Agricultural Technology Adoption under Multiple Constraints: An Analysis of System of Rice Intensification (SRI) in India

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Abstract

The study analyses the role of multiple binding constraints such as information, extension services, availability of labourers and irrigation in conditioning System of Rice Intensification (SRI) adoption by rice farmers in selected rice producing districts of India. The multiple thresholds that farmers need to overcome are analysed using a multi-hurdle model which explicitly incorporates the impact of constraints in adoption decisions. The results showed that age of the farmer reduced the access to information whereas the size of the farm increased the access to information. Gender of the head of the household, education, membership in farmer organisations etc. was crucial in getting access to extension services. Age of the household head, full time farming etc. increased the availability of labourers. Type of soil and terrain were found to be important in getting access to irrigation facility. District wise disparities showed that the disparities were the highest in the case of accessing information and followed by extension services. Although factors influencing the intensity (in terms of acres) as well as the depth of adoption (in terms of packages) were slightly different household assets, number of improved rice varieties known, membership in farmer organisations, risk etc. were significant in influencing the adoption decisions.

JEL Classifications: Q10, Q16, Q18, O31, O33.

Keywords: Natural Resource Management; System of Rice Intensification; Multi-Hurdle Model; Conditional Mixed Process; India.

Introduction

The System of Rice Intensification (SRI) is widely considered as a promising systemic approach to increase rice production at affordable costs for small-scale producers without harming the environment. SRI originated in Madagascar as a way to increase the productivity of rice paddies while simultaneously decreasing water and other input requirements, benefiting Malagasy smallholder farmers who have few economic resources. SRI introduces changes in a range of management practices consisting of (1) use of young seedlings that are 8-12 days old; (2) shallow planting (1-2 cm) of one or two seedlings; (3) sparse planting in a square grid (more than 20 x 20 cm); and (4) intermittent irrigation (Takahashi and Barrett, 2014). It is expected to enhance rice yield and substantially reduce expenditure (Stoop et al., 2002; Uphoff, 2002, 2003) by altering plants, soil, water and nutrients management practices (Satyanarayana et al., 2007). Thus, SRI comprises of three major principles such as soil management, plant management and water management.[1]

In India, SRI is becoming popular with farmers and taking firm root with about 1 million hectares of area under SRI cultivation making it 2.42% of total area under rice cultivation in the country (Gujja and Thiyagarajan, 2013). Field trials are being conducted in all the major rice-producing states of India like West Bengal, Punjab, Gujarat, Uttar Pradesh, Andhra Pradesh, and Tamil Nadu; there is also a widening involvement of farmers, government institutions, research agencies, and funding agencies to work together for a large-scale adoption of SRI. Out of 564 rice-growing districts in India, SRI is being practiced by farmers in about 216 districts (ICRISAT, 2008). Moreover, SRI is regarded as a key means of boosting national rice production under the Government of India's National Food Security Mission (NFSM).[2]

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[1] **Soil management**: The use of organic matter to improve soil quality and performing weeding using a mechanical rotary weeder. **Plant management**: Planting single young seedlings (between 8-12 days old) carefully, gently and horizontally into the soil with wider spacing. **Water management**: Keep the soil moist but not continuously flooded during the plants' vegetative growth phase, until the stage of flowering and grain production.

[2] The National Food Security Mission (NFSM) was launched in 2007 as a centrally-sponsored scheme to enhance food security through targeted production of rice, wheat, and pulses and coarse cereals. Various interventions for commercial crops have also been proposed.

Although several studies have highlighted the high-yield and low-cost benefits of SRI the rate of adoption remains low (Reddy et al, 2005). Studies find SRI to be labour intensive (Noltze et al., 2012). As per the literature the reasons for poor rate of adoption and high non-adoption rates are the labour-intensive nature of SRI and the skill of farming that it requires (Barrett et al., 2004; Palanisami et al., 2013). The major constraints in the adoption of SRI/modified SRI practices are lack of skilled manpower available in time for planting operations, poor water control in the fields, and unsuitable soils. Studies point out that the yield realisation under full adoption of SRI is significantly higher than partial adoption (Palanisami et al., 2013). Aversion to risk by farmers has also been highlighted by some studies as the reason for poor adoption (Johnson and Vijayaraghavan, 2011).

The available studies on SRI in general and that for India in particular point out various constraints faced by farmers in adopting SRI despite the proven benefits. In practice, even farmers with positive demand for adoption may not be able to adopt a new technology due to the multiple constraints in adoption (Shiferaw et al., 2015). Nonetheless, studies investigating adoption of agricultural technologies in the context of multiple binding constraints are very limited. In fact, many adoption decision studies, including some of the studies mentioned above, assume that farmers function in a perfect information setting and, therefore, enjoy an unconstrained access to technology. According to Shiferaw et al. (2015), under such conditions of the zero (non-adoption) generating process, an adoption decision is modelled using probit and logit models for non-divisible technologies and tobit type models for divisible technologies.

Even in a perfect information setting, farmers with positive desired demand for adoption may fail to realise this potential demand owing to various constraints (Croppenstedt et al., 2003; Shiferaw et al., 2008; Shiferaw et al., 2015). The relaxation of constraints may lead to an increased adoption of new technology and, therefore, modelling technology adoption by dividing farmers into adopters and non-adopters fail to bring out the difference between actual and desired demand (Shiferaw et al., 2015). This may lead to inconsistency in estimated parameters.

Although there are studies analysing the factors influencing the adoption of technology under multiple constraints (Shiferaw et al., 2008; Shiferaw et al., 2015), there are hardly any such studies in the context of SRI. An understanding of the factors influencing adoption of environmental friendly methods such as SRI is pertinent to overcome the hurdles that farmers face in the process. The present study analyses the role of information, extension services, irrigation, and the availability of labourers in conditioning technology adoption by rice farmers in selected States of India. Although the present study focuses mainly on SRI adoption, the study intends to make a contribution to agricultural technology adoption in general and SRI adoption literature in particular. Our study analyses the adoption SRI by studying the probability for adoption of SRI conditional upon availability of information, availability of extension services, availability of irrigation, and availability of labour. The joint probability for adoption is estimated using conditional (recursive) mixed process estimator (CMP) developed by Roodman (2009 & 2011).

The remainder of the article is organized as follows. Section 2 presents the data, study area and the socio-economic profile of the sample households. Section 3 provides conceptual framework for household technology adoption in the presence of multiple binding constraints along with variable description and hypothesized relationships. Section 4 deals with the model specification and the main analytical results are presented and discussed in section 5. Concluding observations and policy implications are presented in section 6.

