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Household economy and tree growing in upland Central Java

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Abstract This article tries to identify the key variables that determine landuse patterns and the strategies of households towards tree growing in two upland regions in Central Java. A household's access to land and market opportunities appear to be such key variables. Households with little land use their land more intensively with respect to crop, livestock and tree production. So do households with access to market opportunities. Based on this type of diagnostic research more appropriate tree-based designs could be developed to contribute to the solution of landuse problems in the uplands of Java.

1. Introduction

Unstable agricultural practices and deforestation cause severe erosion in the uplands of Java. This results in the silting up of reservoirs and in irregular floods, which damage irrigation networks vital to rice cultivation in the lowlands of Java [8, 9, 12].

Responsible for this process is the low productivity of dry-land agriculture as it is practised in upland Java. This is demonstrated by the fact that most farming households are unable to be self-sufficient in staple food. Off-farm activities often provide most of the household income and are becoming an increasingly important adjunct [12, 16]. Furthermore an increasing population pressure, results in a diminishing access to land and the fragmentation of land-holdings. The hunger for land is forcing upland farmers to intensity land use by abandoning the fallow period, cultivating steep slopes and replacing traditional crops by food crops that yield more calories. In many areas, upland farmers have entered forest areas and started to cultivate there as well [12].

There is no single type of upland farming; instead there is a large variety of farming systems, as a result of differences in the bio-physical and socio-economic environment. In this article we will concentrate on established permanent field upland cropping systems in Central Java and more specifically on smallholder food cropping, which is the prevalent type of agriculture in this area.

The main staple crop is cassava, which is often intercropped with maize. Occasionally, dry rice is grown for home consumption and peanuts and soybeans for cash.

Although rice is the preferred staple food, the cultivation of maize and cassava gives a higher energy output per ha (feeds more people) and therefore

these crops are increasingly being grown as farmer's holdings become smaller [12]. Furthermore, cassava is a crop with low demands in terms of soil fertility, and its cultivation requires a lower input of labour than rice. The use of manure and fertilizer is widespread, but the quantities used are often insufficient to compensate for the nutrients lost by harvests and erosion.

Throughout Java, farmers grow trees on their land. Trees provide the farm family with timber, fruits, fuelwood and fodder, but also provide shade and may reduce soil erosion and improve soil fertility. Furthermore, tree products may be sold on the market for cash. Thus trees already play a role within the farming system. The Indonesian government has recognized the potential of tree growing in upland areas. In 1976 the 'Reforestation and Regreening' programme was launched. This programme is aimed at the reforestation of upper slope areas (mostly state forest lands) and the introduction of more soil-conserving cropping regimes (mainly through terracing and tree planting) on private land on the low gradient slopes. The package of measures on private land is referred to as Penghijauan (Regreening) [3]. The Indonesian government recognizes that the Penghijauan can only be viable with the cooperation of the upland population [11]. It is recognized that this cooperation will only be forthcoming if the programme contributes to the income and employment of upland farming households [13]. Despite this commitment several studies [2, 4, 13] have shown that the Penghijauan is experiencing great difficulties in achieving its goals. The reason for this is partly logistic. According to Daru and Tips [4] the programme suffers from overcentralization. This is reflected in its approach. The programme fails to distinguish between different land utilization types and hardly recognizes the importance of present tree-growing activities. The Penghijauan program regularly provides farmers with species they do not need or in quantities that they do not want because of competition with food crops [2]. This discourages cooperation.

To improve the results of the Penghijauan program it is thus necessary to decentralize its organization and to introduce measurements that meet the aims of the farmers, instead of focusing on the technical aspects of manipulating selected components of upland farming systems [9]. It should be realized, however, that farmers in different areas and with different access to income-generating resources (e.g. land) have different farming strategies and need different ways to solve their farming problems. It is crucial to understand the farming strategy that is part of the decision-making process within rural households.

2. Tree growing strategies and household decision-making

Various agricultural systems can be found in upland Java. Many of these systems incorporate trees; general descriptions of these agroforestry systems have been given by McCauley [9], Palte [12] and Wiersum [17]. Normally, one

farm comprises various agricultural systems. In the present study the following systems are of most importance:

(a) the homegarden (*pekarangan*); the area next to the homestead, often dominated by trees, but also planted with vegetables and food crops.
(b) the dry field (*tegal*); the area located at some distance from the homestead, where most food crops are grown, often in combination with trees.

