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Factors changing farmers' willingness to grow trees in Gunung Kidul (Java, Indonesia)

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Abstract

Farmers' willingness to grow trees depends on many factors. If governments or other organizations want farmers to grow more trees, they have to understand these factors. This article describes the expansion of the tree component in farming systems in recent decades in the Gunung Kidul district. This trend is then explained with elements of the induced innovation model of agricultural development, namely in terms of resource endowment, demand for products and institutional aspects. An increase in the productivity of staple crops seems to have been an important factor permitting farmers to plant trees. Another factor related to factor endowment that farmers induced to grow trees is the response to declining soil productivity as a result of erosion. The Indonesian government's trade and pricing policy for certain tree products has supported the favourable market trend for these products, and has induced farmers to plant fruit and fodder trees especially. Improvement of the (physical) infrastructure has demonstrably encouraged tree growing. Examples are given of technological change in tree growing that result from farmers' own innovation as well as from research done by various organizations.

Keywords: induced innovation, development, land-use, agroforestry, policy, Indonesia

Introduction

Diminishing tree cover is an important source of environmental problems – especially erosion – on Java and brings considerable costs to Indonesian society in the long run (Repetto *et al.*, 1988). In many situations the rural population is blamed for this type of land degradation. However, a distinction has to be made between different categories of land ownership. Degradation of the public forests is a general phenomenon, but in this study it will be shown that the diminishing tree cover on private land has not generally occured in recent decades, at least not in the Gunung Kidul district, an upland district in Yogyakarta Province. On the contrary, a major characteristic of the dynamics in land use in the Gunung Kidul district has been the increase in the number of trees on private land during this period, mainly within agro-

forestry systems. A similar trend, namely the degradation of the state or communal forests and a substantial increase in the number of trees on private land, has been established elsewhere in Asia (Gilmour, 1987) and in Africa (English *et al.*, 1994).

What might be the impetus behind such a change in land use? In the areas studied by Gilmour (1987) in Nepal the driving force appeared to have been a response by the peasants themselves to a changing situation, resulting from decreased availability of forest products from nearby communal forests. Although the tree cover on state-owned land has diminished in recent decades in the Gunung Kidul district too, this does not automatically mean that the forest products have become scarcer for the local people.

Several theories of agricultural development have been put forward to explain changes in farm management. The theory of induced technological and institutional innovation in agriculture as developed by Hayami and Ruttan (1971) provides a significant advance in economic understanding of agricultural development (Stevens & Jabara, 1988). Technological change was initially conceived as exogenous to the economic system, resulting from an autonomous advance in science and technological knowledge. In the theory of induced innovation, technological change is an endogenous factor to the economic system and represents a dynamic response to change in resource endowments and demand. Recursive relationships exist among resource endowment, institutions, technology and cultural endowments in this model of agricultural development (Hayami & Ruttan, 1985). Below, elements of the induced innovation model will be used to explain the changes in the tree component of the farming systems in the Gunung Kidul district[1]. Special emphasis will be given to resource endowment, product demand and institutional aspects, and various technological changes relating to tree growing will be highlighted.

Land use and farming system in Gunung Kidul

The district of Gunung Kidul, situated in the south of central Java (Figure 1), was chosen as a research area because it had been reported that the tree component of the farming system was increasing here.

Although the average annual rainfall is between 1500 and 2000 mm, agriculture is regularly restricted by droughts in the dry season. Furthermore, the area is intermittently plagued by rats, which diminish yields (especially of rice) considerably (Nibbering, 1991). On many sites, soil fertility has been diminished by erosion – especially in the north and north-east in the Batur Agung zone and the Panggung plateau with steep slopes up to 40% – and by leaching and oxidation – especially in the south in the Gunung Sewu (which means thousand hills), a limestone complex with a typical karst topography and an altitude of 100 to 300 m. The conditions for agriculture on the limestone soils are not optimal. Table 1 shows that only a small

[1] The data used in my explanation were not specifically collected with this model in mind. Rather, the model was used as an analytical tool when collating various studies which had been carried out independently by different students in the second half of the 1980s.