Study Area, Data collection and Socio-Economic Profile of the Households

Among the rice-producing States, the highest differences in gross margin and yield between traditional rice cultivation and SRI method were noticed in the case of three States (Palanisami et al., 2013) namely, Karnataka, Orissa and Madhya Pradesh. Subsequently, 2 districts from each of these three States that belong to the same agro-climatic zones are identified. Out of these two districts, one district has promotion of SRI through NFSM.

For Karnataka, Hassan (SRI-NFSM) and Chikmagalur (SRI) districts are identified. Similarly, for Orissa, Keonjhar (SRI-NFSM) and Mayurbhanj (SRI) districts are identified. For Madhya Pradesh, Sidhi (SRI) and Sahdol (SRI-NFSM) districts are selected.

The primary data is collected through a comprehensive household survey. A stratified random sampling technique has been adopted for selecting farm households. Rice-farming households were identified in the selected blocks/taluks of the districts and stratified into SRI farmers and non-SRI farmers.[3] The list of SRI farmers were obtained from the district agricultural offices of the respective districts.

A random sample of SRI adopters and non-adopters from each block/taluk was selected. The total number of households interviewed was 386. The total sample consists of equal number of adopters and non-adopters. Agriculture was the main occupation and livelihood strategy for most of the farm households in the study districts. Majority of the farm households interviewed were either marginal farmers or small farmers. Marginal farmers were around 45%, small farmers were around 36%, semi-medium farmers were around 16%, medium farmers were around 3% and large farmers were less than 1%.

Conceptual Framework

Knowledge and perception of innovations are fundamental and integral parts of the underlying decision-making process of adoption (Rogers, 2003). Farmers' decision to adopt innovations has been extensively studied in a wide range of literature (Feder et al., 1985; Shiferaw et al., 2008; Teklewold et al., 2013; Kassie et al., 2013; Shiferaw et al., 2015; Manda et al., 2015; Kassie et al., 2015).

The farmers' decision on whether to adopt a new technology or not is based on utility maximisation (Rahm and Huffman, 1984; Shiferaw et al., 2015). The i^{th} farmer will go for new technology if the utility derived from the new technology is greater than the old technology, i.e., $U_{1i} > U_{0i}$. By denoting A for adoption decision we can write:

$$A_d = \begin{cases} 1 \; if \; U_{0i} \; < U_{1i} \\ 0 \; if \; U_{1i} \geq U_{0i} \end{cases} \qquad (1)$$

In the first scenario (A_d=1) the utility from the new technology is higher whereas in the second scenario (A_i=0) the utility is smaller than or equal to the old technology. The probability that the farmer adopts superior technology (A_i=1) depends on a set of explanatory variables.

$$P_i = P_r(A_d = 1) = P_r(U_{1i} > U_{0i})$$
$$= P_r[\alpha_1 F_i(R_i Y_i) + e_{1i} > \alpha_0 \, F_i(R_i Y_i) + e_{o,i} \qquad (2)$$
$$= P_r\left[e_{1i} - e_{0,i} > F_i(R_i, L_i)(\alpha_1 - \alpha_0)\right]$$
$$= P_r(\mu_i \; > -F_i(R_i L_i)\beta)$$

[3] Alur, Hassan and Sakleshpur blocks from Hassan; Chikmagalur block from Chikmagalur; Sadar, Patna, and Harichandapur from Keonjhar; Karanjia and Jashipur from Mayurbhanj; Sidhi and Sihawal from Sidhi; Gohapru and Sohajpur from Shahdol were selected.

$= F_i(X_i\beta)$

Where X is the n x k matrix of the explanatory variables and β is a k x 1 vector of parameters to be estimated, *Pr(.)* is the probability function, μ_i is the random error term, and $F_i\ (X_i\ \beta)$ is the cumulative distribution function for μ_i evaluated at $X_i\ \beta$. The probability that a farmer will adopt a superior method is a function of the vector of explanatory variables and of the unknown parameters and error term.

The expected utility of the new technology is not, however, the only one factor that determines the adoption. This is especially true for small holder farmers in developing countries where they face multiple constraints in adoption. Even under a perfect information setting, farmers may not choose the new method due to several constraints in the form of lack of availability of skilled labourers, irrigation facility etc. In line with Shiferaw et al., (2008; 2015), the present study develops models for information access, availability of extension services, availability of labourers, and availability of irrigation. The information that is required for a farmer to make the adoption decision can be given as:

$$A^i = \begin{cases} 1\ if\ A^i > 0 \\ 0\ if\ A^i \leq 0 \end{cases} \qquad (3)$$

Once the farmer has the information the next step required is the minimum level of extension services which will enable the farmers to access the benefits of the new method. The observed pattern of extension services can be given as:

$$A^e = \begin{cases} 1\ if\ A^e > 0 \\ 0\ if\ A^e \leq 0 \end{cases} \qquad (4)$$

Now the farmer is aware of the new method and has sufficient guidance to implement the new method and to evaluate the benefits. Even when information and extension services are available, a producer with a positive desired demand may not be able to choose the new method due to other constraints such as lack of availability of labourers. The observed pattern of labour constraints can be given as:

$$A^l = \begin{cases} 1\ if\ A^l > 0 \\ 0\ if\ A^l \leq 0 \end{cases} \quad (5)$$

Similarly, irrigation constraints can be given as:

$$A^{ir} = \begin{cases} 1\ if\ A^{ir} > 0 \\ 0\ if\ A^{ir} \leq 0 \end{cases} \quad (6)$$

Whether the new method has been adopted or not by the producers can be given as:

$$A = A^i A^e A^l A^{ir} A^d = \begin{cases} 1, \text{ if the new method is adopted} \\ 0, \text{ if the new method is not adopted} \end{cases} \quad (7)$$

Adoption of new method would occur only when the farmers are able to overcome all the initial constraints.

Model Specification

The farmer’s demand for new method can be written as below.

$$y_i^* = x_i' \propto + u_i \quad (8)$$

Where X_i is vector of variables that determine the demand function, ∝ is a parameter vector, u is an error term with mean 0 and variance σ_u. Similarly, the latent variable underlying a farmer’s access to information, availability of extension services, availability of labourers and availability of irrigation can be modelled with equation (9) to (12).

$I_i^* = z_i' \beta + \epsilon_i$ (Access to information) (9)

$E_i^* = g_i' \theta + \omega_i$ (Availability of extension services) (10)

$L_i^* = h_i' \lambda + v_i$ (Availability of labourers) (11)

$IR_i^* = k_i' \delta + u_i$ (Availability of irrigation) (12)

In the above equations z, g, h and k are vector of variables that affect the availability of information, availability of extension services, availability of labourers, and availability of irrigation. And β, θ, λ and δ are the parameters to be estimated; $\boldsymbol{\epsilon}$, ω, v, u are the error terms with mean 0 and variance 1.

