Understanding the adoption of systemic innovations in smallholder agriculture: the System of Rice Intensification (SRI) in Timor Leste

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1. Introduction

The rise in global food grain prices continues to threaten food security in many low-income countries. Besides wheat and maize, rice is the main affected cereal, which faces an average price increase of about 50% since 2007 (Food and Agriculture Organization, 2010). In the last decades global rice production increased remarkably following the Green Revolution pathway by the widespread adoption of high-yielding varieties and high-input packages across millions of hectares. However, recently rice farmers experience a downturn in productivity growth associated with a loss of soil fertility, salinisation and other forms of land degradation (International Food Policy Research Institute, 2009). Moreover, climate change is expected to lead to higher temperatures, greater water demand by crops, more variable rainfall and extreme weather events, causing negative effects for agricultural production (International Panel of Climate Change, 2007). Accordingly, agricultural innovations are in need to address rising food demand, land degradation, technical feasibility and economic and social acceptability in a systemic manner.

The System of Rice Intensification (SRI) is recognized as a promising systemic approach to increase rice production at affordable costs for small-scale producers without harming the environment. SRI continuously proved higher yields in various agroecosystems with less inputs such as water, seeds or fertilizer (Barah, 2009; Zhao, et al., 2009). Thereby SRI principles focus on neglected potentials to raise yields by changing farmers' agronomic practices towards more efficient use of natural resources. Improved land preparation, plant maintenance and water management address a variety of environmental factors such as climate, natural resources and soils in particular (Knowler & Bradshaw, 2007). Recent studies on SRI have primarily focused on various physiological aspects, addressing improved water management, planting patterns, soil ecology and root development (Ceesay, Reid, Fernandes, & Uphoff, 2006; Mishra & Salokhe, 2010). Since the mid 1980s, SRI spread far beyond its place of origin in Madagascar, and it is currently estimated to be applied by more than one million smallholders worldwide (European Technology Assessment Group, 2009). Besides these promising figures, in some areas, partial adoption, discontinuance and disadoption are commonplace (Moser & Barrett, 2006). Studies found SRI too labor demanding for smallholders who often face seasonal labor shortages and persistent liquidity constraints (Moser & Barrett, 2002a). These findings jeopardize large-scale adoption and continuance and, therefore, long-term benefits for farmers and the environment.

Sustainable agricultural technologies and natural resource management practices raised considerable attention within the last decades, but many systemic innovations have missed a widespread takeoff in smallholder agriculture. Most related concepts are recognized as highly complex, knowledge-based and qualified labor-intensive. Furthermore, associated practices are often found location-specific, which means that adaptation differs according to the heterogeneity of agro-climatic conditions, natural resources and human capital (Lee, 2005). If innovations are highly variable, upscaling is a difficult process as specific practices and experiences cannot easily be shared and transferred among farmers. To control for heterogeneity of agroecological conditions, regional characteristics are commonly used as explanatory factors. This is deficient since regional aggregates are not fully able to capture micro-level variation. Due to the high variability of systemic innovations in various agroecosystems, we assume that plot level characteristics offer great potential to understand the decision-making process of farmers in order to derive causal conclusions towards the acceptance, adoption and diffusion among farmers. However, detailed plot level data is rarely available and studies focus primarily on household and farm-level attributes (Doss, 2006). This study overcomes the limitations of aggregated data by looking precisely at plot-specific variables assuming that intra-farm characteristics are critical determinants for the adoption of systemic innovations using household and plot level data from smallholders in Timor Leste. This paper is organized as follows. The next section introduces the concept of SRI in the case of Timor Leste. In section 3 an analytical framework is given and the chosen models are introduced. Section 4 gives a descriptive view on the data set. The model specifications are tested and empirical results are discussed in section 5. The paper ends with some concluding remarks.

