FACTORS UNDERLYING ADOPTION OF RICE POWER-THRESHERS IN WEST SUMATERA

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Abstract

Since the use of threshers in post harvest operation has shown promise of providing higher technical as well as allocative efficiency, this study was focused primarily on how such a device could be adopted and diffused more rapidly in response to the government's emphasis on rice quality improvement. Not only was this study interested in farmer's constraints to adopt such a technology, but it also investigated the role of innovating agents as well as the institutional nature of rural labor relation in the adoption process. The former has been analyzed by fitting logistic regression procedure towards data of 75 farmers in six villages while the latter is presented in the form of comparison between West Sumatera and Java.

Introduction

Background

West Sumatera may be considered unique in the sense that its adoption path of mechanical technology has been remarkably different from that in other parts of Indonesia. The difference can be inferred from several phenomena depicted below. The first noticeable phenomenon is the fact that technology in harvest and post harvest operation has been altering more rapidly than in land preparation, while the reverse is true in other parts of Indonesia.

The second phenomenon is the use of prominent manual winnowers (*lumbo*) which has diffused widely after this type of indigenously produced equipment was invented for the first time by a carpenter at Batu Ampar, Payakumbuh in 1964. In the last few years, the use of such a technology has been diffusing in the surrounding provinces. The third phenomenon has appeared in the use of power threshers which has been diffusing in this area much faster than that in other areas. The fourth phenomenon, which commonly occurs in every process of diffusion, is the fact in which traditional practices such as by-foot threshing (*irik*), by-beating threshing (*malambuik*), and by-wind winnowing (*menampi*) are still in existence, vis-a-vis the new practices using power threshers and manual winnowers.

A thorough explanation about the abovementioned tendencies seems to be extremely required for policy measures not only for West Sumatera itself but also for other parts of Indonesia. As far as the new technique in rice threshing is concerned, this paper is primarily aimed to explain the adoption of power threshers in West Sumatera.

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Problem

Since the rice intensification task using improved pre-harvest technology has remarkably increased rice production in this country, more emphasis has been placed on the quality improvement of rice. The grain quality, characterized at least by its moisture content and the proportion of unusual-colored grain as well as the proportion of undesired materials, is influenced not only by pre-harvest practices but also by harvest and post-harvest operations such as threshing, cleaning and drying the grains. The adoption and diffusion as well as the impact of such a technology should appear to be the frontiers of socio-economic studies because of its significance in the quality as well as in the quantity aspects of rice production.

In 1979, the introduction of power threshers ranging from 5 to 7 horse powers with gasoline or karosene as fuel was initiated in West Sumatera. The number of threshers in this area has tremendously increased from 25 threshers in 1980 to 189 threshers in 1982, and 556 threshers in 1983. In this regard, there are at least two important aspects of policy consideration: (i) factors affecting the adoption and diffusion of such innovation, and (ii) the impact of such a technical change on labor utilization, farm income and income distribution among factor owners involved in the operation. This paper is aimed at the former while the latter has been discussed by Siregar (1985).

Objectives

The only objective of this paper is to collect information on several socio-economic determinants in owning or using threshers on rice farms in West Sumatera. This objective may be broken down into:

1. To identify institutional inducement and restraint in the introduction of threshers.
2. To find out major characteristics of rice farmers owning or using threshers in threshing.