A further important characteristic of the Javanese upland farming system is the prevalence of supplementary off-farm activities. In Fig. 1 a general model is given of the various elements of a Javanese upland farming system. This model has been adapted from the model presented by McDowell and Hildebrand [10]: we have replaced the role of the forest as a source of fodder, timber and fuelwood by the tree production system, which is present within the Javanese upland farming system. The box identified as Market represents all off-farm activities and off-farm resources (except land); hence it includes products sold or labour going off the farm, as well as purchased inputs and household items.

Besides recognizing the importance of the market as a major influence, attention should also be given to the role of government institutions (e.g. the Penghijauan program). In the upland areas of Java, government agencies are stimulating the cultivation of high-yielding rice varieties, the use of fertilizers and pesticides, tree growing, terracing, family planning, transmigration, etc., which will all influence the farming system somehow.

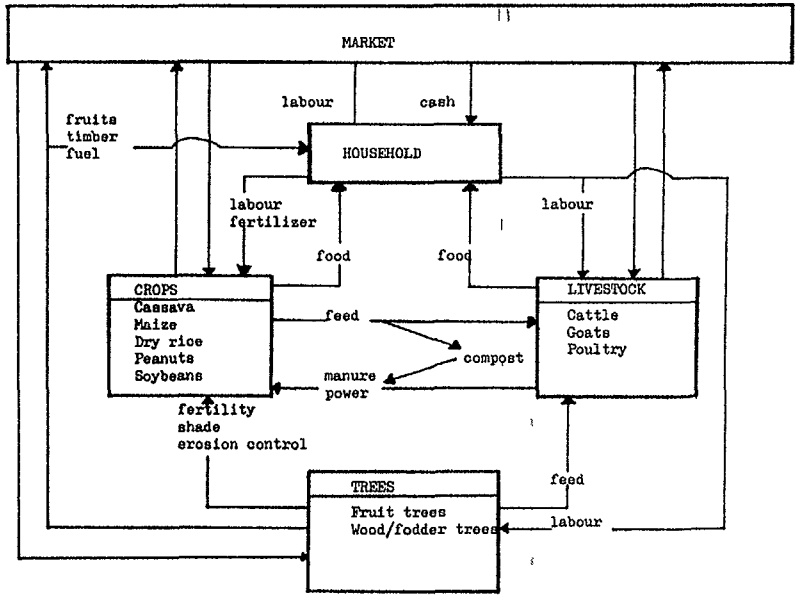

Fig 1 A model of an upland Javanese farming system

In this article we will consider the four production systems that can be distinguished within the upland Javanese farming system; the crop production system, the livestock production system, the tree production system and off-farm activities. In farming systems research (e.g. 14) so far little attention has been given to the role of trees. However, as discussed before, for a proper design of tree-planting programmes like the Penghijauan an understanding of both the farming system and its tree component, and of the household decision-making strategies is crucial. ICRAF [6, 7] was among the first to recognize the importance of the tree component in farming systems and devised a research and development methodology aimed at intervening with and in agroforestry systems. In our opinion, however, the ICRAF methodology pays too little attention to the various factors at the household level that influence decisions on land use strategies. Therefore we constructed a household model, adapted from a similar model proposed by Deere and de Janvry [5] (see Figure 2).

The farming system consists of several components, which are linked by the household decision-making process. The household has various assets (land, labour, capital, knowledge) which can be put to use in the farming system. This results in a certain type of land use and the choice of a number of off-farm activities. Thus land use is the result of the decision-making process of the household. The products produced are those preferred by the household, within the limits set by household assets and the bio-physical and socio-economic environment.

3. Research methodology

3.1 Aims and methods

The aim of this research is to analyse the role of tree growing in upland farming systems. More specifically, the research emphasizes the relation between the household economy and tree growing; which factors within the household (e.g. access to land and off-farm activities) and from outside (e.g. market situation, government programmes) determine actual land use and tree growing activities on farmers' land. Through a better understanding of the farmers' strategy towards tree growing it should be possible to develop more appropriate innovations which may improve the results of the Penghijauan.