2. SRI in Timor Leste

Agriculture sums up to one third of the national GDP of the young nation-state of Timor Leste, generating incomes for more than 80% of the population. Rice is the main staple food and a widely grown field crop. However, domestic production is far from meeting the demand of the fast growing Timorese population. Today, the country depends heavily on rice imports costing the government an estimated average of US$ 58.4 million (Ministry of Agriculture and Forestry, 2008). Therefore, the country emphasizes strategies to increase domestic rice production and to reduce import dependencies. Since 2007, SRI was jointly introduced by the Ministry of Agriculture and Fisheries (MAF) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in two major rice producing districts. Working with farmer groups through the national extension service, the program covered 35 farmers in 2007, 450 in 2008 and 1,228 in 2009 (28% of all rice farmers in the two target districts). This remarkable trend was emphasized by the declaration of SRI as a national extension strategy in 2008. In the Timorese context, SRI is expected to increase domestic rice production by simultaneously referring to overall low levels of mechanization and limited access to external inputs by resource poor producers.

In general, SRI is understood as a set of agroecological principles and, therefore, does not provide a fixed manual to the farmer. This opens some space for adapting techniques to local characteristics and offers opportunities for farmers to experiment. In Timor Leste, the core practices include early transplanting (less than 15 days) of single seedlings in square patterns of a minimum distance of 20 x 20 cm, together with alternate flooding and drying practices. Before transplanting, seedlings should be raised in carefully managed mat or tray nurseries. Additionally, compost application and regular weeding is recommended. Early transplanting of single seedlings in a high distance aims to support root growth and tillering (Mishra & Salokhe, 2008). In Timor Leste, where rainfall levels record a strong seasonality and water shortages are persistent during the second half of the year, improved water management might be able to reduce overall water usage significantly. Saturated non-flooded fields register better soil aeration which enhances root generation and anaerobic microbial activities. However, if water levels are reduced permanently, weeds are likely to grow. Weeding restricts weed occurrence and enhances soil aeration. The incorporation of organic manure substitutes chemical fertilizer stimulating growth-promoting bacteria (Mishra, Whitten, Ketelaar, & Salokhe, 2007). Considering all mechanisms, the SRI technology package is strongly based on knowledge and the perceived characteristics of relevant practices. In order to adopt SRI effectively, it is crucial that farmers obtain qualified information about the effects of all interacting components.

3. Analytical framework

Knowledge and perception of innovations are fundamental and integral parts of the underlying decision-making process of adoption (Rogers, 2003). In the case considered here, knowledge is generated initially by exposure to extension services with perception influenced by the perceived characteristics of modified practices, gained by observation or exchange of experience with peers. Farmers' decision to adopt innovations has been extensively studied in a wide range of literature (Feder, Just, & Zilberman, 1985). Adoption is not simply a yes/no decision; farmers often choose only parts of a technology package or apply innovative practices only on small parts of their cultivated area (Smale, Heisey, & Leathers, 1995). Whereas a majority of adoption studies has focused on binary adoption settings (Doss, 2006), a growing number of studies does also focus on continuous (Sall, Norman, & Featherstone, 2000) and count data outcomes (Sharma, Bailey, & Fraser, 2011).

Farmers do often face a long pathway from the first hearing to the full adoption of novel technologies. In order to understand this process in the case of systemic innovations, this study considers different decision stages being based on various household and plot level determinants. Firstly, the farmer decides to adopt an innovation (status of adoption). Secondly, a share of total farm size has to be allocated (intensity of adoption). Additionally, in the case of a technology package, a number of components has to be applied on the selected plots (depth of adoption) (Feder, et al., 1985). Studies from Madagascar have focused primarily on status and intensity of SRI adoption (Moser & Barrett, 2002a, 2002b, 2006). However, the depth of adoption has been widely disregarded. This is deficient since research on SRI continues to point at complementary and synergistic performances among the different components. Even though empirical evidence for the relationship among practices is limited, several studies showed that partial adoption and non-adoption of some of the main components changes potential outcomes significantly (Mishra & Salokhe, 2008, 2010). This study aims to explore farmers' adoption patterns using two discrete double-hurdle (D-H) specifications. At household level, farmers pass the initial adoption decision before land size is allocated to SRI practices. At plot level, potential SRI plots are identified before a number of technological components is applied. The use of two separate double-hurdle specification is motivated by the assumption that land allocation, plot and component selection are primarily non-sequential and often parallel incidents and cannot be modeled by one gradual process.