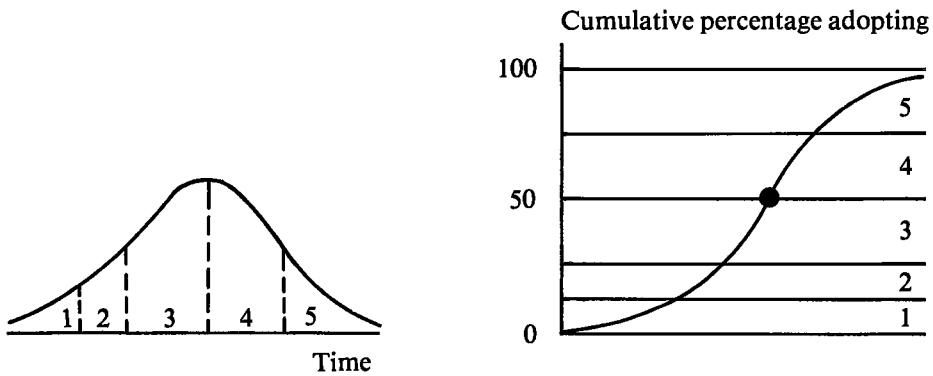
Methodology

Analytical Technique

In a discussion of imitation, Tarde described the process of innovation adoption as ..... a slow advance in the beginning, followed again by a progress that continues to slacken until it finally stops (Roger, 1962). In terms of the adopting population, Tarde suggested this process for the diffusion of new ideas: a few individuals adopt initially; they are followed by a large number of others, who are followed in turn by a gradually dwindling group of late adopters (Havelock, 1969).

That the rate of diffusion of innovation may be pictured as a normal curve has been suggested by a number of studies reviewed by Rogers (1962). Plotting the normal curve to represent such diffusion is often a useful tool for describing adopter categories (Figure 1A). It should be noted that the adopter categories are arbitrary descriptive labels based on deviation from the mean.

If, instead of plotting the number of people who adopt in a given time unit, we plot the percentage of the adopting population who have adopted at each given time, we have the familiar cumulative S-shape curve as shown in Figure 1B. Although it is essentially interchangeable with the normal curve in terms of describing the process of diffusion, one curve or the other may be more useful in presenting the data of a particular case or in illustrating a particular point (Havelock, 1969).



A. Relative Time

B. Cumulative Curve

Notes:

1. Innovarots, 2. Early adopters, 3. Early majority, 4. Late majority, 5. Laggards.

Figure 1. Adopter Categorization (from Rogers, 1962 and Havelock, 1969).

It is obvious that figure B can not easily be drawn from data assembled from the field since it requires a persistent observation for a relatively long period of time. Although there is no intention in this study to do so, the S-curve presented in figure 1B is almost similar with logistic curve which may serve to depict the relationship between the probability of a farmer's adoption of innovation and his constraints.

Let the logistic function with k independent variables be[2]:

$$P = \text{Prob.}\,(y=1) = 1/(1 + \exp.\,(-a - \sum_{j=1}^{k} b_j x_j)) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where:

P = the probability of a farmer's adoption of innovation;
x_j = the jth independent variable;
a and b_j = parameters.

One of the analytical techniques which may be employed in estimating a and bj is the fitting of the logistic regression model to a single binary (0-1) dependent variable. Logistic regression is often preferred over discriminant analysis because the logistic regression model has fewer assumption than the linear discriminant model does; for examples, it has no multivariate normality assumption for covariates (see Harrell, 1983).

Taking the natural logarithm of both sides of equation (1) we find.

$$\ell n\, P = -\ell n\,(1 + \exp.\,(-a - \sum_{j=1}^{k} b_j x_j)) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Taking the partial derivatives of both sides with respect to x_j, multiplying both sides by x_j, and rearranging them, we finally have.

$$(\partial P/\partial x_j)(X_j/P) = b(1 - P)\, x_j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

which is nothing but the elasticity (η) of the probability (P) with respect to changes in x_j; thus

$$\eta = b(1 - P)\, x_j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Equation (4) reflects how a particular independent variable x_j should be changed so that the farmers most likely adopt an innovation under study.

The Data

Information presented in this paper is mostly based on data gathered in 1984 from a survey in three districts of West Sumatera selected on the basis of the highest number of threshers, i.e. Padang Pariaman, Agam and Sawah Lunto Sijunjung. Two sample villages were chosen from each district; the first and the second represented low and high adoption of threshers respectively.

A number of 80 sample farmers comprising 20 thresher-owners, 31 thresher-users and 29 non-user were chosen proportionally based on secondary information available at district and village levels. Aside from these respondents, officials and farmer groups were also interviewed to obtain additional information on the nature of diffusion processes.

Results and Discussion

Agents Initiating the Innovation of Thresher

Since 1978, the IRRI industrial extension project has been undertaken in collaboration with the Indonesian Directorate of Food Crop Production (DIT-PROD). The aim was to transfer small farm equipment technology to Indonesia. Since West Sumatera was selected as a pilot area in 1979, several hand tractors, paddy threshers, water pump and a dryer were dispatched to this province to enable the Agricultural Extension Service (Dinas Pertanian) to conduct demonstration in the farmer's field.