The observed demand for new method by a farmer (Y_i) is characterised by the interaction of model (8) to (12). The adoption of new method is observed only when all the initial hurdles have been overcome. This comprises the first group-adopters. Group 2 consists of farmers who do not have any information about SRI and hence cannot adopt SRI irrespective of whether they have availability of labourers or irrigation. In such case they will be indifferent to extension services. The third group will have availability of information but do not have sufficient knowledge in adoption due to lack of extension services. The fourth group consists of those farmers who have information and access to extension services and therefore have positive demand but are unable to adopt the new method due to the lack of availability of labourers. The fifth group will have information, extension services etc., and therefore positive demand but unable to adopt due to the lack of irrigation facility. The last group do not have positive demand for adoption of SRI and hence information, availability of labourers etc., are irrelevant for them.

In line with Shiferaw et al. (2008; 2015), the probability for adopting a new method can be given as:

$$P(A) = P(A)^d * P(A)^i * P(A)^e * P(A)^l * P(A)^{ir} \qquad (13)$$

The model estimated through CMP will analyse the joint probability of adoption of SRI by incorporating multiple constraints in the model. CMP estimates multi-equation, recursive mixed process models. "Mixed process" means that different equations can have different kinds of dependent variables. CMP can only fit “recursive" models with clearly defined stages. A and B can be determinants of C and C a determinant of D--but D cannot be a determinant of A, B, or C (Roodman. 2011). Equations from 9 to 12 are estimated using probit models while a truncated normal model estimates the intensity as well as the depth of adoption (equation 8, where Y_i represents the adoption of farmer in terms of both the intensity of adoption as well as the depth of adoption). The depth of adoption is defined in terms of the number of SRI packages adopted by a farmer[4]. The intensity of adoption is defined as the number of acres devoted for SRI cultivation by a farmer.

[4] The depth of adoption of SRI is analysed using the total packages as dependent variable. The SRI emerged as a set of six practices. They are as follows:

1. Transplanting of young seedlings
2. Shallow planting of seedlings
3. Single seedling at wider spacing

Description of variables

The selection of variables included in our analysis is based on literature review and insights from other studies on farm household behaviour under imperfect market setting (Shiferaw et al., 2008; Shiferaw et al., 2015). Imperfect information, labour markets etc., will have direct impact on adoption as marginal cost of adoption will be higher for those households that face these constraints (Shiferaw et al., 2015). Therefore, we include many household and farm characteristics that have an impact on adoption decisions. Several studies have included household characteristics such as **age of the head** of the household, **gender of the head** of the household, **size of the household**, **education** etc., as important factors influencing the adoption decision by farmers (Feder et al., 1985; Uaiene, 2011; Teklewold et al., 2013; Ogada et al., 2014; Manda et al., 2015). Another important human capital which is relevant in influencing the adoption and the extent of adoption is **number of active family labourers** (Langyintuo and Mungoma, 2008; Noltze et al., 2012). Adoption of a new technology can be less attractive to those who do not have sufficient family labourers (Langyintuo and Mungoma, 2008). Also the **household size** is used as a proxy to capture labour endowment (Pender and Gebremedhin, 2008). As far as the importance of total **farm size** is concerned, studies on SRI shows a positive relationship between the size of the farm and intensity of SRI in Timor Leste (Noltze et al., 2012), whereas studies on the adoption of improved maize varieties in Zambia showed a negative relationship (Langyintuo and Mungoma, 2008).

Higher initial **Assets owned** by the farmer is expected to relax many of the above-mentioned constraints and, therefore, is an important factor in deciding the adoption (Langyintuo and Mungoma, 2008). Also, we consider the impact of farmers who have **farming as main occupation** on adoption decisions. The study by Noltze et al. (2013) show that household heads whose main occupation is farming are much less likely to adopt SRI. **Access to off-farm activities and income** in general are expected to have a positive impact on adoption decisions (Davis et al., 2009). The study by Langyintuo and Mungoma (2008) found a

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4. Weeding by mechanical weeder
5. Use of organics
6. Efficient water management: Alternate wetting and drying

For the purpose of our analysis, we have decided to split the third package into two—single seedling and wider spacing. We observed that many farmers, although allowing wider spacing, were planting more than one seedling.

positive relationship in the case of adoption of improved maize varieties and the study by Noltze et al. (2012) found a positive relationship in the case of SRI adoption. However, the studies by Mathenge et al. (2014) and Manda et al. (2015) found a negative relationship between the two. Farmers' aversion to risk has also been highlighted by some studies as the reason for poor adoption (Johnson and Vijayaraghavan, 2011). To capture this effect, we include a variable, **fear of poor yield**, in our model to see how this has an impact on adoption decision.

From the studies mentioned earlier, we understand that SRI is labour intensive. Therefore, an important factor for adoption of SRI even when the farmer has positive demand for adoption is the **availability of labourers**.

Similarly, a farmer with positive demand may be constrained by lack of **availability of credit, access to extension services, access to information, access to seed** etc., and these factors play a significant role in adoption decisions (Langyintuo and Mungoma, 2008; Mazvimavi & Twomlow, 2009; Shiferaw et al., 2015). Since SRI is a knowledge-based innovation, extension services play even an even greater role in wider adoption (Noltze et al., 2012). Studies in the context of technology adoption in general have confirmed this view (Langyintuo and Mungoma, 2008). Moser and Barrett (2003) found a positive relationship between information availability and SRI adoption in Madagascar. Similar is the case with **access to irrigation**. There are studies that highlight the importance of **irrigation** and irrigation management in deciding adoption of SRI (Tsujimoto et al., 2009; Noltze at al., 2012; Uphoff, 2012). Some studies also found **terrain type** to be important in deciding adoption of SRI (Moser and Barrett, 2003). Significant differences in adoption intensity between regions have been reported by some studies (Langyintuo and Mungoma, 2008). Also, there are studies on technology adoption that has captured the differences in regions through **district dummies.** Therefore, in our analysis we include district dummies to capture the differences in adoption across regions.

