7
Output buyers/food processors	Private	2.0	2.7	3.1	2.4	2.7
Village fair	Social networks	2.7	2.3	1.7	2.2	2.1
Telephone, mobile, and Internet	Private	2.4	2.0	1.5	1.8	1.8
Credit agency	Government	1.2	1.2	1.6	1.6	1.5
Participation in training program	Government	1.0	1.5	1.3	1.7	1.4
KrishiVigyan Kendra	Government	0.3	0.5	1.1	1.5	1.1
Para-technician/ private agency/ NGO	Private	0.4	0.4	0.6	0.7	0.6
Farmers' study tour	Government	0.4	0.4	0.3	0.3	0.3
Any source		20.0	23.2	27.3	34.8	27.6

Table A2: Net returns for broad crop groups by farm size (rupees per hectare)

	Sub-marginal	Marginal	Small	Medium	Large	Total
(a) Exclusively food grains	8393	6531	5888	5020	4464	7159
(b) Food grains and other crops	18097 (-10.12)	10478 (-12.86)	8751 (-8.59)	9041 (-6.46)	7220 (-6.32)	11737 (-13.22)
Full sample	12067	8500	7593	7764	6574	9489

Note: t statistic for difference in mean test between category (a) and (b).

Table A3: Ordinary least squares estimates of impact of use of information from formal and informal sources on net farm returns per hectare

	Full sample	Food grains and other crops	Exclusively Food grains
Dependent variable: Ln(net returns per hectare)			
Formal sources of information	0.0847***	0.0763***	0.0481*
	(0.0160)	(0.0195)	(0.0250)
Informal sources of information	0.0708***	0.0619***	0.0562**
	(0.0168)	(0.0212)	(0.0245)
Includes all the controls as in table 9(b)			
Constant	8.1171***	8.9713***	7.5245***
	(0.5744)	(0.7933)	(0.7933)
No. of observations	40291	22399	17892
F	51.24	42.32	19.65
Adjusted R^2	0.3418	0.3549	0.3368

Notes: District dummies included. Figures in parentheses are village clustered standard errors.
***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

Table A4: Impact of information by source

(a) Formal sources of information and the impact on incomes: Results from instrumental variable regression.

	Full sample	Food grains and other crops	Exclusively food grains
First stage: Dependent variable: use of information from formal sources=1, zero otherwise			
Formal local social network	0.4372***	0.4566***	0.3765***
	(0.0135)	(0.0162)	(0.0206)
Includes all the controls as in table 9(b)			
Constant	-0.2405	-0.4042	0.0986
	(0.2393)	(0.3494)	(0.3249)
No. of observations	40291	22399	17892
F	167.28	119.52	45.52
Adjusted R^2	0.2981	0.2928	0.3179
Second stage: Dependent variable: Ln(net returns per hectare)			
Use of information	0.1542**	0.1824**	-0.0198
	(0.0623)	(0.0726)	(0.1061)
Includes all the controls as in table 9(b)			
Constant	9.0068***	9.7364***	8.2496***
	(0.5726)	(0.7876)	(0.8031)
No. of observations	40291	22399	17892
Adjusted R^2	0.3409	0.3534	0.3359

Notes: District dummies included. Figures in parentheses are village clustered standard errors.
***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

(b) Informal sources of information and the impact on incomes: Results from instrumental variable regression.

	Full sample	Food grains and other crops	Exclusively food grains
First stage: Dependent variable: use of information from informal sources=1, zero otherwise			
Informal local social network	0.5357***	0.5063***	0.5503***
	(0.0111)	(0.0144)	(0.0156)
Includes all the controls as in table 9(b)			
Constant	-0.4255*	-0.5188	-0.2229
	(0.2297)	(0.3442)	(0.2958)
No. of observations	40291	22399	17892
F	264.24	151.37	107.68
Adjusted R^2	0.3412	0.3139	0.3885
Second stage: Dependent variable: Ln(net returns per hectare)			
Use of information	0.0986**	0.1466**	0.0094
	(0.0463)	(0.0637)	(0.0592)
Includes all the controls as in table 9(b)			
Constant	8.9971***	9.7287***	8.2578***
	(0.5732)	(0.7872)	(0.8023)
No. of observations	40291	22399	17892
Adjusted R^2	0.3414	0.3541	0.3363

Notes: District dummies included. Figures in parentheses are village clustered standard errors.