In order to distinguish between the different farming systems and strategies of farmers towards tree growing that result from differences in the bio-physical and socio-economic environment, two research areas were selected. The selection criteria; (a) the condition of the physical environment (soil fertility and soil erosion); (b) the market situation; (c) the presence of external resources of tree products (e.g. state forest); (d) the presence of a Penghijauan project.

The study was done in Bunder in the regency of Gunung Kidul, and Merden in the regency of Banjarnegara (see Fig. 3). In both areas a random sample of households was taken: 22 households in Bunder and 50 in Merden. Over a

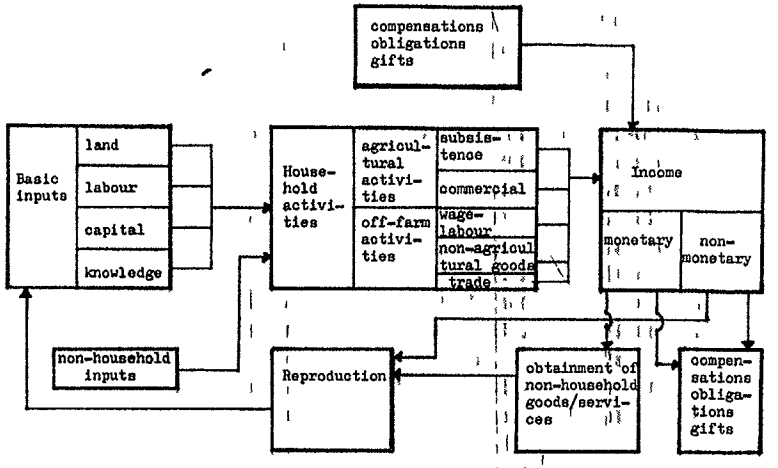

Fig. 2. A household model.

period of two months these households were interviewed with the help of a checklist, and their fields were surveyed. In addition, key informants were interviewed and general information was gathered from village records. For the analysis of data households were classified according to their access to land. This classification was based on the assumption that the upland farmers are subsistence-oriented and therefore will regard land as their most important resource. Consequently, the amount of land will have considerable influence on household decision-making. In this article the households will be divided into two categories; farmers that have access to less than 0.5 ha of land (A), and those that have access to more than 0.5 ha of land (B).

3.2 Description of the research areas

Bunder is situated in the Gunung Kidul area, which has long been known as a critical area prone to erosion. Severe drought has plagued the area and contri-

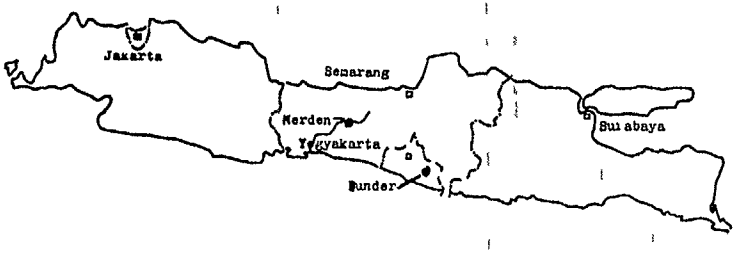

Fig 3. Location of the survey areas, Merden and Bunder

buted to famines in the past [1, 15]. For a long time the area was sparsely planted with trees. The main staple crop was cassava. Recently, various development efforts have been undertaken in this area to improve the infrastructure. Part of the population has been transmigrated to other areas. Better varieties of dry rice, peanuts and soybeans have been introduced via agricultural development programmes, as have soil and water conservation measures. In this village tree products can be marketed, which are transported to large towns like Yogyakarta. In 1982 a Penghijauan demonstration plot was established. Near the village there is a state forest. Annual rainfall is about 2300 mm. The soils (mainly Grumusols) are shallow and susceptible to erosion.