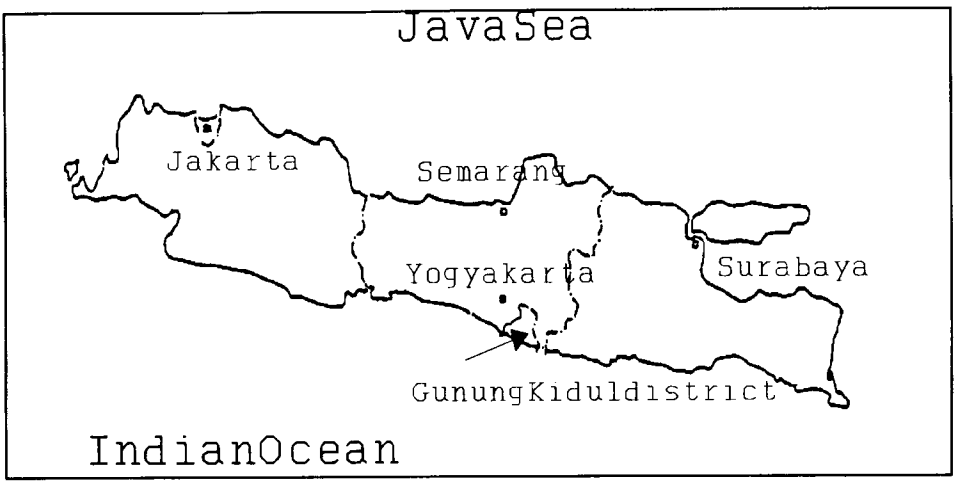

Figure 1. Location of the Gunung Kidul district in Java.

part of the area is in use as *sawah* (Javanese for irrigated or rain-fed ricefield). In the 1950s the area was already recognized as subject to serious erosion, resulting in lower yields per hectare of annual upland crops and in regular famines, and the actual forest cover was only three percent (Bailey & Bailey, 1960).

Several types of cropping systems including trees may be distinguished, such as the home garden (in Javanese *pekarangan*) and the dry fields (in Javanese *tegal*). Although the density of biennials and perennials usually is much lower in the *tegal* than in the *pekarangan* (Table 2), the total number of trees in this cropping system can be considerable, because the *tegal* is the largest type of land use (Table 1). Especially in the hills in Rongkop and Tepus subdistricts, perennials (mainly trees for wood production) rather than annual crops dominate on private lands. Wiersum (1982) calls this cropping system 'forest garden'.

Since grazing land is very rare in Gunung Kidul and grazing in the state-owned forest is officially prohibited in young stands, the cattle are mostly kept in sheds. Farmers often grow fodder trees in their farming system to reduce the amount of time needed to collect fodder, and to increase the supply of fodder.

Suitable land seems to be the scarcest factor in agriculture in Gunung Kidul. Until late into the 19th century the agricultural area on Java could be extended by converting forest land into agricultural land. With the Agrarian Law of 1870 (*Domeinverklaring*) villagers lost the free access to the forest, both for obtaining forest products and for conversion to agricultural land. Nevertheless, a considerable area of forest was cleared in the uplands of Java since then (Palte, 1989; Peluso, 1992). The supply of agricultural land can be considered inelastic in Gunung Kidul[2].

[2] The increase of dry land area according to the Agricultural Census 1973 and 1983 in the Province Yogyakarta reflects rather a more careful enumeration in 1983, than an actual increase (Booth, 1988)

Table 1. Land use (total ha and % in 1982) and population density (inhabitants per km^2 in 1980) in the Gunung Kidul subdistricts.

Sub-district	% of land as						Total land use (ha)	Population density (people per km^2)
	home garden	upland dry fields	wet rice fields	forest	other	total		
Karanmojo	38.5	43.2	2.2	11.6	4.5	100	8,012	651
Ngawen	26.7	44.2	24.8	–	4.3	100	5,354	624
Nglipar	21.5	36.8	13.5	20.8	7.5	100	10,304	432
Paliyan	10.5	68.4	0.4	17.8	2.7	100	14,590	412
Panggang	5.8	73.6	1.2	13.8	5.6	100	17,156	280
Patuk	25.9	43.2	16.1	6.9	5.9	100	10,099	422
Playen	17.2	36.2	1.7	34.8	10.1	100	10,925	478
Ponjong	19.5	70.9	5.5	–	4.6	100	10,449	490
Rongkop	5.0	87.3	0.1	1.4	6.1	100	17,803	297
Semanu	17.4	68.2	0.2	5.3	7.7	100	10,839	454
Semin	24.9	45.7	19.2	1.1	9.0	100	7,777	618
Tepus	6.5	89.7	0.5	0.3	2.9	100	17,654	338
Wonosari	23.4	64.7	0.4	6.8	4.9	100	7,551	867
Total	15.8	64.1	4.8	9.4	5.9	100		444
Total (ha)	23,342	95,148	7,148	14,026	8,759		148,513	