At the household level, two decision stages have to be passed to report non-zero SRI acreage. Oftentimes, the two hurdles are econometrically estimated using a binary outcome model for the initial adoption decision, and a Tobit model for the second stage. However, in the second stage, a standard corner solution is restrictive as it assumes all zeros to be farmers' deliberate choices (Cragg, 1971; Wodajo, 2008). Thereby, the value of the dependent outcome variable y, given $y > 0$ and the choice of $y > 0$ are determined by the same underlying process (Burke, 2009). The double-hurdle (D-H) model, a generalized Tobit specification, is potentially able to overcome this restriction by accounting more flexible for these two sequential decisions (Cragg, 1971). Both hurdles must be crossed before an overall positive outcome can be observed.

Different latent variables are used to model the two related decisions stages. A probit model estimates the probability that a household will adopt SRI, while a truncated normal model estimates the intensity of adoption (Burke, 2009). Let $y_{i1}^{*} = x_i'\alpha + u_i$ represent the decision to adopt SRI, whereas the land size in hectare can be modeled as $y_{i2}^{*} = z_i'\beta + v_i$, where y_{i1}^{*} and y_{i2}^{*} are the two latent variables describing the initial decision to adopt and the land size allocated to SRI, respectively. x_i and z_i are vectors of variables determining the adoption decisions. u_i and v_i represent the respective error terms, which are assumed to be independent and distributed as $u_i \sim N(0,1)$ and $v_i \sim N(0, \sigma^2)$. The likelihood function can be written as (Jones, 1989):

$$L(y_i|x_i, \theta) = \prod_{y_i=0} [1 - \Phi\left(\frac{x_i\alpha}{\sigma_u}\right)]\Phi\left(\frac{z_i\beta}{\sigma_v}\right) \times \prod_{y_i>0} \Phi\left(\frac{x_i\alpha}{\sigma_u}\right)\Phi(\frac{z_i\beta}{\sigma_v})\frac{\phi[(y_i - z_i\beta)/\sigma_v]}{\sigma_v\Phi(z_i\beta/\sigma_v)}$$

where ϕ and Φ are the probability and cumulative distribution functions of the normal distribution. σ_u and σ_v are the standard deviations of u_i and v_i, respectively. The first term estimates the status of $y_i = 0$, the second term the intensity, the exact value of y if $y_i > 0$. In order to assess the impact of the independent variables towards adoption, marginal effects are estimated following Burke (2009). They refer to the main outcome scenarios if one or both hurdles are crossed: the decision to adopt, the conditional average partial effect (CAPE) if the initial adoption decision is positive and the unconditional average partial effect (UAPE) as the combined effect of both decision stages.

At plot level, the study focuses on the depth of adoption representing the number of SRI components applied. Count data models imply that the outcome is a non-negative integer variable. Thus estimators gain positive probability only on discrete events. The second D-H model follows a framework developed by Mullahy (1986) and assumes that within a modified count data model the processes of reporting zero and positive outcomes are not constrained to be the same either. For crossing the first hurdle of y > 0, farmers have to report at least one adopted practice, which can be estimated by a binomial probability model before a conditional distribution refers to positive outcomes given y > 0 by a zero-truncated count data specification (Greene, 2005). The probability that 1,2,..,4 components are adopted refers to the nonzero counts of 1,2,..,4, respectively. The underlying assumptions and the two-part likelihood function can be replicated using the terminology given above and follows the work of Cragg (1971), Mullahy (1986), Burke (2009) and Jones (1989).

4. Data and descriptive statistics

Data was collected through a comprehensive household survey in late 2009. Households were selected using a stratified random sampling procedure. First, all rice-farming households in the two districts Bobonaro and Covalima were listed and stratified into participants and non-participants of SRI training. Since the introduction of SRI started in 2007, this recall process found 1228 participants and 3220 non-participants. Second, from each group, 200 households were selected. This procedure purposively over-sampled the group of participants in order to get a sufficient number of SRI farmers. Finally, 397 households were interviewed. Additionally, detailed plot level data has been collected for a total of 475 rice plots. Together with farmers, field visits have been conducted and soil samples collected. Soil analysis was based on easy-to-use soil testing methods including structure and saturation tests as well as pH and electric conductivity tests using a variety of tools and electronic instruments which allow for a relative comparison among plots.