While stimulating farmer's interest in these types of equipment, the project has successfully motivated quite a few small workshops to fabricate the types of equipment after they had been trained from 1979 to 1983. The other agents stimulating the pabrication of these types of equipment are the Industrial Extension Service (Dinas Perindustrian), the Bank of Indonesia (PPMU) and dealers.

The Nature of Rural Labor Relation

After high yielding rice varieties have been introduced in 1968, many institutional changes have taken place in rural areas of Indonesia. In the case of Java, Hayami and Kikuchi (1981) have promulgated what they called the logical context of the paradigm of changes from *bawon* to *tebasan* in rice harvesting systems established by Collier, *et al.* (1974) and others. Basically, the changes revolve around the community members who may participate in rice harvesting, their responsibility, devices being used, and the share of output[3].

Rice harvesting in the traditional *bawon* system is a community activity in which all or most community members can participate and receive a certain share of output. Since around 1970, a new system called *tebasan,* in which farmers sell their standing crop to middlemen a few days before harvest, has been taking place[4]. The two systems seems neutral to the change from *ani ani* to sickle which is more appropriate to modern rice varieties since they are short-stalked.

The two systems, however, are not always neutral to every new device because cutting, threshing, and winnowing are usually done by the same laborers, unless the new device is under their management. The use of power thresher in Java, for example, can not be diffused rapidly because power threshers are usually owned by person outside the group of laborers particularly for its high price that is more than Rp. 500,000 each. In contrast, the use of pedal threshers is found in East Java since it is under the laborers management.

Contrasted with the circumstances prevailing in Java, each part of harvest and post-harvest operation in West Sumatera may be done by different laborers, and wage payments can be either in kind or in cash. In the cases of by-foot threshing and by-thresher threshing, the rice was gathered in the field after it was cut, and threshing operation might be done after several days depending on the availability of laborers or power thresher. Seldom did farmers accomplish cutting and threshing in one day in the two techniques of threshing. Only when farmers would thresh their rice by beating did they finish cutting and threshing in one day because the two operations were done by the same laborers.

To sum up the main point, labor relation in harvest and post harvest operation in West Sumatera is neutral to every new technique as long as it promises technical superiority over the old one. This section help to clarify the reason why power threshers can diffuse more rapidly in West Sumatera than in Java. Even manual winnower has long been invented indigenously in West Sumatera before the introduction of modern rice varieties, and it noticeably lessens farmers' depending on the wind during cleaning their rice grains.

Reasons for Owning and Using Threshers

Among the types of agricultural equipment introduced by the IRRI Industrial Extension project, threshers were fabricated first by the trained-workshops in West Sumatera. In the later stages, the workshops have even been producing threshers more than the other types of equipment. Not only was it because threshers were simpler to fabricate, but it was also because of farmer's urgent need to substitute threshers for human labors that were frequently scare during the peak season of harvest especially for threshing.

As depicted in Table 1, labor shortage was one of the significant reasons given by the sample farmers for owning or using threshers. Actually, the term labor shortage was nothing but it connoted a relatively high level of wage rate in the substitution view sense proposed by Binswanger (1980)[5]. In other words, farmers obtained an allocative efficiency gain to a certain extent when they substituted threshers for human labors. It was not surprising, therefore, lower cost of threshing as shown in Table 1 was also another reason for using power threshers instead of using human labors (see also Siregar, 1985).

The reason that the use of power threshers in threshing was easier and quicker than by-foot threshing or by-beating threshing was the most important reason for using this equipment. Another technical efficiency merit of using power threshers was that it resulted in lower losses than the two traditional techniques did. To what extent the losses may be reduced, however, has to be tested conscientiously by mechanical engineers in the farmers' fields.

Table 1. Percentages of Respondents by Reasons for Using or Not Using Threshers in West Sumatera, 1984.

Reasons	Thresher Owners (n = 20)	Thresher Users (n = 31)	Non-Users (n = 29)
Reasons for purchasing or hiring threshers			
a. Source of income	65	x	x
b. Shortage of labor	60	68	x
c. Lower cost for threshing	90	45	x
d. Lower losses	45	52	x
e. Ease and quickness	75	90	x
Reasons for not using threshers			
a. Not known	x	x	20
b. Not available	x	x	69
c. Too costly	x	x	52
d. Far from the road	x	x	21
e. Enough hired labor	x	x	14
f. Enough family labor	x	x	3

Notes: n = number of respondents in each category; x = irrelevant.