Source: Anonymous, 1984a.

To meet the hunger for land, the State Forest Service applies the taungya system, locally called *tumpangsari*, in reforestation. Under this system participants can in-

Table 2. Trees*) in the home gardens and the upland dry fields in some subdistricts in the Gunung Kidul district.

	Subdistrict						
	Playen	Patuk			Rongkop	Tepus	Ngawen
		Widoro	Ngepung				
			<.5ha	≥.5 ha			
Home garden							
no. respondents	30	20	8	14	20	30	25
average size (ha)	0.25	0.13	0.12	0.25	0.06	0.12	0.12
trees/ha	542	185	605	1047	400	620	958
trees/home garden	136	24	73	262	24	74	115
Upland dry fields							
no. respondents	29	20	8	14	19	29	
average size (ha)	0.41	0.67	0.15	0.55	0.92	0.63	
trees/ha	390	252	637	295	241	286	
trees/dry field	160	169	96	162	222	180	

*) Except for Ngepung subdistrict species occurring in homegardens in < 10% of the households, bamboo (mainly *Bambusa* spp.) and banana (*Musa* spp.) are excluded. In the dry fields these species made up 20–30% of the number of trees.

terplant a plot of 0.25 ha with agricultural crops for three years (Simon & Wiersum, 1992).

Land scarcity is determined both by the availability of suitable land and by population density. The population density in Gunung Kidul was 470 inhabitants per km^2 in 1985. Compared to Yogyakarta Province (936 per km^2) and the whole island of Java (753 per km^2) this is low. However, because the land quality in Gunung Kidul is low, population density can be considered to be high. The low carrying capacity and the absence of a noteworthy growth in the industrial sector are reflected in the low population growth: less than 1% per annum on average in recent decades – compared with more than about 2% on Java – and in the period 1980–1985 only 0.37% annually. In the past the relatively low population growth was mainly the result of a high emigration rate. In recent years, the low birth rate has also contributed to the low population growth. Furthermore, a substantial number of people from the area joined the transmigration schemes. Physical and socio-economic characteristics in this district and external conditions have influenced the relative position of trees in the farming systems, as discussed below.

Changes in the tree component of the farming system

Tree density on the rather small farms is often high (Table 2), not only in the home garden but also on the dry fields. This high tree density is a recent phenomenon. Key informants mentioned that at the beginning of the 1960s Gunung Kidul was almost treeless. The claimed increase in tree density was in the first place measured by comparing tree canopy cover on aerial photographs of certain sample areas taken at different times. From table 3, it can be concluded that in some areas of the subdistrict the tree cover decreased, but on balance the tree cover increased.

In the second place, field surveys and interviews were conducted on changes in home gardens in some subdistricts in Gunung Kidul (Ngawen, Patuk, Playen,

Table 3. Changes in tree canopy cover in the Patuk subdistrict per landscape type and per sample area (1973–1979 in sample area I; 1976–1981 in sample area II).

	Type of landscape											
	undulating				rolling				hilly			
	increase	no change	decrease	total	increase	no change	decrease	total	increase	no change	decrease	total
Area I												
ha	14	43	9	66	9	39	5	53	16	16	1	33
%	21	65	14	100	17	74	9	100	49	48	3	100
Area II												
ha	126	315	7	448	104	277	72	453	198	428	128	745
%	28	70	2	100	23	61	16	100	25	58	17	100

Rongkop and Tepus) during 1987/88 and on changes in the *tegal* of the same farms in 1988 (except in Ngawen), to ascertain the development of the tree component in the various cropping systems. In both surveys, farmers were asked about the number and species of trees cut and planted during the last year. In the survey of home gardens it was found that on 57% of the farms (n = 86) the number of trees in the home garden had increased and on 38 % the number of trees had decreased. From the survey of the *tegal* it can be concluded that there were more trees on the *tegal* on 58% of the farms (n = 88) and fewer on 13%. A possible explanation for the fact that on balance more farmers increased the tree density of the *tegal*, could be that the tree density in this cropping system was lower to start with.