It cannot be assumed a priori that training participants are SRI adopters and non-participants are non-adopters. As SRI involves substantial changes of common agronomic practices, some participants may not adopt or only partially adopt, while some non-participants may have adopted due to information and knowledge spill-over. Moreover, there is a need to define a minimum SRI package required since SRI consists of a number of practices. In accordance with the SRI International Network and Resources Center of the Cornell International Institute for Food, Agriculture and Development (CIIFAD) we define plots as SRI plots on which farmers adopt all of the core practices including (1) transplanting young and (2) single seedlings in a (3) planting distance of at least 20 x 20 cm and (4) circular re-irrigation. Even though additional practices such as compost application, the use of improved nurseries or weeding are often included, these above mentioned main practices are common throughout the SRI research community and can be found in nearly all SRI manuals, reports or research articles (Glover, in press). In the following, all households with at least one SRI plot are understood as SRI farmers, which lead to 159 (40%) households which practice SRI on 167 (35%) plots.

A comparison between adopters and non-adopters found significant differences in farmer and farm characteristics. Detailed results are not included here due to brevity, but the main findings can be subsumed as follows. Adopters have on average larger farms with higher rice acreage, higher nonfarm incomes, better access to formal credit institutions, and a higher participation in extension training. Additionally, SRI practitioners are found in villages where overall training participation is high. This could point at potential spill-over effects among training participants and non-participants in the research area. Most of these villages are located in the district of Bobonaro, where SRI was initially introduced in 2007. Looking at average differences at plot level, SRI is common to be adopted on plots nearby the households' place of residency, which have a technical irrigation system that can be individually controlled by the farmer. This indicates that adopters select plots for SRI practices purposely due to specific characteristics. The descriptive outcomes help to specify the following empirical models, which will be used to derive causal conclusions on adoption and non-adoption of SRI.

5. Empirical results and discussion

This chapter presents the results from the econometric models. In the following both double-hurdle specifications are tested before the determinants of status, intensity and depth are discussed.

5.1. Model specification

In order to statistically rationalize the use of the models outlined in section 3 the chosen specifications are tested against their alternatives. As mentioned above, the first D-H model is a generalized Tobit specification. This implies that a Tobit model is nested in the D-H model. Therefore the D-H model is tested against the Tobit alternative using a likelihood-ratio test (Greene, 2008). Results reject the null hypothesis that the Tobit model is appropriate and indicate that the estimated D-H model is preferred (Table 1).

Because count data are highly non-normal and not well estimated by OLS a Poisson hurdle-model was specified in section 3. In order to verify the chosen specification, the

Poisson model is compared to the alternative Negative Binomial Regression Model (NBRM) in the first step (Cameron & Trivedi, 2001). Thereby no over-dispersion of the data can be detected and the estimated α coefficient, which reflects unobserved heterogeneity among observations, is not significantly different from zero, suggesting that Poisson is appropriate. In the second step, the D-H logit-Poisson model is tested against a single Poisson regression. Using a likelihood-ratio test the Poisson regression model can be rejected and the D-H model is found appropriate (Table 1).

Insert Table 1 here

The results derived from maximum likelihood estimation are presented in Table 2 for the status and intensity hurdles at household level, and in Table 3 for status and depth at plot level. Marginal effects are also included and present the expected effects of the corresponding predictors on the probability of having a non-negative outcome in the first stage and a conditional positive outcome at the second stage.