Table 1 also shows the distribution of sample farmers based on their reasons for not using threshers. It could be understood that the unavailability of thresher was one of the very significant reasons for not using thresher since it was still in its relatively early stages. Approximately one-fifth of the non-users even did not know the existence of threshers. Although the role of extension workers in the introduction and the use of threshers was, as shown in Table 2, undoubtedly very significant, but it was still essential that the use of threshers and its merit be informed widely to farmers particularly in relatively remote areas.

Table 2. Percentages of Respondents by Sources of Information Related to Threshers, West Sumatera 1984.

Sources of Information	Thresher Owners (n = 20)	Thresher Users (n = 31)
Agricultural extension workers	65	45
Demonstration	20	19
Brosures	15	6
Other farmers/contact farmers	40	84

The reason that the use of threshers was too costly was stated by about 52 percents of non-users. This was interesting not only because it appeared to be contradictory to the users' reason, but it also occurred even in the sample villages (e.g. Kapau village in Agam District and Sikayan village in Sawah Lunto Sijunjung District) where laborers' share in kind for threshing was the highest; that was 10 percents of the total amount of rice grains threshed. Conversely, the labor shares in the other four sample villages, where the use of threshers have been diffusing further, just varied from 6 to 8 percents.

Regardless of meal expenses, which were higher in the two traditional labor-using techniques of threshing, capital (i.e. thresher) share in the new labor-saving technique tended to be the same with labor shares of traditional techniques in the same village (see Siregar, 1985). Since the level of threshing share in each village was determined by the interaction between the supply of and the demand for laborers including power threshers, the high levels of prevailing threshing shares in the villages of Kapau and Sikayan indicated that the available services of threshers in the two villages were still so scare that the shares remained undwindled. This was exactly what the non-users meant by the term too costly, which was one of the reasons for not using threshers.

The abovestated information also referred to the so-called segmented labor market in the sense that labor market in one village had little, if any, influence on labor market in its neighboring villages because many people in this province tended to migrate permanently outside the province rather than to migrate seasonally inside the province[6]. This unique, prominent tendency of migration brought about a demographic structure where approximately 60 percents of the people living in this province were below 15 years and above 49 years of age[7].

The next farmers' reason for not using threshers was associated with their rice field parcels which were located so far from the road that it was hard for thresher operators to serve such places. Nevertheless, only when the operators still had custom work near the road was the reason true because as a matter of fact, a thresher weighing about 75 kilograms could be partitioned into three parts so that the operators could easily move it to such parcels.

Less than 15 percents of the non-user respondents stated that they did not use threshers because they could obtain hired labor or they had enough family labor to accomplish threshing (Table 1). This reason, however, should be considered special cases for the number of non-users giving the reason was quite small. Not to mention, before threshers were introduced, approximately 61 percent of user respondents had to put off harvest from 6 to 10 days because of the difficulty to find laborers. The delay in harvest was hazardous for the new rice varieties such as IR-42 and IR-54 because not only it enabled an amount of grains to fall off before and after it was cut, but it also worsened the quality of rice.

Characteristics of Farmers Adopting Threshers

In order to find out factors explaining either thresher owners or thresher users, parameters in equation (1) are estimated by using stepwise methods. Stepwise variable selection, however, can potentially be abused when it is being utilized to examine many variables because it can easily find significant factors which even have no real associations with the dependent variable. To avoid this problem, if there are m observations for the category of a binary response variable, Harrell (1983) suggested that the number of independent variables be not more than m/10 variables. In this relation, the comparison in arithmetic means of socio-economic variables by farm classes are considered the rules of thumb in ruling out few factors. As a result of doing so, the remaining variables incorporated in equation (1) are presented below.

y = Adoption of thresher. In the analysis of thresher owners' characteristics, y takes the value of unity if the farmer is thresher owner, and zero otherwise; while in the analysis of thresher users' characteristics, y takes the value of unity if the farmer is user, and zero otherwise.

x1 = Rice area in hectares.

x2 = Farming experience in years.

x3 = Extension dummy variable, taking the value of unity if the farmer attended demonstration or received advise about thresher, zero otherwise.

x4 = Non-rice income (excluding thresher-share income) dummy, taking the value of unity if the income is higher than the average income of the whole samples, zero otherwise.

x5 = Custom rate of thresher in each village under study in percents.