Merden is located 20 km west of Banjarnegara at the footslopes of the South Serayu mountains. The northern part of the village is a lowland (sawah) area; the southern part, in which this research was conducted, is an upland area. During recent decades people originating from the lowland area have moved into the upland area and started to cultivate dry rice on unterraced slopes. Soil fertility declined very rapidly as a result of soil depletion and erosion, and the people changed to the cultivation of cassava on badly terraced slopes, often intercropped with maize. About 15 years ago farmers started to use fertilizer and to plant trees on their land. This area regularly suffered from famines caused by severe droughts, the most recent of which occurred 5 years ago. The hills are much steeper than in Bunder and the erosion rates are exceptionally high. This erosion is exacerbated by the quarrying of minerals in open pits, which deprives farmers of their land in the long run but offers them cash in the short term, through job opportunities and the renting out of pits to others. The people who rent out pits also own sawah and do not depend on their dry land for food. Annual rainfall is about 3300 mm. The soils are not very fertile and crop yields are low. The market for timber is of little importance and is located a considerable distance away. There is no state forest nearby. Penghijauan programmes have failed twice; a third programme was introduced at the end of 1984.

4. Results

4.1 Household characteristics

Access to land. Table 1 shows the average area of land worked for each household category in both villages. In Bunder some land is rented. Generally, the

Table 1. Mean area of the land worked (ha) per household category, and numbers of households per category

category	Merden area	N	Bunder area	N
A	0 20	35	0 27	8
B	0 81	15	0 80	14
Mean	0.37	50	0 61	22

households in Bunder have access to more land. The farmlands may consist of fields with different agricultural systems, both homegardens and dry fields. Access to land seems to be important in determining farming strategies. Considerable differences were found in productivity, input level, tree densities and livestock densities. Households in category A use their land more intensively. The quality of the land does not differ much between the household categories within the survey areas; differences between the survey areas, however, are considerable. Land in Merden is steeper than in Bunder. Furthermore, terracing in Bunder is better, and consequently erosion rates are lower. Soil fertility is low in both areas.

Access to labour. In both villages households are the main source of labour. In Merden labourers are rarely hired; working on each other's land is based on reciprocity. In Bunder, households with little land and remunerative off-farm activities can afford to hire labour. Others mobilize labour by the farmers' groups they belong to. Table 2 shows that the B category households (which have more land availabe) consist of more people. This is because the bigger, often extended, families have not yet split up and the younger generation is waiting until they inherit land before they establish their own household. In general there is sufficient labour available for agricultural activities within the households of category A. The existence of farmers' groups in Bunder, composed of farmers from category B, indicates that from time to time households within this category have difficulties in mobilizing sufficient labour. It is considered too expensive to hire labour.

Access to capital. Most households have only very small amounts of cash. They are unable to save money for longer periods of time. Capital is accumulated via the raising of animals (goats, cattle) and tree growing; the standing stock of trees may represent a large amount of money. Most capital accumulated in this way is spent on social necessities, such as funerals and weddings, or for emergency purposes in times of famine, but some is used to buy fertilizer. In this respect households in Bunder have many more resources at their disposal than those in Merden.

Access to off-farm activities. All households engage in off-farm activities to supplement agricultural activities with cash. The most important off-farm activities are summarized in Table 3. These data indicate important differences between the two sample villages in regard to off-farm activities. An average household in Merden engages in two or more off-farm activities, whereas in Bunder only one off-farm activity per household is the norm. These differences

Table 2. Number of people and number of adults (over 15 years) per household (hh) in Merden and Bunder

category	Merden hh size	adults	Bunder hh size	adults
A	4 5	3 0	4 4	2 3
B	6 1	3.7	5.9	3 4
Mean	5 0	3 2	5 3	3 0

Table 3. Most important off-farm activities in the sample vilages

category	Merden	Bunder
A	wage-labour, mining, carpentry, palm sugar	government jobs (pensions)
B	wage-labour, mining, carpentry, trade	carpentry, trade, (selling wood/charcoal)

partly result from the fact that the households in Bunder have access to more land. Consequently, their household needs are generally better met by agricultural activities than in Merden.

In Merden most of the off-farm activities are open to everyone (except trade and wage-labour). Here the households may choose from a great variety of off-farm activities, but in general these give very low returns to labour. In Bunder the households in category A often have a government job with high returns to labour, or a pension, which makes them less dependant on agricultural production. For the households in category B, access to off-farm activities such as government jobs, trade and shop-keeping is limited by a lack of education and capital.