From the review of literature undertaken above we model lack of access to information, access to extension services, availability of labour, and availability of irrigation as the major constraints in adoption along with several other household, farm, and institutional factors. The key variables hypothesized to affect ***access to information*** include human capital variables such as age, gender and education; social capital variables such as whether household members hold an official position; number of assets owned; communication technology (ICT) such as radio, TV and mobile; farm size; and number of other crops cultivated. Similarly, access to ***extension services*** is expected to depend upon human capital variables mentioned above as well as social capital variable such as membership in input supply cooperatives, ICT variables, farm size, whether farming is main occupation, and other crops cultivated. ***Access to labourers*** is expected to link with the wage rates, human capital variables, number of family labourers, access to off-farm activity, assets etc. Similarly, ***availability of irrigation*** is expected to depend upon assets and human capital variables (assets, age, gender, education etc.), experience in agriculture, soil and terrain type, availability of credit etc. The final equation of ***intensity of SRI adoption*** (in terms of acres allotted for SRI) after overcoming multiple hurdles is expected to depend upon human capital variables, experience in agriculture, assets, credit, number of improved varieties known etc**.** Similarly, the ***depth of adoption*** in terms of the number of packages is estimated within the same constraints. [5]

Estimation Results and Discussion

Descriptive Statistics

Total sample size was 386, of which 193 households were non-adopters of SRI. Among non-adopters around 38 farmers didn't have any information about SRI. This is interesting as it shows that around 80% of farmers were aware of SRI. Therefore, the lack of information did not play a role in non-adoption. Rather it points to the role of other constraints. Among the non-adopters, around 122 farmers didn't have any sort of extension services, 115 farmers faced difficulty with respect to irrigation, and 117 farmers reported difficulty in getting labourers. Availability of labourers was a problem even among the adopters of SRI. Descriptive statistics of the explanatory variables that are hypothesised to influence the constraints as well as the adoption of SRI are presented in Table 1.

[5] Although credit can be a major constraint in adoption even for a farmer with positive demand, we do not consider credit constraint as a hurdle in our present analysis. Rather we include it as a factor deciding adoption decision. This is due to the fact that our field-level observations did not find credit as a major constraint faced by farmers. Rather non-adopted farmers highlighted the reasons such as lack of availability of labourers, lack of information, irrigation etc., as the major reasons for non-adoption. This is intuitively true. Unlike other technologies SRI do not drastically change the cost of cultivation. Similarly, access to seed is considered as an important hurdle that need to be overcome to adopt technology in the context of improved maize or other varieties (Shiferaw et al., 2015). This hurdle makes sense as the adoption of a new variety depends on the access to seed. However, in our case we do not treat seed access as a hurdle as SRI is not specific to any particular rice variety.

Multiple Hurdles in terms of the Intensity of Adoption (in terms of acres of land under SRI)

The multiple hurdle model results for intensity of SRI adoption are presented in Table 2. The information access model results showed that size of the farm increased the access to information whereas the age of the farmer reduced the access to information. The result for farm size is in line with existing studies on technology adoption in agriculture (Shiferaw et al., 2015). The dummy variables for the districts showed that as compared to Chikmagalur, the availability of information was significantly lower in districts such as Hassan, Shahdol, and Keonjhar. Interestingly, Hassan, Shahdol and Keonjhar are the districts selected by the Government of India to promote SRI within the National Food Security Mission. As compared to Chikmagalur, Sidhi had better information about SRI.

Education did not play a major role in getting access to information. Nonetheless, education was found to be important in getting access to extension services. Apart from education, membership in input supply cooperatives, access to off-farm activities etc., were also found to have a positive impact in getting access to extension services. Those farmers who had farming as main occupation also had greater access to extension services indicating the importance of the amount of time that a full-time farmer is able to devote for agriculture. As far as dummy variables for districts are concerned, although Chikmagalur was a relatively better informed district, the availability of extension services were higher in Hassan, Shahdol, and Keonjhar. Therefore, better extension services were noted in those districts where SRI is promoted under government's food security mission.

Age, cultivation of only rice, farming as main occupation, and access to off-farm activities were found to be significant in providing greater availability of labourers. As compared to Chikmagalur, access to labour was significantly higher in Sidhi. Soil type, terrain type and farming as main occupation had a positive impact on having access to irrigation. It has been pointed out that SRI is mainly suitable for environments with high acid, iron-rich soil availability (Dobermann, 2004). Studies in the Indian context also show the importance of soil type in adoption of SRI (Palanisami et al., 2013). Terrain type is also very crucial to have the type of irrigation required for SRI. Land selected for SRI should be well levelled and should not have the problem of waterlogging. Also, when the plot is irrigated the water should spread uniformly across the field. As compared to Chikmagalur, access to irrigation was higher in Keonjhar.

Although farm size had a positive impact in accessing information, it had a negative impact on the intensity of SRI adoption. This indicates that more small farmers adopt SRI than do large farmers. SRI, which originated in Madagascar, was aimed at promoting rice production among small farmers. However, as mentioned earlier, studies on SRI showed a positive relationship between the size of the farm and adoption of SRI in terms of area in Timor Leste (Noltze et al., 2012) whereas studies on the adoption of improved maize varieties in Zambia showed a negative relationship between farm size and adoption (Langyintuo and Mungoma, 2008). Assets owned and rented and number of improved varieties of rice known had a positive and significant impact on the intensity of SRI adoption. There is consensus in the literature on technology adoption on the view that higher initial assets owned by the farmer is expected to relax many of the constraints such as credit and, therefore, is an important factor in making the adoption decision (Langyintuo and Mungoma, 2008).

However, the fear of poor yield is negatively related to the intensity of SRI adoption. Aversion to risk by farmers is highlighted as one of the reasons for poor adoption of SRI (Johnson and Vijayaraghavan, 2011). As far as the district dummies are concerned, there have been no major differences in the intensity of adoption among the districts except for the fact that Shahdol and Mayurbhanj had greater intensity of adoption of SRI as compared to Chikmagalur. Interestingly, Shahdol is an NFSM district where SRI is promoted under NFSM whereas Mayurbhanj is not. The results indicate that promotion of SRI through NFSM is effective only in some districts and not in all districts.

Multiple Hurdles in Terms of the Depth of Adoption (in terms of number of packages)

The multiple hurdle model results for intensity of SRI adoption are presented in Table 3. The results for the initial four hurdles were more or less the same in both the models. The only striking difference was in the case of access to extension services by a male head of the household in package adoption. The results show that access to extension services is better when head of the household is a male (see Table 3).

As far as the depth of adoption of SRI is concerned, wage rates, assets of the households, membership in farmers' organisations, cultivation of only rice etc., had significant impact. Interestingly, wage rates for male labourers had a positive impact whereas wage rates for female labourers had negative impact. Majority of labourers employed in paddy cultivation in the selected districts were female labourers. The weeding operations under conventional rice cultivation have been traditionally done by women. However, as a result of SRI adoption, rice farmers hire more and more of male labourers for mechanical weeding (Senthilkumar et al., 2008). Therefore, the shift from manual weeding to mechanical weeding resulted in greater demands for male labourers, leading to a positive relationship between male wage rates and SRI adoption. This also points out the skill-intensive nature of SRI adoption and gender-biased technical change.