5.2. Status and intensity at household level

The factors influencing the status and intensity emanate from modeling adoption using household level determinants. For the adoption of knowledge-based systemic innovations, human capital is a considerable factor. However, family labor availability has no influence at the first stage decision, but determines the extent of adoption, measured as the farm size under SRI in hectare. Having more family labor available enhances the land size allocated to SRI significantly. The unconditional average partial effect, which is the combined effect of both decision stages, shows that having one additional family laborer increases the SRI acreage by 0.05 hectares. On the one hand these results are due to higher labor needs of adopting a novel technology in general, on the other hand, it can be assumed that in the initial phase of SRI adoption farmers depend on family labor rather than hired labor due to knowledge deficits of external laborers and limited training capacities. In the initial adoption phase, it seems important that farmers gain experience with SRI principles and practices by self-experimentation before external laborers will be involved. Thus farmers may face difficulties compensating higher labor needs with paid labor in the early years of SRI adoption.

Farm size is found to determine both the initial adoption decision as well as it controls for SRI acreage. Owners of larger farms are more eager to adopt SRI. Conditional on a positive outcome of the initial adoption decision, one additional hectare of total farm size increases SRI acreage by 0.57 hectare. Additionally, the share of rice area to total land size is also positively influencing adoption. It can be assumed that farmers specialized on wet rice production tend to search for innovative cultivation practices in order to increase production output.

In Timor Leste SRI is introduced by the national extension service working with farmer groups. Therefore the participation of farmers in extension services is very important for knowledge generation. Due to the fact that SRI is largely knowledge-based we found participation of farmers in SRI training strongly determining adoption. Attending SRI training increases the likelihood of adoption by 64%. Contrarily to the findings from the first stage decision, participation in SRI training has no significant effect on intensity. Nevertheless, the overall combined effect is estimated at 61%. Even though, farmers are meant to participate in SRI training by self-selection, until recently, extension services have concentrated on a few main target villages and invited farmers rather randomly by announcing SRI via local radio stations or demonstration sites. These findings lessen the threat that training participation might be endogenous assuming that some factors influencing the participation and the adoption outcome.

Other household level determinants, such as additional family characteristics, social and financial capital or contextual variables have been included in the analysis but failed to explain the intensity of adoption. This indicates that household determinants are not fully sufficient to explain the adoption of SRI in the research area and reinforces that other, more specific variables, may be more relevant in the context of systemic innovations. In the following chapter, plot level analysis provides further insights in the decision-making process of SRI adoption.

Insert Table 2 here

5.3. Status and depth at plot level

In the previous chapter farmers had to pass two sequential decisions to report a positive outcome of SRI acreage. However, SRI is a package of components and partial adoption is commonplace. Therefore it is crucial to understand why farmers are adopting only some but not all modified practices. Plot level determinants are considered to influence the following decision making process. In the first step, farmers select specific plots for adopting the novel technology. In a second step, they choose a number of innovative practices. As shown above, a specified double-hurdle model was found appropriate to explain both outcomes. Controlling for heterogeneity among plots, for households with more than one rice plot different adoption outcomes have been recorded. We account for that issue by clustering household variables for the plot level analysis, so that the standard errors allow for correlation at the household level relaxing the usual necessity that the observations are independent.

We find that the distance from the farmer's dwelling to the rice plot determines the number of components applied. Farmers adopt fewer components if the distance increases. Choosing plots which are nearby the farmer's dwelling enable farmers to observe progress and outcomes of the innovative technology and encourage further experimentation. Additionally, proximity makes it easier for practitioners to deal with the higher labor needs associated with SRI. Circular re-irrigation water management is one SRI component which doesn't necessarily need higher but more continuous labor input as farmers have to control water levels on almost a daily basis. Both decision stages are f highly dependent on the existence of a technical irrigation system. Conditional on the first stage being positive, having an irrigation system on plot increases adoption by 0.51 components. Furthermore, the initial decision is based on whether the farmer has full control over water management or not. In the Timorese context, water usage is often dependent on decisions of water user groups and farmers facing difficulties to organize individual water levels. The probability of adopting a higher number of components is also associated with the slope of plots. With regard to water management, it can be expected that on plots which have a slight downward slope farmers are facing difficulties following traditional continuously flooded techniques. Therefore these plots could be favorable for SRI which claims that soils should only be saturated. While soil conductivity is negatively associated with adoption, plots with higher loam contents increase the probability of being chosen for SRI. Compared to soils with higher shares of sand, loam has superior water holding capacity and higher nutrient potential. Referring to the first point, conductivity is affected by a number of soil properties such as clay content, temperature, organic materials and salinity (Ezrin, Amin, Anuar, & Aimrun, 2009). As salinity and electronic conductivity are positively correlated and many of the recorded paddy fields are located nearby the Timorese coastline, it can be expected that high conductivity levels reflect extreme salt contents in the research area. Therefore farmers seem to prefer plots with lower salinity for SRI adoption.