4.2 Farming system characteristics

4.2.1 Crop production system.. Most crops are grown on the dry field (tegal), but if the size of the dry field becomes too small to satisfy the household's consumption demands, part of the homegarden is also used for the cultivation of food crops.

In Merden there is one planting season only. The main agricultural activities during the cropping period are hoeing and the upkeep of the terraces. These activities are often combined with the cassava harvest. This work, which is mainly done by men, takes about two-thirds of all the time spent on crop production; 15–19 days out of a total of 20–130 labour days (from 6.00–11 a.m.) spent on crop production. Besides this work the farm family has to plant maize and cassava, weed once or twice, apply manure and fertilizer, and harvest the crops.

In Bunder there are two planting seasons. In the first season rice is intercropped with maize and cassava. In the second season, when the rice and maize have been harvested, peanuts are planted in between the cassava crop. This cropping system requires a higher input of labour, ranging from 30–250 labour days per household, depending on the farm size. Hoeing is not as important as in Merden because the households keep cattle for ploughing. Most time is spent on the application of manure (men's work) and weeding (which is done by both men and women).

Data on the land productivity (Table 4) indicate that in Merden a higher calorific output (maize, cassava) is combined with a lower input of cash. Here fewer inputs like manure, fertilizer and pesticides are applied than in Bunder. In

Table 4 Crop production (kg/ha/year) and production valued in calorific output (kcal/ha/year) and cash volume (Rp 1,000/ha)

Bunder	maize	cassava	rice	peanuts	kcal/ha/yr	Rp/ha/yr
A	485	1770	440	1020	5240	332
B	270	1025	415	655	3565	233
Mean	348	1295	425	790	4177	269
Merden						
A	795	3790	–	–	7000	97
B	450	1740	–	–	3515	49
Mean	700	3200	–	–	6010	83

Notes: a. Estimated energy per ha per year obtained from: maize; 100 g = 360 kcal, cassava; 100 g = 109 kcal, rice; 100 g = 356 kcal (peanuts are sold). b. Estimated cash volume required by: maize, 1 kg = Rp 50, cassava; 1 kg = Rp 15, rice; 1 kg = Rp 175, peanuts; 1 kg = Rp 200 (1$ = ± 1050 Rp).

Bunder a lower calorific output is combined with higher quality crops (rice, peanuts). Here peanuts are an especially important source of cash.

In all categories of households crop production for subsistence is considered to be the prime objective. Total reliance on off-farm opportunities is considered too risky. The land of category A households is much more productive than that of category B households. Nevertheless, all the households (categories A and B) are far from self-sufficient in food crops. They fill this subsistence gap by buying food with money derived from off-farm activities. This may explain why households in category B do not use their land as intensively as households in category A. Much labour is needed to earn cash, both to buy staple food and to fulfil other obligations. This labour is subtracted from agricultural activities, because it is more profitable to devote it to off-farm activities.

Crop production is much more intensive in Bunder. Not only are crops of higher quality (rice, peanuts) produced than in Merden, but also more cash is generated via crops in Bunder (peanuts). On the input side, in Bunder more labour, manure and fertilizer are applied: households are able to do this because they have larger resources to mobilize capital for fertilizer, have more livestock and consequently are able to apply more manure, and have more remunerative off-farm activities, so that more labour can be hired for agricultural activities.

Table 5 illustrates the consumption of crops produced by the household and the production of cash crops per household (peanuts). In both areas, total calorific intake from own production is about the same, but there are great differences between the categories A and B. There is, however, also a qualitative difference, for households in Bunder consume more home-grown rice which has a higher nutritional value than cassava (cassava 1.5 g of protein per 100 g, rice 7–7.5 g protein per 100 g).

4.2.2 Livestock production system.. Cattle and goats are important sources of manure and are kept as 'live-money' capital reserves. A goat has a market value

Table 5 Consumption of crops grown by the household (kg per year), in calories per day (kcal/capita/day) and valued in cash (Rp/year)

Bunder	maize	cassava	rice	peanuts	kcal/c/day	Rp/yr
A	55	220	90	200	472	61
B	210	570	235	570	1028	174
Mean	154	443	182	444	871	135
Merden						
A	105	515	–	–	572	13
B	320	1290	–	–	1148	35
Mean	166	735	–	–	767	20

of Rp 15,000, cattle are worth Rp 150,000–200,000 per head. Furthermore, in Bunder cattle are used for ploughing. If a household cannot afford to buy cattle and/or goats it can look after someone else's livestock and share the offspring. In Merden this was done by 40% of the households, in Bunder by only a few poor households.