The relationship between the number of years farmers are in agriculture and the SRI adoption was negative and statistically significant. Perhaps this indicates a clear preference for SRI by young farmers. There was a positive and significant relationship between farmers with farming as main occupation and the intensity of adoption of SRI. Nonetheless, the result contradicts the findings of Noltze et al. (2013) for Timor Leste. As per the study by Noltze et al. (2013), the household head whose main occupation is farming is much less likely to adopt SRI. The contradictory results point out the fact that the nature, intensity, and the factors contributing to it can vary quite considerably across regions.

Assets owned and rented also had a positive impact on adoption. This finding is in line with the existing studies (Langyintuo and Mungoma, 2008). Number of improved varieties known, membership in input supply cooperatives, and cultivation of only rice had positive impact on adoption. However, higher the fear of poor yields lesser was the intensity of adoption. The result that was contrary to our expectation was the distance from main market. The results showed that distance from main market had a positive impact on adoption of SRI. However, the results are not counter-intuitive. We noticed that small farmers, farmers who have farming as main occupation as well as those who are cultivating only rice were more enthusiastic about adopting SRI. So it is obvious that farmers who are remotely located from the market are adopting SRI as a survival strategy. Unlike other technology adoption, SRI does not require any particular variety of seeds as it can be implemented using any rice variety. So apart from information and extension services, SRI is not market dependent. Therefore, this could explain why distance has a positive impact on adoption. In addition to this, farmers with proximity to main market will have greater tendency to produce and sell those crops, other than rice, in the market for better prices. None of the distance dummies were significant, indicating only little difference in depth of adoption across these districts.

Conclusion

The article analysed the determinants of adoption of SRI in India. The study observed that adoption of SRI in the selected districts of India is constrained by imperfect markets for information, and access to extension services, labourers and irrigation facility. Most of the previous studies assume that markets are perfect and thereby non-adopters of a technology are not interested in adoption. However, the studies fail to capture the reality of farmers' lack of information and access to some of the factors which are crucial for adoption. Therefore, even a farmer with positive demand for adoption may not be able to adopt owing to several constraints. These lacunae may lead to inconsistent parameter estimates (Shiferaw et al., 2008; Shiferaw et al., 2015). Therefore, in line with some of the recent studies (Shiferaw et al, 2008; Shiferaw et al., 2015), the present study makes use of a multi-hurdle model. There have not been any such attempts to analyse the multiple constraints in the context of SRI, which is especially true for India.

The results showed that age and farm size are important in getting access to information indicating that younger and large farmers had greater access to information. Gender of the head of the household, education, membership in farmers' organisations was crucial in getting access to extension services. Age of the head of the household, cultivation of only rice, farming as main occupation, access to off-farm activity etc., are found to be important when it comes to the availability of labourers. Those who have farming as main occupation and rice as main farming crop find it relatively easier to get labourers indicating the important role of social network. Full-time farmers, especially rice farmers, might have developed a rapport with the labourers.

District-wise analysis of constraints showed that the disparities were the highest in the case of accessing information, followed by extension services. This highlights the important role of extension services in wider dissemination of SRI practices.

After overcoming the hurdles of information access, access to extension services, availability of labourers and irrigation, the final decisions relating to the number of acres and packages will be made by the farmers. The results showed that the factors influencing the intensity (in terms of acres of land for SRI) of SRI adoption were slightly different from the factors influencing the depth of SRI adoption (in terms of packages). Nonetheless, the common factors that influenced both intensity and depth were assets owned and rented, number of improved rice varieties known, membership in input supply cooperatives, and fear of poor yield. So, it is clear that financial capital such as initial wealth and social capital such as membership in farmers' organisations are very crucial in affecting the adoption of SRI. Wage rates for labourers were crucial in the depth of adoption of SRI. Wage rates of woman labours were negatively related to adoption whereas wage rate for male labourers were positively related to adoption. This is perhaps due to the fact that the shift away from manual weeding to mechanical weeding creates more demand for male labourers. So, the skill-intensive nature of mechanical weeding is leading to higher demand for male labourers and thus higher wages. It points to the possibility of a gender-biased technical change.

References

Adesina, A. A., and M. M. Zinnah (1993). Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. *Agricultural Economics*, *9*(4), 297-311.

Barrett, C. B., C. M. Moser, O. V. McHugh, and J. Barison (2004). Better Technology, Better Plots or Better Farmers? Identifying Changes in Productivity and Risk Among Malagasy Rice Farmers. *American Journal of Agricultural Economics*, 86(4), 869-889.

Cragg, J. (1971). Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods. *Econometrica*, 39(5), 829-844.

Croppenstedt, A., M. Demeke, and M. M. Meschi (2003). Technology adoption in the presence of constraints: the case of fertilizer demand in Ethiopia. *Review of Development Economics*, 7, 58-70.

Davis, B., P. Winters, T. Reardon, and K. Stamoulis (2009). Rural nonfarm employment and farming: household-level linkages. *Agricultural Economics*, 40(2), 119-123.

FAOSTAT (2014). Food and Agriculture Organization of the United Nations Statistics Division, Available at: http://faostat3.fao.org/.

Feder, G. (1982). Adoption of interrelated agricultural innovations: Complementarity and the impacts of risk, scale, and credit. *American Journal of Agricultural Economics*, 94-101.

Feder, G., R. E. Just, and D. Zilberman (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic development and cultural change*, 255-298.

Gujja, B., and T. M. Thiyagarajan (2013). New Hope for Indian Food Security? The System of Rice Intensification. The gatekeeper series of the Natural Resources Group at IIED, Available at http://pubs.iied.org/pdfs/14587IIED.pdf, Accessed on 2 November 2015.

Haldar, S., Honnaiah and G. Govindaraj (2012). System of Rice Intensification (SRI) method of rice cultivation in West Bengal (India): An Economic analysis. Selected Poster prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August 2012, Available at http://ageconsearch.umn.edu/bitstream/126234/2/IAAE%20conference%20paper%20on%20 SRI-uploading.pdf, Accessed on 16 November 2015.

ICRISAT, (2008). System of Rice Intensification. Available at http://www.sri-india.net/html/aboutsri.html, Accessed on 22 October 2015.

International Food Policy Research Institute, IFPRI (2009). *Millions fed: Proven successes in agricultural development*. Washington, DC: International Food Policy Research Institute (IFPRI).

Johnson, B., and K. Vijayaragavan (2011). Diffusion of System of Rice Intensification (SRI) Across Tamil Nadu and Andhra Pradesh in India. *Indian Research Journal of Extension Education*, 11(3), 72-79.

Jones, A. (1989). A double-hurdle model of cigarette consumption. *Journal of Applied Econometrics*, 4(1), 23-39.

Just, R. E., and D. Zilberman (1983). Stochastic structure, farm size and technology adoption in developing agriculture. *Oxford Economic Papers*, 307-328.