The parameters in equation (1) are estimated by using both backward elimination and forward inclusion techniques. Although a significant level of 0.3 is imposed as a restriction for entry in the case of forward inclusion, both forward and backward stepwise techniques bring about the same results.

Rice area and non-rice income. If the two variables could be regarded together as a proxy or reflection of farmers' socio-economic status, one would conclude from Table 4 that most early adopters of threshers were, relatively, farmers of affluence. Only when the diffusion has longer been taking place will more small farmers adopt the innovation. The reason is simply related to resource endowment as well as to their accessibility to services which, in turn, affect their perception and decision. Such a significant parameters was the coefficient of rice area in the case of thresher ownership that it indicated the purchase of threshers was highly attributable to labor shortage problem; a problem which was felt more crucial for thresher owners than for thresher users because the average farm size of the former

was much larger than that of the latter, i.e. 0.94 and 0.47 hectares respectively (see Appendix Table).

Farming experience. The coefficient of this variable was significant in the case of thresher ownership but not significant in the case of thresher utilization. In spite of the difference, however, the negative signs of the coefficients indicated a tendency that the younger a farmer was, the more responsive he was to own or to use thresher. Nevertheless, it should be borne in mind that only with investigation could we draw a conclusion that it was true in other cases of innovation adoption.

Thresher shares. Another negative sign of coefficient appeared from the variable of thresher share. Of course, one could anticipate that the higher the share was, the lower the probability of a farmer's using thresher was (Table 4); but hardly had we expected such a negative sign of thresher share coefficient in the case of purchasing thresher (Table 4). Intuitively, a higher thresher share should induce farmers' investment in threshers. Such an intuitive hypothesis, however, was temporarily violated because several sample thresher-owners were drawn from two sample viilages where thresher shares were still at the highest level among those in the six sample villages. Only when the diffusion of threshers in the two villages has taken place much further will the hypothesis be most likely acceptable.

Table 4. Factors Affecting the Ownership of Threshers in West Java 1984.

Independent Variables	Ownership of Threshers		Use of Threshers	
	Coefficients (equation 1)	Elasticities (equation 4)	Coefficients (equation 1)	Elasticities (equation 4)
Intercept	-2.8815^{ns}	na	0.2941^{ns}	na
	(1.47)		(0.02)	
Rice area (in hectares)	5.5087***	2.17	2.4104*	0.50
	(10.10)		(3.15)	
Farming experience (in years)	-0.0782*	-1.11	-0.0501^{ns}	na
	(3.76)		(2.15)	
Extension dummy	2.4603**	0.99	3.8882***	0.82
	(5.83)		(15.02)	
Non-Rice income dummy	3.2259**	1.89	2.9070***	0.90
	(5.12)		(7.52)	
Thresher share (in percentages)	-0.5477*	-3.38	-0.5080*	-1.65
	(3.73)		(3.73)	
R statistic (prediction ability)	0.567***		0.608***	
Model chi-square (DF = 5)	37.99***		47.05***	
Number of observations	75		75	

Notes:

*** = Significant at 0.01 level, ** = Significant at 0.05 level, * = Significant at 0.10 level.

ns = Not significant at 0.10 level, na = Not applicable.

Figures in parentheses are chi-square values.

Access to extension services (demonstration and visit about thresher). The significant coefficient of extension seemed to indicate that extension was potentially powerful in inducing farmers to adopt such an innovation. In other words, since the use of threshers was promising in terms of allocative and technical efficiency, more extension work could accelerate the diffusion of threshers despite farmers' resource constrain and resource endowment. Having realized the seemingly high elasticities of the adoption probabilities with respect to variables other than extension dummy, one may recommend from Table 4 that the role of extension be emphasized as the only policy measure since it is not easy, at least in the short run, to alter the other variables so that the thresher diffusion can be accelerated. Thresher shares, for example, will be dwindling eventually if the supply of thresher services is increasing; while rice area alone will never become larger, unless a tremendous change of occupational structure in the society takes place.