Livestock management requires considerable labour investments. In Merden on average 2–3 hours per day were spent to gather fodder by men, women and children alike. In Bunder, fodder gathering took a daily average of 3–4 hours; also by men, women and children alike. Fodder is gathered on farmer's land and consists of grasses, cassava leaves and leaves from trees (see also below). In Bunder the Penghijauan introduced elephant grass (*Pennisetum purpureum*), which is grown on the borders of the terraces by almost all farmers. They also grow more fodder trees (*Leucaena leucocephala, Sesbania grandiflora*) the more livestock they have In times of shortage, farmers in Bunder collect fodder in the state forest. Table 6 gives an overview of the numbers of livestock in the survey areas

4.2.3 Tree production system. Trees form an important component of the Javanese upland farming systems. Here we will consider the following characteristics of this component.

Table 6 Livestock per household (hh) and per ha of arable land

Bunder	% hh with goats	herd size	goats per ha	% hh with cattle	herd size	cattle per ha
A	63%	3 2	11 9	50%	2 2	8 1
B	57%	2 3	2 9	93%	2 2	2 8
Mean	59%	2 4	4 0	77%	2 2	3 6
Merden						
A	69%	2 4	12 0	–	–	–
B	100%	5 1	6 3	–	–	–
Mean	78%	2 8	7 6	–	–	–

(1) The contribution of different tree species to the needs of the household and the farming system.
(2) The spatial distribution of trees with respect to different land utilization types and to competition with crops.

(a) In both areas we identified about 50 species, 20 of which occur regularly. These can be broadly divided into trees grown for their fruits (fruit trees) and trees grown for timber, fuelwood and/or fodder (wood/fodder trees). Table 7 shows the relative importance of various species in both villages. Bamboo species and the screw palm (*Pandanus* spp.) have not been included in this table. These species are mostly planted on critical spots; along gullies and on steep slopes. This illustrates how farmers recognize the importance of certain species for erosion control. The function of bamboo as a source of building material, however, is gradually being usurped by timber species like *Albizzia falcataria* in Merden and *Tectona grandis* and *Swietenia macrophylla* in Bunder.

Table 8 shows the number of trees per household. Households in Bunder grow far more trees (both fruit and wood/fodder trees) than households in Merden. In the first place, trees serve household needs for fruits, fuelwood, fodder and timber. After subsistence goals have been met, surpluses can be sold. In most cases, trees are able to fulfil subsistence demands in Merden, but tree products are seldom sold. In Bunder most households sell tree products in the form of fuelwood or fruits. Some households in category B also sell timber.

(b) The distribution of trees over various fields with different agricultural systems is an important aspect. The data from the survey indicate that both fruit and wood/fodder trees are grown in the homegarden and on the dry field and that tree densities on the dry field are considerable

About half of the trees grown by the household are on the dry field (see Tables 9 and 10). The aim of the distribution of trees is to limit competition with food

Table 7 Presence (% found) of main tree species in the survey areas

Fruit trees	Merden	Bunder	wood/fodder trees	Merden	Bunder
Banana	17%	22%	*Albizzia falcataria*	34% +	0%
Coconut	9%	4%	*Albizzia lebbeck*	3%	2%
Psidium spp	8% +	1% +	*Swietenia macrophylla*	2% +	20%
Jackfruit	3%	1%	*Tectona grandis*	1%	12%
Cashew	0%	6% +	*Acacia auriculiformis*	3% +	6% +
Coffee	3%	0%	*Leucaena leucocephala*	1%	9% +
Clove	2%	1% +	*Sesbania grandiflora*	0%	4% +
Mango	1%	1%	*Calliandra calothyrsus*	0% +	0% +
Citrus spp	0%	2% +	*Dalbergia latifolia*	0%	1%
Gnetum gnemon	1%	1%	*Gliricidia sepium*	1%	0%
Ceiba petandra	2%	0%			
Others	9%	3%	Others	0%	3%
Total	55%	41%	Total	45%	49%