Kassie, M., M. Jaleta, B. Shiferaw, F. Mmbando, and M. Mekuria (2013). Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania. *Technological forecasting and social change*, 80(3), 525-540.

Kassie, M., H. Teklewold, M. Jaleta, P. Marenya, and O. Erenstein (2015). Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. *Land Use Policy*, 42, 400-411.

Khandker, V., and V.P. Gandhi (2012). Introduction of New Technologies in Agriculture: A Study of the Challenges in the Adoption of Hybrid Rice in India, paper prepared for presentation at the 56th AARES annual conference, Fremantle, Western Australia, February 7-10, 2012, Available at http://ageconsearch.umn.edu/bitstream/124325/2/2012AC%20Khandker%20CP.pdf, Accessed on 1 October 2015.

Langyintuo, A. S., and C. Mungoma (2008). The effect of household wealth on the adoption of improved maize varieties in Zambia. *Food policy*, 33(6), 550-559.

Mal, P., A.R. Anik, S. Bauer, and P.M. Schmitz (2012). Bt Cotton Adoption: A Double-hurdle Approach for North Indian Farmers. *AgBioForum*, 15(3), 294-302.

Manda, J., A.D. Alene, C. Gardebroek, M. Kassie, and G. Tembo (2015). Adoption and Impacts of Sustainable Agricultural Practices on Maize Yields and Incomes: Evidence from Rural Zambia. *Journal of Agricultural Economics*, DOI: 10.1111/1477-9552.12127.

Mathenge, M. K., M. Smale, and D. Tschirley (2015). Off-farm Employment and Input Intensification among Smallholder Maize Farmers in Kenya. *Journal of Agricultural Economics*, 66(2), 519-536.

Mazvimavi, K., and S. Twomlow (2009). Socioeconomic and institutional factors influencing adoption of conservation farming by vulnerable households in Zimbabwe. *Agricultural systems*, 101(1), 20-29.

Moser, C. M., and C. B. Barrett (2003). The disappointing adoption dynamics of a yield-increasing, low external-input technology: the case of SRI in Madagascar. *Agricultural Systems*, 76(3), 1085-1100.

Noltze, M., S. Schwarze, and M. Qaim (2012). Understanding the adoption of system technologies in smallholder agriculture: The system of rice intensification (SRI) in Timor Leste. *Agricultural systems*, 108, 64-73.

Noltze, M., S. Schwarze, and M. Qaim (2013). Impacts of natural resource management technologies on agricultural yield and household income: The system of rice intensification in Timor Leste. *Ecological Economics,* 85, 59-68.

Ogada, M. J., G. Mwabu, and D. Muchai (2014). Farm technology adoption in Kenya: a simultaneous estimation of inorganic fertilizer and improved maize variety adoption decisions. *Agricultural and Food Economics*, 2(1), 1-18.

Palanisami, K., K.R. Karunakaran, U. Amarasinghe, and C.R. Ranganathan (2013). Doing Different Things or Doing it Differently? Rice Intensification Practices in 13 States of India. *Economic and Political Weekly*, Vol. XLVIII No. 8, 51-58.

Pender, J., and B. Gebremedhin (2008). Determinants of agricultural and land management practices and impacts on crop production and household income in the highlands of Tigray, Ethiopia. *Journal of African Economies*, 17(3), 395-450.

Rahm, M. R., and W. E. Huffman (1984). The adoption of reduced tillage: the role of human capital and other variables. *American journal of agricultural economics*, 66(4), 405-413.

Reddy, V.R., P.P. Reddy, M.S. Reddy, and D.S. Rama Raju (2005). Water Use Efficiency: A Study of System of Rice Intensification (SRI) Adoption in Andhra Pradesh. *Indian Journal of Agricultural Economics*, 60(3): 458-472.

Rogers, E. (2003). *Diffusion of innovations*, New York: Free press.

Roodman, D. (2009). Estimating fully observed recursive mixed-process models with cmp, Available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1392466

Roodman, D. (2011). Fitting fully observed recursive mixed-process models with cmp. *The Stata Journal*, 11(2), 159-206.

Senthilkumar, K., P. S. Bindraban, T. M. Thiyagarajan, N. De Ridder, and K. E. Giller (2008). Modified rice cultivation in Tamil Nadu, India: yield gains and farmers' (lack of) acceptance. *Agricultural Systems*, 98(2), 82-94.

Shiferaw, B. A., T. A. Kebede, and L. You (2008). Technology adoption under seed access constraints and the economic impacts of improved pigeonpea varieties in Tanzania. *Agricultural Economics*, 39(3), 309-323.

Shiferaw, B., T. Kebede, M. Kassie, and M. Fisher (2015). Market imperfections, access to information and technology adoption in Uganda: challenges of overcoming multiple constraints. *Agricultural Economics*, 46(4), 475-488.

Stoop, W. A., Uphoff, N., & Kassam, A. (2002). A review of agricultural research issues raised by the system of rice intensification (SRI) from Madagascar: opportunities for improving farming systems for resource-poor farmers. *Agricultural systems*, *71*(3), 249-274.

Takahashi, K and C. Barrett (2014). The System of Rice Intensification and its Impacts on Household Income and Child Schooling: Evidence from Rural Indonesia. *American Journal of Agricultural Economics*, 96(1), 269-289.

Teklewold, H., M. Kassie, and B. Shiferaw (2013a). Adoption of multiple sustainable agricultural practices in rural Ethiopia. *Journal of agricultural economics*, 64(3), 597-623.

Tsujimoto, Y., T. Horie, H. Randriamihary, T. Shiraiwa, and K. Homma (2009). Soil management: The key factors for higher productivity in the fields utilizing the system of rice intensification (SRI) in the central highland of Madagascar. *Agricultural Systems*, 100(1), 61-71.

Uaiene, R. (2011). Determinants of agricultural technology adoption in Mozambique. In *African Crop Science Conference Proceedings*, Vol. 10, pp.375-380.

Uphoff, N. (2002). Opportunities for raising yields by changing management practices: the system of rice intensification in Madagascar. *Agroecological Innovations: Increasing Food Production with Participatory Development*, 145-161.

Uphoff, N. (2003). Higher yields with fewer external inputs? The System of Rice Intensification and potential contributions to agricultural sustainability. *International Journal of Agricultural Sustainability*, 1(1): 38-50.

Uphoff, N. (2012). Raising smallholder food crop yields with climate-smart agricultural practices. Report accompanying presentation on 'The System of Rice Intensification (SRI) and Beyond: Coping with Climate Change,' World Bank, Washington, DC.