Effect of change of resource endowment on tree growing

In a situation where land is scarce because of population growth and inelastic supply of land, it is often expected that farmers will decide not to grow many trees. Instead, they prefer to intensify food crop production, which enables them to meet subsistence needs and usually gives a higher return per hectare. From this perspective, it seems particularly likely that farmers in Gunung Kidul will refrain from growing trees, since the rural population has access to state forest land to collect dead wood to meet their energy needs. This access was not denied in the Agrarian Law of 1870. However, this situation has not occurred in the Gunung Kidul district in recent decades; instead, a considerable numbers of trees have been planted. There seem to be three reasons for this change in land use related to what can be called factor endowment.

– Technological change in upland agriculture increased subsistence food production. There is no evidence of widespread changes in the varieties of cassava – as a type of technological change similar to the one that occurred in irrigated rice production – grown on Java during the seventies (Roche, 1984). However, the use of chemical fertilizers on cassava, maize and upland rice increased considerably during the 1970s. Fertilization can give a high financial return (see Roche, 1984). As a result of this intensification, the average yield of cassava per hectare increased from about 2 to 10 tonnes per hectare during the period 1963–1988, and that of dry rice from about 0.8 to 2.5 tonnes during the same period (Nibbering, 1991). Cassava produces better on shallow soils than other crops and also lends itself better to intercropping because of the flexibility with which it can be planted and because of its ability to grow well in dry periods when other crops do poorly (Roche, 1984). It is possible that the increase in cassava and rice production per hectare reduced the pressure on the land for subsistence food production, thereby creating opportunities for other crops and for trees.

How have different farm sizes been affected by this trend, and what are the consequences for tree growing? The hypothesis that smaller farms have a lower tree density because they need a larger part of their farm for staple crops could not be confirmed. In Ngepung (Patuk district), the average tree density on farms smaller and

larger than 0.50 hectare is about the same (624 and 614 per ha respectively), although the tree densities in the home garden and on the *tegal* differed considerably (Table 2). The lack of a clear relationship between tree density and farm size might be attributable, however, to the concept of tree density being very imprecise; some trees – such as fruit trees – lead to a more labour intensive cropping system, others – such as timber species – are less labour intensive. This might also explain why it is difficult to find a clear relationship between tree density and off-farm employment. Off-farm employment can result in a shift toward tree crops in a system that can be typified as low-input, low-management forms of land use (Arnold, 1990).

According to Roche (1988), the scarce statistics on acreage suggest that tree-crop plantings in Java's uplands have resulted in a small but significant decline in the area planted to cassava and other upland crops. On the *tegal*, farmers often try to minimize competition in the resulting agroforestry system by planting tree species that have an extensive root system and compete considerably for light, e.g. mahogany (*Swietenia macrophylla*) and *jati* (*Tectona grandis*) in hedges around the plot and on the edges of the terraces. To reduce erosion these trees are often planted at a high density. Species with a thin crown or those that cause fewer problems with ploughing are often planted scattered over the field. Nitrogen-fixing trees – such as *lamtoro* (*Leucaena leucocephala*) and *turi* (*Sesbania grandiflora*) – are often sown in rows and regularly pruned/coppiced.

– The change to trees as a response to declining soil quality.
Growing trees can be an induced innovation to help maintain agricultural productivity because they may reduce erosion and enrich the soil (Scherr, 1995) or to increase the carrying capacity of the shallow soils (Carson, 1989). In general, trees need deep soils but, like cassava, some can also be grown on shallow soils. Many farmers have planted fruit trees such as cashew *(Anacardium occidentale)*, citrus (*Citrus* sp.), coconut palm (*Cocos nucifera*), *melinjo* (*Gnetum gnemon)*, mango (*Magnifera indica*) and parkia (*Parkia speciosa*) which are able to withstand dry periods and a poor soil.