***, ** and * denote significance at the 1%, 5% and 10% level, respectively.

NIAP Publications

Policy Papers

13. Haque. T. 2001. *Impact of Tenancy Reforms on Productivity Improvement and Socio-Economic Status of Poor Tenants.*
14. Selvarajan, S., A. Ravishankar, and PA. Lakshmi Prasanna. 2001. *Irrigation Development and Equity Impacts in India.*
15. Birthal, PS., P.K. Joshi, and Anjani Kumar, 2002. *Assessment of Research Priorities for Livestock Sector in India.*
16. Pal, Suresh and Derek Byerlee. 2003. *The funding and Organization of Agricultural Research in India: Evolution and Emergency Policy Issues.*
17. Adhiguru, P. and Ramasamy,C. 2003. *Agricultural-based Interventions for Sustainable Nutritional Security.*
18. Birthal, PS. 2003. *Economic Potential of Biological Substitutes for Agrochemicals.*
19. Chand, Ramesh. 2003. *Government Intervention in Foodgrain Markets in the New Context.*
20. Mruthyunjaya, Pal, Suresh and Saxena, Raka. 2003. *Agricultural Research Priorities for South Asia*.
21. Dastagiri, M.B. 2004. *Demand and Supply Projections for Livestock Products in India*.
22. B.C. Bhowmick, B.C. Barah, Sushil Pandey, and N. Barthakur. 2005. *Changing Pattern of Rice Production Systems and Technology in Assam.*
23. DayanathaJha and Sant Kumar. 2006. *Research Resource Allocation in Indian Agriculture.*
24. Anjani Kumar.2009. *India's Livestock Sector Trade: Opportunities and Challenges.*
25. Chand, Ramesh, Praduman Kumar, and Sant Kumar. 2011. *Total Factor Productivity and Contribution of Research Investment of Agricultural growth in India.*
26. Chand, Ramesh, S.S. Raju, Sanjeev Garg, and Lai Mani Pandey. 2011. *Instability and Regional Variation in Indian Agriculture.*
27. S.S. Raju, Shinoj Parappurathu, Chand, Ramesh, P.K. Joshi, Praduman Kumar and Siwa Msangi. 2012. *Biofuels in India: Potential, Policy and Emerging Paradigms.*
28. Shinoj Parappurathu, Anjani Kumar, Shiv Kumar and Rajni Jain.2014. *Commodity Outlook on Major Cereals in India.*

Policy Briefs

22. Pal, Suresh, Prasoon Mathur and A. K. Jha. 2005. *Impact of Agricultural Research in India: Is it Decelerating?*
23. Chand, Ramesh. 2005. *Post WTO Agriculture Trade and Agenda for Negotiations on Agriculture.*
24. Birthal, P. S. and P. K. Joshi, 2006. *High-value Agriculture for Accelerated and Equitable Growth.*
25. Barah, B. C. 2006. *Agricultural Development in North-East India- Challenges and Opportunities.*
26. Ganesh Kumar, B. and K. K. Datta. 2008. *Tackling Avian Influenza, An Emerging Transboundary Disease.*
27. Beintema, Nenke, P. Adhiguru, Pratap S. Birthal and A.K. Bawa. 2008. *Public Agricultural Research Investments: India in a Global Context.*
28. Chand, Ramesh. 2009. *Demand for Foodgrains During 11" Plan and Towards 2020.*
29. Shinoj, P. 2009. *India-ASEAN Trade in Agriculture: Retrospect and Prospect.*
30. Birthal, Pratap S. and Shiv Kumar. 2009. *Conditions for the Success of Contract Farming in Smallholder Agriculture?*
31. Raju, S.S. and Ramesh Chand. 2009. *Problems and Prospects in Agricultural Insurance in India.*
32. Birthal, Pratap S. and P.K. Joshi. 2009. *Agriculture and Regional Disparities in India.*
33. Singh, Harbir and Ramesh Chand. 2010. *The Seeds Bill, 2010: A critical Appraisal*.
34. Kumar, Sant, PA. Lakshmi Prasanna and Shwetal Wankhade. 2010. *Economic Benefits of Bt Brinjal-An Ex-Ante Assessment.*
35. Chand, Ramesh, Ashok Gulati, P. Shinoj and Kavery Ganguly. 2011. *Managing Food Inflation in India: Reforms and Policy Options.*
36. Shinoj, P, S.S. Raju, Ramesh Chand, Praduman Kumarand Siwa Msangi. 2011. *Biofuels in India: Future Challenges.*
37. Ramasundaram, P, Suresh AKurup and Ramesh Chand. 2011. *Maneuvering Technology for Surplus Extraction: The case of Bt Cotton in India.*
38. Chand, Ramesh and Jaya Jumrani. 2013. *Food Security and Undernourishment in India: Assessment of Alternative Norms and the Income Effect.*
39. Chand, Ramesh and PS. Birthal. 2014. *Buffer Stock Norms for Food grains during Twelfth Five Year Plan.*
40. Chand, Ramesh and S.K. Srivastava. 2014. *Changing Structure of Rural Labour Market: Trends, Drivers and Implications for Agriculture.*
41. Birthal Pratap S., Digvijay S. Negi, Md. Tajudding Khan and Shaily Agarwal. 2015. *Is Indian Agriculture Becoming Resilient to Droughts ? Evidence form Rice Production.*

भा.कृ.अ.प.–राष्ट्रीय कृषि आर्थिकी एवम् नीति अनुसंधान संस्थान

ICAR – NATIONAL INSTITUTE OF AGRICULTURAL ECONOMICS AND POLICY RESEARCH

(Indian Council of Agricultural Research)

P.B. No. 11305, Dev Prakash Shastri Marg, Pusa, New Delhi-110 012, INDIA

Phone : 91-11-25847628, 25848731, Fax : 91-11-25842684 E-mail : director@ncap.res.in

http: // www.ncap.res.in