Besides these plot characteristics, household determinants are also relevant for farmers to report a positive outcome of adopting SRI practices. Family labor and the availability of non-farm income are positively related to the adoption decision. Thus households having nonfarm income are more likely to invest in innovative practices. In the case of SRI, labor might be a potential investment factor. Total farm size and the share of rice acreage to farm size are both negatively associated with the adoption status at plot level. Concerning this matter, larger farms can be expected to have other farm activities such as livestock or other field crops, thus have limited labor and time capacities to focus on the novel practices. This is also indicated by the fact that having larger herds of buffaloes decreases the probability of adopting SRI components. Even though participation in SRI training repeats to influence adoption significantly by an increase of 2.1 components on average, various other household determinants again fail to explain the state of adoption. To conclude, plot level analysis found a high variability of adoption patterns and plot-specific characteristics, and the results confirm that plot-specific variables are crucial determinants concerning the adoption of SRI in the research area.

Insert Table 3 here

6. Conclusion

Using detailed household and plot level data from small-scale rice producers collected in Timor Leste in late 2009, this study identified various factors determining the adoption of SRI. Household and plot level analysis confirmed that plot-specific variables are the most relevant factors for explaining adoption of the innovative practices. Plot location, slope, irrigation facilities as well as management attributes and soil quality are important aspects for a number of practical reasons. Adoption patterns are found to differ substantially among plots. These outcomes indicate that detailed farm data is crucial to fully understand the adoption of systemic innovations in smallholder agriculture. Accordingly, aggregated adoption models are less suitable to capture the observed heterogeneity of location-specific practices and might fail to reflect adoption outcomes in an adequate manner.

Information is the main driving-force for enhancing management capacities of systemic innovations. Knowledge and awareness are particularly relevant in the context of sustainability-oriented approaches as payoffs, such as improved soil fertility, are cumulative and occur in the long run whereas farmers face food insecurity and poverty today. Training participation proved significant impacts on all investigated adoption outcomes and can therefore be considered as particularly relevant for the introduction as well as for the upscaling of innovative practices. However, results confirm that systemic innovations have to be adjusted to location-specific attributes. Thereby adaptation shouldn’t fully be covered by farmers as experimentation requires comprehensive knowledge and involves a considerable amount of risk. Furthermore, considering seasonal constraints, labor availability may reduce experimentation capacities among small-scale producers. Thus extension efforts have to focus on strategies related to the adaptation and dissemination of systemic practices. Concerning this matter, extension services need the financial and personnel capacities which are necessary for a successful and sustainable uptake of novel technologies.

Positive economic and ecological effects of SRI were documented in several studies and offer various benefits for the Timorese rice sector, which is characterized by low levels of mechanization and limited access to external production inputs. However, it can be expected that partial adoption diminishes and hinders the economic and environmental benefits of SRI in the long run. The implementation of SRI in Timor Leste is still in its early stages and extension efforts have the potential to increase adoption rates by adjusted training efforts. In order to achieve large-scale adoption, strategies have to reveal how to implement SRI practices on plots with less-favorable conditions. In order to understand the relationship among SRI adoption and its benefits for the Timorese rice sector, impact analysis has to focus especially on income and employment effects related to the dissemination of SRI.