– Change in the labour supply.
Employment in the manufacturing sector in Indonesia grew considerably in the 1970s and 1980s, so that a large part of the increase in the labour force could be absorbed in non-agricultural sectors (Douglass, 1987). Roche (1988) observed a labour scarcity in rice farming during the early 1980s and a subsequent rapid increase in real agricultural wages on Java. This in spite of declining oil revenues and slower growth of the industrial sector during that period.

As already mentioned, population growth was rather limited in the Gunung Kidul district largely because of out-migration and it seems likely that employment increased because the yield per hectare of annual crops increased. Whether this trend directly influenced the willingness to grow trees cannot be deduced in a simple way, but it may have influenced tree growing indirectly since it influences the feasibility of keeping livestock. Fodder collection takes up a considerable amount of the farmer's time: 3 – 4 hours a day in Ngepung. Therefore, time can be saved by growing fodder trees. One third of the trees in Ngepung are fodder trees, such as

Dalbergia latifolia, *Leuceana leucocephala*, *Sesbania grandiflora* and *Swietenia macrophylla*. Saving time may have been an important reason for farmers to plant trees (see below, however, the remark on species choice and Regreening Programme).

Influence on tree growing of changes in demand for tree products

Several factors have led to an increase of the demand for tree products. The most important are population growth, income growth and maybe a change in preference.

– Fruit.
As already mentioned, in Java the population growth outside the Gunung Kidul district has been considerable in recent decades. The increase in the urban population has been even greater (Douglass, 1987). Urbanization is expected to lead to commercialization of tree products.

Likewise, the real income per capita has increased substantially. The increase in income is favourable for the demand for some tree products; both fruit and meat – fodder trees play a vital role in meat production – have large positive income elasticities: food expenditure elasticities in Java in 1980 in urban versus rural areas were 0.89 versus 1.29 for papayas, 1.49 versus 2.32 for oranges, 1.91 versus 2.93 for meat (other than chicken) (Roche, 1988).

As a result, demand for fruits (such as bananas, papayas, mangoes, guavas and avocados) as well as for cloves and coconuts and meat increased considerably and their prices rose significantly with respect to prices for staples in the period 1976 – 1984 (Roche, 1988). This price increase has surely encouraged the propensity to plant trees. Farmers in the survey reported in Table 2, mainly planted fruit species and mainly felled timber species. Nibbering (1991) reported that in his three research hamlets, 60% to 90% of the fruits were sold in markets. Although the selling of fruits was by far the most important source of cash income in Gunung Kidul, it should be noted, however, that a considerable part of the trees on private land were planted to meet subsistence needs. Small farmers only sell fruits if they have a surplus.

– Fuelwood.
The demand for commercial fuelwood has increased significantly. The increase stems from increased demand for home consumption, as well as for fuelling tile and brick kilns and the commercial processing of coconut sugar, *tahu* and *gudeg* which are important users of fuelwood in Gunung Kidul and adjacent areas/cities. According to Dick (1980), this increase in demand and the acute deforestation have together resulted in a scarcity and a steadily rising real price of fuelwood. It is questionable, however, whether the development of fuelwood consumption has greatly influenced tree planting by farmers. Despite its relative increase, the price is still too low to make fuelwood production profitable. Although many of the tree species planted, are quantitatively and qualitatively excellent fuelwood producers, the main purpose of growing them is not for fuelwood. Fuelwood for subsistence consumption

can be provided by pruning perennials growing on the farm, supplemented by agricultural waste like maize and cassava stalks and leaves. In Gunung Kidul (and elsewhere on Java) commercial fuelwood stems largely from (illegal) cutting by the villagers – often landless people – in the state-owned forests. Fuelwood supplied in this way only involves the costs of collection and transport. The production of fuelwood on the farmers' own land also implies establishment and maintenance costs and the opportunity costs of the land. Supply from the farmers' own land is only financially attractive if this occurs in the form of multiple use.