Notes a + indicates that this species has been promoted/introduced by an institutional agent of change (e g the Penghijauan programme) b 0 % mean present but only in very small numbers For example *C calothyrsus* is present but kept very small and therefore was not counted

Table 8 Number of trees and species mix per household

Fruit trees	Merden			Bunder		
	A	B	Mean	A	B	Mean
Banana	17	17	17	40	64	56
Coconut	7	14	10	7	10	9
Psidium spp	5	11	7	2	3	3
Cashew	–	–	–	11	17	15
Citrus spp	–	–	–	3	4	4
Others	8	7	8	12	19	16
Subtotal	37	49	42	75	117	103
Wood/fodder trees						
Albizzia falcataria	32	35	33	1	–	–
Albizzia lebbeck	2	6	3	3	7	5
Swietenia macrophylla	1	1	1	35	57	50
Tectona grandis	1	1	1	20	36	31
Acacia auriculiformis	3	2	2	12	18	16
Leucaena leucocephala	–	–	–	10	28	22
Sesbania grandiflora	–	–	–	1	16	11
Others	1	1	1	15	15	15
Subtotal	40	46	42	97	177	150
Total	77	95	84	172	294	253

crops. The second aspect of the spatial distribution of trees that should be taken into account is their distribution over the farmer's land. In Bunder the trees are mainly grown on the borders of the plot and on the bunds, to reduce competition with food crops. The most important tree species in Bunder, *T. grandis*, *S macrophylla* and *Acacia auriculiformis*, have extensive root systems and the litter of *T. grandis* and *A. auriculiformis* decomposes slowly (and is mostly burnt) Furthermore, trees distributed in this way do not hamper ploughing. In

Table 9 Number of fruit trees (fruit) and wood/fodder trees (w/f) in the homegarden and on the dry field and as % of the total number of trees

	Merden			Bunder		
	fruit	w/f	total	fruit	w/f	total
Homegarden	25	9	43%	60	79	55%
Dry field	17	33	57%	43	71	45%
Total	50%	50%	100%	41%	59%	100%

Table 10 Tree densities in numbers of trees per ha in the homegarden and on the dry field, for A and B households

	Merden			Bunder		
	A	B	Mean	A	B	Mean
Homegarden	1445	320	1125	605	1048	949
Dry field	385	100	305	637	295	428
Mean	650	220	377	624	613	617

Merden, where *A. falcataria* is the most important species, trees are distributed randomly over the plots. Ploughing is not possible here because of the steepness of the hills. Furthermore, *A. falcataria* has an open crown and does not compete seriously for light with maize and cassava. In general, trees with extensive root systems and low revenues are not appreciated by the farmers, if they are to be grown in combination with food crops. Examples are *Calliandra calothyrsus* (which also requires too much labour for proper maintenance) and cashew. Both were introduced by the Penghijauan programme. In both survey areas *C. calothyrsus* has been removed or reduced to small stumps and cashew is kept as small as possible. All households manage trees on their land. No households reported having severe problems in meeting fuelwood needs. If no wood is available, all kinds of agriculatural waste are used as fuel. The same applies to fodder requirements and the supply of fruits. It is noteworthy that households keep a certain minimum number of trees to supply these products If we subtract banana (which supplements the diet with carbohydrates) and fruit trees grown for cash (*Citrus* spp., cashew) from the number of fruit trees per household, in both areas the same number of fruit trees is grown per household member (approximately 5).

4 3 Household income

Both in Bunder and in Merden households need cash income to supplement agricultural production (crops, livestock, trees), to pay for taxes, social obligations, school fees, health care, etc. Most of this cash income is generated via off-farm activities. Next to income in kind, agricultural production may also provide a cash income, when products are sold. Table 11 provides an estimate of the relative importance of off-farm activities and agricultural production in generating cash income. Total cash income in Merden is much lower than in Bunder, because off-farm activities have very low returns on labour compared with Bunder. Furthermore, cash income from agriculture is very small, because of the absence of cash crops and a sufficient tree stock to generate surpluses. Livestock has not been added to the table as it was difficult to estimate the annual income it yields. But it is expected that cash income from livestock in Merden is much less than in Bunder.