Table 1: Definition and Summary Statistics of Variables used in the Analysis

Variables	Description	Mean	Std. Dev
Age HoH	Age of the head of the household	50	11.35
HoH Gender	Gender of the head of household, Male=1	.90	.29
Education	No. of members educated higher than 10th	.79	1.1
Farm Size	Size in terms of marginal, small, semi-medium, medium and large	.78	.84
ICT (TV, Radio)	Information and communication technology, yes=1	.30	.46
Mobile	Yes=1	.70	.46
Other Crops Cultivated	Only rice=1	.34	.48
Assets owned	Number of assets like tractors, bullock carts etc.	1.4	1.9
Anyone from family holding official position	Yes=1	.02	.19
Farming as main occupation	Yes=1	.80	.40
Membership in input supply co-operative(s)	Yes=1	.40	.49
No. of years in Agriculture	Experience in agriculture	24.66	11.74
Land on rent	Land cultivated on rent	.14	.59
Assets rented	No. of assets rented	.58	.97
Value of assets owned (in lakhs)	Total value of farm assets	2.53	6.5

Distance from main market (in km)	Distance from main market	11.48	10.58
Active family labourers	No. of active family labourers	2.51	1.26
Access to off-farm activity	Yes=1	.32	.47
Wage rate for female	Wage rate in rupees	138.51	59.77
Wage rate for male	Wage rate in rupees	167.51	75.50
Soil type	1. White and Black 2. Red 3. Black 4. Sandy mix 5. Red & Black 6. Red & sandy.	3.92	1.55
Terrain type	Levelled=1, step=0	.29	.45
Agricultural loan	Yes=1	.40	.49
No. of improved varieties known	In terms of number of rice varieties known by farmer	.68	.83
Fear of poor yield	Yes=1	.66	.47
No. of Observations: 386			

Table 2: Multiple-Hurdle Model for Intensity of Adoption (no. of acres for SRI)

A. Information	**Coefficient**	**Z-Statistic**	**Marginal Effects**
Age of head	-.012(.007)	-1.79*	-.004
Male head (yes=1)	-.265(.256)	-1.04	-.076
Education	-.099(.076)	-1.30	-.028
Farm Size	.203(.102)	1.99**	.058
ICT (Radio, TV) (yes=1)	.116(.253)	.46	.033
ICT (Mobile) (yes=1)	.095(.169)	.56	.027
Other crops cultivated (only rice=1)	.213(.165)	1.29	.061
Assets owned (numbers)	-.022(.038)	-0.59	-.006
Anyone holding official position (yes=1)	-.019(.360)	-0.05	-.005
Hassan	-1.08(.313)	-3.47***	-.312
Shahdol	-1.73(.381)	-4.53***	-.497
Sidhi	.688(.405)	1.70*	.198
Keonjhar	-.899(.330)	-2.72**	-.258
Mayurbhanj	.274(.341)	0.80	.079
Constant	.971(.501)	1.94**	
B. Extension services			
Age of head	-.005(.008)	-0.64	-.001
Male head (yes=1)	.413(.299)	1.38	.099

Education	.170(.083)	2.05**	.041
Farm Size	.051(.112)	1.46	.012
ICT (Radio, TV) (yes=1)	-.152(.272)	-0.56	-.037
ICT (Mobile) (yes=1)	.199(.185)	1.08	.048
Other crops cultivated (only rice=1)	-.055(.182)	-0.30	-.013
Assets owned (numbers)	-.020(.041)	-0.49	-.005
Membership in input supply cooperatives (yes=1)	1.54(.176)	8.78	.373
Farming as main occupation	.370(.209)	1.77*	.089
Hassan	1.09(.336)	3.25***	.264
Shahdol	1.20(.426)	2.82**	.290
Sidhi	-.153(.429)	-0.36	-.037
Keonjhar	.800(.368)	2.17**	.193
Mayurbhanj	.356(.365)	0.98	.086
Constant	-1.44(.556)	-2.59**	
C. Labourers			
Age of head	-.018(.007)	-2.54**	-..005
Male head (yes=1)	-.367(.251)	-1.46	.111
Education	.088(.071)	1.23	.026
Active family labourers	.061(.057)	1.07	.019
Other crops cultivated (only rice=1)	.359(.160)	2.24**	.108
Assets owned	.008(.037)	0.22	.002
Assets rented	.034(.086)	0.40	.011
Farming as main occupation (yes=1)	.559(.266)	2.10**	.169
Access to off-farm activity (yes=1)	.630(.223)	2.82**	.190
Wage Female	-.004(.003)	-1.13	-.001
Wage Male	.001(.004)	0.26	.003
Hassan	-.252(.323)	-0.78	-.076
Shahdol	.136(.468)	0.29	.041
Sidhi	1.66(.539)	3.08***	.502
Keonjhar	-.633(.428)	-1.48	-.191
Mayurbhanj	.083(.441)	0.19	.025
Constant	.553(.780)	0.71	
D. Irrigation			
Age of head	-.003(.008)	-0.41	-.001

Male head (yes=1)	-.373(.242)	1.54	.132
Education	.022(.068)	0.32	.008
Active family labourers	.004(.055)	0.07	.001
No. of years in agriculture	-.008(.007)	-1.16	-.003
Farm Size	.090(.104)	0.86	.032
Rented land (in acres)	-.034(.115)	-0.30	-.012
Soil type	.190(.051)	3.67***	.067
Terrain type	.710(.207)	3.42***	.251
Other crops cultivated (only rice=1)	-.116(.157)	-0.74	-.041
Value of assets in lakhs	.0004(.012)	0.04	.000
Farming main occupation (yes=1)	.314(.184)	1.70*	.111
Agricultural loan (yes=1)	.03(.156)	0.47	.026
Hassan	-.384(.308)	-1.25	-.136
Shahdol	.226(.296)	0.76	.080
Sidhi	.231(.323)	0.72	.082
Keonjhar	.489(.283)	1.73*	.173
Mayurbhanj	.078(.284)	0.27	.028
Constant	-1.13(.476)	-2.37**	
E. Intensity of SRI adoption			
Age of head	-.002(.001)	-1.50	-.001
Male head (yes=1)	.015(.026)	0.58	.006
Education	.007(.011)	0.62	.003
Farm size	-.057(.016)	-3.71***	-.023
No. of years in agriculture	-.0003(.001)	-0.27	-.000
Rented land (in acres)	0007(.018)	0.37	.003
Terrain type	.036(.030)	1.19	.014
Wage Female	-.0004(.0006)	-0.69	-.000
Wage Male	.0002(0005)	0.43	.000
Assets owned	.010(.005)	1.87*	.004
Assets rented	.029(.013)	2.23**	.012
Farming as main occupation (yes=1)	.028(.027)	1.05	.011
No. of improved varieties known	.042(.016)	2.64**	.017
Other crops cultivated (only rice=1)	-.018(.023)	-0.77	-.007
Membership in input supply cooperatives	.072(.024)	2.99***	.028

Distance from main market	.001(.001)	0.93	.000
Fear of poor yield	-.045(.023)	-1.93**	-.017
Hassan	-.019(.050)	-0.39	-.008
Shahdol	.130(.072)	1.80*	.051
Sidhi	.089(.074)	1.19	.035
Keonjhar	.105(.066)	1.59	.041
Mayurbhanj	.122(.070)	1.74*	.048
Constant	.112(.109)	1.02	
No. of observations	386	LR chi2(85)	507.49
Log Likelihood	-695.7997	Prob>Chi2	0.000

Note: *, **, and *** indicate significance levels at 10%, 5%, and 1% level respectively. Standard errors are in parenthesis.