Farmers in the Gunung Kidul district receive a relatively small part of the retail price of woodfuels. According to research in four villages in Gunung Kidul this was only 38% for fuelwood and 44% for charcoal. This is very low compared to soybeans (80–85%) and maize (60–65%) (Anonymous, 1987). Not only the relatively high transport costs but also the high profit margins for traders contribute to this low margin for the fuelwood 'producer'. Despite the low price, 28% of the farmers in these villages on average had sold fuelwood in the last year; the highest figure (41%) was found in Patuk village which has a state-owned forest nearby, and the lowest in Tepus village (13%) which has no state-owned forest nearby. This is in accordance with the outcome of a logit analysis (Pindyck & Rubinfeld, 1991) with data on wood-selling activities in the four villages mentioned. This analysis not only shows that the distance to state-owned forests negatively affects wood-selling, but also that the presence of a wood-consuming industry within the household and off-farm employment negatively influence the probability of selling wood. It was estimated that the contribution of fuelwood selling to income is on average Rp. 37,600 annually or almost 7 % of the total annual income. In the Patuk village – with a nearby state-owned forest – however, this percentage amounts to almost 19.

However, the price of tree products is not only influenced by market forces but also by government policies, as will be discussed in the next section. This has made cropping systems with trees more profitable. In Gunung Kidul, the revenues per hectare and per annum for *sawah*, *tegal* and home garden was Rp 202, Rp 216 and Rp 245 thousand respectively (Anonymous, 1984b). Roche (1988) reports net returns per crop in 1984–85 of Rp 200 – 450 thousand for irrigated rice and <Rp 260 thousand for cassava and a net income of Rp 900 –2,000 thousand per hectare for fruits (orchards of apples, grapes and mangoes). These figures for tree-based cropping systems undoubtedly result in a wider application of these systems which may also be favourable to soil conservation.

Institutional factors that influence tree growing

An extraordinarily important institutional factor influencing tree growing is tenure (Cernea, 1992). Because there are no indications that changes of this institution may have influenced tree planting during the period concerned, it will not have attention here. At least three instruments have been applied by the Indonesian government which potentially influence tree growing, namely the Regreening Programme, pricing/trade policies and infrastructural policies.

– The Regreening Programme.

Severe soil erosion and its consequences for the productivity in the uplands as well as elsewhere, induced the Indonesian government to implement a soil conservation programme in the 1960s. In 1975, this programme was continued as an INPRES (INstruction of the PRESident) programme, known as the Reforestation and Regreening Programme. The former aimed at conservation of public land, the latter at conservation of private land. In the latter programme – *penghijauan* – farmers are assisted in the application of measures to vegetate land and to build erosion-control constructions.

The endangered resources also induced the Indonesian government to set up several research programmes. The government-sponsored introduction of new tree growing practices on Java stem partly from the effects of several watershed management research projects, like the FAO-funded Solo project and the Dutch-funded Kali Konto project. The latter project included both research aimed at innovation in tree growing on private land and in tree growing by farmers on state-owned land.

Changes in forest land-use can also be considered as having been induced, at least partially, by the results of research on agroforestry. The International Centre for Research on AgroForestry (ICRAF) in Nairobi was set up to design agroforestry land management systems (Raintree, 1987). Several Indonesian research institutes and universities have worked in this field in Gunung Kidul, sometimes in collaboration with NGO's (e.g. Foster Parents Plan) and other donor organizations (Wiersum, 1994).

The goal of the Regreening Programme was initially to plant trees on ridges constructed on private land at a density of 400 trees per hectare. Species that give a quick return (within five years) were to be used. Seedlings were provided free by the programme and at the beginning of INPRES farmers received a grant of Rp 4750 per ha (if 400 trees per hectare were planted). As a consequence of this goal the programme focused on the *tegal* and fuelwood/fodder species. *Calliandra* spp. were especially recommended. The area planted under this programme is considerable (for an overview of the realization in the Five Year Plans I, II and III see Anonymous, 1984b), but questions have been raised (within the government agencies involved too) about their effectiveness with respect to soil conservation (Pickering, 1979). One of the criticisms is the centralization of the decision-making in the programme. A danger of this type of decision-making is that the farmers' wishes and needs are not recognized. In Gunung Kidul species, such as cashew, were (re)introduced by the programme although the farmers did not favour this species because of its low yield and extensive roots, but the programme did not supply popular species, neither fruit species nor timber species for construction wood. This could be because long rotation species do not give a return within five years. The success of *penghijauan* could have been increased initially if there had been more emphasis on fruit species, since many farmers preferred to plant fruit trees. As already noted, farmers mostly cut less valuable timber species and mostly planted both fruit species and valuable timber species such as *jati* and *mahogany*. The reason that the programme initially mainly provided fuelwood/fodder species probably has to do with the fact that the programme was implemented by the Directorate/Ministry of Forestry. Maybe that 'pro-