Table 11 Estimated cash income (× Rp 1,000) and the relative importance (%) of three sources of revenue in generating cash income

	Merden		Bunder	
	A	B	A	B
Total income per hh	221	250	769	481
Income per capita	49	41	175	82
off-farm activities	95%	90%	93%	70%
crops	2%	4%	4%	16%
wood/fruits	3%	6%	3%	14%

5. Discussion

5.1 Effect of differences within farming systems on tree growing

The tree species grown and their spatial distribution can be explained both from the characteristics of the trees and the requirements from the farming system. In Merden *A. falcataria* is grown randomly over the field, for it does not strongly compete for light with maize and cassava because of its open crown. Moreover, it yields large amounts of timber, fuelwood and fodder on relatively little space within a short span of time. *A. auriculiformis*, *T. grandis* and *S. macrophylla* are popular species in Bunder, because they yield good prices at the fuelwood and timber market and are preferred for house-building. They are, however, planted in hedges to reduce competition with food crops, especially rice which is more vulnerable to competitors for light. Furthermore, planting in hedges leaves the fields clear for ploughing with cattle traction.

With decreasing size of the holding and increasing stress on the household resources the trees are distributed more evenly over the homegarden and the dry field. This occurs on the smaller category A holdings in both Merden and Bunder. In this way dry fields begin to resemble homegardens. Households in category B separate trees more from crops, so that two distinct land utilization types can be discerned.

5.2 Effect of non-farm characteristics on tree growing

The survey areas are very different with respect to off-farm sources of cash income. In Bunder important amounts of cash income are generated via the government. Households in Bunder have more jobs outside the village, whereas in Merden few people have regular jobs. Important off-farm activities, like the quarrying of minerals and the extraction of sand, moreover, not only owe their existence to the high erosion rates in Merden but contribute to erosion too. Bunder has received much more attention from government programmes, directed towards improving agricultural practices, in the past and present. In Merden, farmers have received little extension or other help from government programmes. Penghijauan programmes influence land use and tree growing. It was observed that recently introduced plant species that fit into the farming system or give high returns are successful. Examples of this are *A. falcataria* in Merden and *P. purpureum* in Bunder, because they fit into the farming system, and *Citrus spp.* and clove in Bunder for their high returns. Species that are unpopular give too low returns; e.g. *C. calothyrsus* in both areas.

A further very important difference between the villages is the existence of a market outlet. The market serves as a commercial outlet for tree growing activities. Fuelwood, charcoal and timber fetch good prices in Bunder and this has promoted tree growing, whereas in Merden these stimuli are almost absent. The market outlet also contributes in other ways to more profitable farming in Bunder. The wide opportunities to market cattle indirectly boost the growing of grasses and fodder trees. Similarly opportunities to market cash crops stimulate the growing of grasses and fodder trees.

Market outlets are not absent in Merden, but they are less developed in the case of agricultural products. The markets for minerals and sand are organized in a monopolistic way. Returns on labour for the quarrying of minerals and the extraction of sand are low. Moreover, these activities contribute to environmental degradation in this area.

6. Conclusions

In response to various local circumstances, farmers in upland Java follow different strategies towards farming and tree growing. Access to land and market opportunities are key variables in this respect. Households with little land use their land more intensively with respect to crop, livestock and tree production. Householders with access to market opportunities also use their land more intensively. We have shown that the production systems (crops, livestock, trees) are strongly interrelated. Interventions in the tree production system will only be successful if they can be integrated in the farming system by the farmer and if they give sufficient returns.

The presence of a market outlet can provide an impetus to more intensive land use and to the development of a farming system. This is only the case, however, when production opportunities for the market can successfully be integrated in productive (Bunder) and not exploitative (Merden) land use systems. The Penghijauan programme does not pay sufficient attention to local differences and though it will be successful in some areas it will result in many failures in other areas. Decentralizing the organization of the programme will greatly improve its results.

Due to a lack of time no on-farm trials could be done. However based on this kind of diagnostic research it should be able to come up with more appropriate alternative tree-based designs.

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