Table 3: Multiple Hurdle Model for Depth of Adoption (SRI Packages)

A. Information	**Coefficient**	**Z-Statistic**	**Marginal Effects**
Age of head	-.013(.007)	-1.81*	-.004
Male head (yes=1)	-.275(.254)	1.08	-.079
Education	-.100(.076)	-1.31	-.029
Farm Size	.208(.102)	2.04**	.060
ICT (Radio, TV) (yes=1)	.120(.254)	0.47	.034
ICT (Mobile) (yes=1)	.079(.169)	0.47	.023
Other crops cultivated (only rice=1)	.216(.165)	1.31	.062
Assets owned (numbers)	-.022(.038)	-0.58	-.006
Anyone holding official position (yes=1)	-.029(.359)	-0.08	-.008
Hassan	-1.08(.314)	-3.44***	-.310
Shahdol	-1.73(.382)	-4.55***	-.498
Sidhi	.696(.404)	1.72*	.200
Keonjhar	-.888(.330)	-2.69**	-.255
Mayurbhanj	.277(.340)	0.82	.080
Constant	.973(.500)	1.94**	
B. Extension services			
Age of head	-.004(.008)	-0.46	-.001
Male head (yes=1)	.503(.299)	1.68*	.121

Education	.152(.086)	1.86*	.037
Farm Size	.050(.112)	0.45	.012
ICT (Radio, TV) (yes=1)	-.202(.267)	-0.76	-.049
ICT (Mobile) (yes=1)	.230(.184)	1.25	.055
Other crops cultivated (only rice=1)	-.063(.182)	-0.35	-.015
Assets owned (numbers)	-.020(.042)	-0.49	-.005
Membership in input supply cooperatives (yes=1)	1.56(.176)	8.80***	.374
Farming as main occupation	.373(.209)	1.79*	.090
Hassan	1.11(.334)	3.32***	.267
Shahdol	1.14(.424)	2.70**	.275
Sidhi	-.232(.426)	-0.55	-.056
Keonjhar	.734(.365)	2.01**	.176
Mayurbhanj	.337(.361)	0.93	.081
Constant	-1.45(.552)	-2.64**	
C. Labourers			
Age of head	-.017(.007)	-2.45**	-.005
Male head (yes=1)	-.284(.250)	-1.13	.086
Education	.085(.071)	1.20	.026
Active family labourers	.063(.058)	1.10	.019
Other crops cultivated (only rice=1)	.355(.160)	2.22**	.108
Assets owned	.008(.037)	0.22	.002
Assets rented	.037(.087)	0.43	.011
Farming as main occupation (yes=1)	.540(.267)	2.02**	.164
Access to off-farm activity (yes=1)	.620(.224)	2.77**	.188
Wage Female	.001(.004)	0.34	.000
Wage Male	-.004(.004)	-1.21	-.001
Hassan	-.239(.321)	-0.74	-.072
Shahdol	.136(.469)	0.29	.041

Sidhi	1.64(.541)	3.05***	.500
Keonjhar	-.626(.428)	-1.46	-.190
Mayurbhanj	.101(.441)	0.23	.031
Constant	.529(.777)	0.68	
D. Irrigation			
Age of head	-.002(.008)	-0.32	-.001
Male head (yes=1)	-.326(.241)	-1.35	.116
Education	.019(.068)	0.27	.007
Active family labourers	-.001(.055)	-0.02	-.000
No. of years in agriculture	-.008(.007)	-1.22	-.003
Farm Size	.090(.104)	0.86	.032
Rented land (in acres)	-.034(.115)	-0.30	-.012
Soil type	.185(.052)	3.58***	.066
Terrain type	.714(.207)	3.44***	.253
Other crops cultivated (only rice=1)	-.113(.156)	-0.72	-.040
Value of assets in lakhs	-.001(.011)	-0.05	-.000
Farming as main occupation (yes=1)	.319(.184)	1.74*	.113
Agricultural loan (yes=1)	.070(.156)	0.44	.025
Hassan	-.377(.309)	-1.22	-.134
Shahdol	.223(.296)	0.75	.079
Sidhi	.225(.324)	0.70	.080
Keonjhar	.494(.283)	1.75*	.175
Mayurbhanj	.086(.285)	0.30	.031
Constant	-1.12(.477)	-2.34**	
E. Depth of SRI Adoption			
Age of head	-.005(.007)	-0.76	-.001
Male head (yes=1)	-.017(.159)	0.11	-.003
Education	.006(.067)	0.10	.001
Farm size	-.010(.096)	-0.11	-.002
No. of years in agriculture	-.015(.006)	-2.48**	-.003

Rented land (in acres)	.080(.112)	0.71	.016
Terrain type	-.010(.185)	-0.05	-.002
Wage Female	-.008(.003)	-2.26**	-.001
Wage Male	.006(.003)	2.03**	.001
Assets owned	.171(.033)	5.08***	.034
Assets rented	.206(.081)	2.55**	.042
Farming as main occupation (yes=1)	.552(.169)	3.26***	.111
No. of improved varieties known	.196(.099)	1.99**	.040
Other crops cultivated (only rice=1)	-.255(.146)	-1.75*	-.051
Membership in input supply cooperatives	.472(.147)	3.21***	.095
Distance from main market	.013(.006)	2.11**	.003
Fear of poor yield	-.266(.140)	-1.89**	-.054
Hassan	-.252(.314)	-0.80	-.051
Shahdol	.151(.446)	0.34	.030
Sidhi	-.001(.459)	-0.00	-.000
Keonjhar	-.133(.408)	-0.32	-.027
Mayurbhanj	-.050(.431)	-0.12	-.010
Constant	.907(.673)	1.35	
No. of observations	386	LR chi2(85)	544.90
Log Likelihood	-1392.70	Prob>Chi2	0.0000

Note: *, **, and *** indicate significance levels at 10%, 5%, and 1% level respectively. Standard errors are in parenthesis.