Conclusion and Recommendation

During the peak season of harvest, labor availability in many parts of West Sumatera appeared to be the constraint towards higher quality as well as higher quantity of rice production. Since the use of thresher has showed promise of providing technical and allocative efficiency gain, it is essential that its diffusion be accelerated.

Agents of innovation such as Agricultural Extension Service (Dinas Pertanian), Industrial Extension Service (Dinas Perindustrian), Bank of Indonesia (PPMU), dealers and workshops have, to some extent, attempted to spread the adoption and diffusion of threshers. In spite of this effort and not to mention the neutrality of rural labor institution with respect to such an innovation, the adoption or diffusion of threshers in this area was considered somewhat slow though it was much faster than that in densely populated areas such as in the case of Java.

Using logistic, function analysis in order to find out factors constraining farmers' adoption of threshers, this study had arrived at a conclusion that the adoption was in its post early stages. The conclusion was drawn from the significant level of coefficients and the high figures of adoption probability elasticities. However, since all variables incorporated in the model, but extension variable, appeared to be more difficult to be changed and manipulated in real world, the study therefore pointed out that more emphasis should be placed on extension work as a major policy measure. Top priority of extension work ought to be launched particularly in villages where thresher shares are relatively high because threshers may serve to offset labor shortage problem by dampening delays in

harvest and threshing operation which are extremely crucial as far as rice quality is concerned.

Discussion on the nature of labor relation in this paper provides a hint that labor relations in densely populated areas such as those in Java will, at least in the short run, be a problem in the adoption of new devices in threshing and winnowing unless such devices are managed by laborers. In drying, however, since drying is usually separated from harvest operation, an invention in appropriate drying especially for rainy season may be easily adopted by farmers. Research in appropriate dryers, therefore, should be considered urgent.

Notes

1. Information presented in this paper is based on a survey which was carried out in collaboration between Centre for Agro Economic Research and IRRI-DITPROD Project and sponsored by International Labor Office, Geneva.
2. For a comparison see Pindyck and Rubinfeld (1981).
3. The term "changes from **bawon** to **tebasan**" is somewhat misleading because the former is not totally replaced by the latter. Apparently, the two systems are just alternatives for rice farmers in Java.
4. That the population pressure and modern rice varieties are considered the factors underlying the rise of **tebasan** system has been discussed by Hayami and Kikuchi (1981).
5. He concluded that the main division among analysts of mechanization process are between those who believe in substitution view and those who believe in net contribution view. See Binswanger (1978) for further clarification.
6. Factors underlying permanent migration from West Sumatera has been thoroughly discussed by Naim (1979).
7. Labor scarcity in this area seemed to have raised agricultural wage rate about twice as much as that in Java (see paper presented by Development Plan Agency BAPPEDA at the seminar on the development of locally made farm tools and mechanical devices. Padang, 1982).

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Appendix Table. Comparison Between Thresher Users and Non-Users on the Basis of Several Socio Economic Variables, West Sumatera 1984.

Variables	Thresher Users		Non-Users (n=29)
	Owners (n=20)	Customers (n=31)	
Age of household head (years)	41	43	43
Education (years)	7	7	7
Farming experience (years)	19	22	21
Family size:	5.1	5.6	4.9
a. Male above 10 years	2.5	2.2	2.0
b. Female above 10 years	2.0	2.2	2.0
c. Children below 10 years	0.6	1.4	0.9
Operated farm land (ha):	0.94	0.47	0.34
a. Owned (ha)	0.58	0.39	0.32
b. Sharecrop (ha)	0.25	0.39	0.32
c. Rent (ha)	0	0	0.02
Leased Out Land (ha)	0.13	0.09	0.06
Land Owned:			
a. Lowland (ha)	0.81	0.48	0.38
b. Upland (ha)	0.72	0.23	0.27
Non-rice income:			
a. Percentage of households	38	30	31
b. Income (in Rp. 1000/year)	155	120	110
Off-farm income:			
a. Percentage of households	59	58	17
b. Income (in Rp. 1000/year)	590	203	166

Note: n = number of observations.