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Appendix

Table 1. Specification tests

LR statistic ($\chi2$)	Critical value ($\chi2$)	Conclusion
LR-test against Tobit specification (H_0=Tobit is appropriate)		
252.94	19.81	H_0 rejected
LR-test against Poisson specification (H_0=Poisson is appropriate)		
45.71	23.54	H_0 rejected

Table 2. Maximum likelihood estimates and marginal effects for status and intensity of adoption

Variable	Maximum likelihood estimates		Marginal effects (total SRI area)		
	Decision to adopt SRI	Decision on SRI acreage	Decision to adopt SRI	Decision on SRI acreage	
				CAPE[1]	UAPE[1]
No. of adult HH member (18-65)	0.0650	0.0700***	0.0237	0.0626	0.0451*
	(0.0559)	(0.0220)	(0.0203)	(0.0503)	(0.0256)
Total farm size (ha)	0.120*	0.637***	0.0439*	0.5698***	0.2674***
	(0.0725)	(0.0267)	(0.0264)	(0.0757)	(0.0469)
Share of rice area / total farm size	0.638*	2.332***	0.2324*	2.0869***	1.0390***
	(0.351)	(0.149)	(0.1279)	(0.1555)	(0.1407)
Training participation (dummy)	2.001***	0.00478	0.6401***	0.0042	0.6102***
	(0.171)	(0.0999)	(0.0392)	(0.0876)	(0.0426)
Bobonaro District (dummy)	0.269*	0.0714	0.0979	0.0638	0.1076**
	(0.161)	(0.0673)	(0.0571)	(0.0607)	(0.0540)
Constant	-2.118***	-1.682***			
	(0.531)	(0.256)			
Sigma		0.357***			
		(0.0215)			
Observations	397	397	397	397	397
Log-Likelihood		-219.1701			

*,**,*** significantly different at the 10%, 5% and 1% level, respectively. Standard errors in parentheses; [1]CAPE=Conditional average partial effect, UAPE=Unconditional average partial effect, bootstrapped standard errors. Due to brevity, the table presents significant variables only.

Table 3. Maximum likelihood estimates and marginal effects for status and depth of adoption

Variable	Maximum likelihood estimates		Marginal effects	
	Decision to adopt SRI	Decision on number of components	Decision to adopt SRI	Decision on number of components
Time from house to plot (min)	0.0012	-0.0021***	0.0001	-0.0048***
	(0.0047)	(0.0007)	(0.00033)	(0.0018)
Plot level (1=flat,…,4=slight slope)	0.829	0.155***	0.0587	0.3814***
	(0.6120)	(0.0531)	(0.0428)	(0.1204)
Irrigation system on plot (dummy)	1.700***	0.205**	0.2068***	0.5051**
	(0.4260)	(0.0898)	(0.0777)	(0.2226)
Control over water managment (dummy)	1.233***	0.0499	0.1306**	0.1229
	(0.4541)	(0.0981)	(0.0652)	(0.2421)
Conductivity (mS/cm)	-0.460***	0.0207	-0.0325***	0.0412
	(0.149)	(0.0269)	(-0.0325)	(0.0661)
Loam content (%)	0.0288**	-0.00175	0.0020***	-0.0043
	(0.012)	(0.0018)	(0.0008)	(0.0045)
No. of adult HH member (18-65)	0.337***	-0.0236	0.0238***	-0.0581
	(0.125)	(0.0232)	(0.0084)	(0.0569)
Total farm size (ha)	-0.223*	0.0261	-0.0158*	0.0643
	(0.134)	(0.0171)	(0.0095)	(0.0421)
Share of rice area / total farm size	-1.237*	0.120	-0.0875*	0.2949
	(0.731)	(0.106)	(0.0513)	(0.2623)
No. of buffaloes owned	-0.0160	-0.0141**	-0.0011	0.0347**
	(0.0420)	(0.0065)	(0.0029)	(0.0160)
HH has nonfarm income (dummy)	0.696**	-0.0539	0.0490**	-0.1330
	(0.336)	(0.0498)	(0.0238)	(0.1225)
Training participation (dummy)	2.171***	0.850***	0.18424***	2.0975***
	(0.351)	(0.0855)	(0.0337)	(0.1906)
Constant	-3.181*	-0.0443		
	(1.674)	(0.233)		
Observations	447	381	447	381
Log-Likelihood		-694.57135		

*,**,*** significantly different at the 10%, 5% and 1% level, respectively. Robust standard errors in parentheses. Due to brevity, the table presents significant variables only.