motion of tree growing on farms was seen to be necessary in order to create new wood stocks where they were readily accessible to the main body of users, thereby reducing pressure on remaining forests ...' (Arnold, 1995). The programme is currently coordinated by the Ministry of Home Affairs and other ministries are involved and fruit species are now also provided. Nowadays fruit species are also frequently planted on the *tegal*.

Important questions are to what extent tree planting has been stimulated by the Regreening Programme and whether a grant is an effective incentive. It seems likely that a grant will be important since income in the Gunung Kidul district is very low compared with elsewhere on Java (Roche, 1984). This income just exceeds the expenditure on necessities. The grant, however, was only sufficient to cover the cost of labour for planting and maintenance. Poor farmers can be expected to have a high discount rate, which means that they cannot afford to forego the revenue from the crops replaced and the competition between the planted trees and annual crops, and cannot wait a long time for revenue from trees. These costs are not included in the grant and may have deterred farmers from participating and from maintaining the trees planted and the ridges constructed. Reports of a high mortality rate of the planted trees and neglect of the ridges are common. It has already been mentioned that planting trees for fuelwood is not very attractive because of the relatively low price of fuelwood. This low price may also have contributed to the species choice.

The conclusion that farmers cannot afford to wait a long time for revenue from trees seems to contradict the earlier observation that farmers in the area prefer to grow the long rotation species *jati*. Price expectations (the price of *jati* has increased considerably in recent decades) can be an important explaining factor.

The figures on the origin of the seedlings planted during one year indicate the importance of government assistance in seedling supply is relatively limited. Only 15% and 24% of the seedlings planted in the home garden and *tegal* respectively were obtained from a government agency. Most seedlings come from relatives, neighbours and the market. Farmers turned to the government mainly for seedlings of fruit species, and many respondents stated that they would like to obtain assistance in this respect in the future.

The preceding comments do not imply, however, that the Regreening Programme has to be assessed as being of limited importance for tree growing on private land. The mass movement, in which farmers could not always refrain from accepting seeds/seedlings, has given farmers the opportunity to experience the beneficial functions of trees and to experiment with tree growing. Nowadays, seedlings of a wide assortment of species are available in the villages. In the Gunung Kidul district, the fact that a forester was the district head in the period 1973 – 1981 may have contributed to the results of the programme.

– Trade/pricing policy.

The rather high government subsidies on inputs – about 38% for fertilizers, more than 40% for pesticides and an implicit rate of 8% for credit (Anonymous, 1987) – have changed the relative profitability of perennials and annuals. According to Roche (1984), a change in fertilizer prices has a greater impact on cassava than on

other crops and if world prices for fertilizer were to prevail, it would not be attractive to use chemical fertilizers in Gunung Kidul. Tree growing could have been more attractive with world prices for chemical fertilizers. On the other hand, the use of chemical fertilizers and the availability of relative cheap credit have increased the supply of staple crops, thereby permitting farmers to plant a larger part of their land with other crops such as tree crops.

Not only market development but also the trade and pricing policy of the Indonesian government during the late 1970s and the early 1980s encouraged tree growing by upland farmers in Gunung Kidul. According to Pearce *et al.* (1990), the terms of trade for paddy rice have declined sharply and these for secondary food crops, like cassava, maize, soybeans, groundnuts and other legumes have risen only marginally, except for more significant increases in central Java. It should be mentioned, however, that in 1985 and again in 1987 the price of cassava doubled in response to domestic shortages and the EEC export quotas. Further, the effective protection rates of fruits have to be mentioned. During the period 1976 –1984 their prices rose considerably compared to those of staple crops (Roche, 1988). The figures given by Roche (1988) also show a similar increase in the price of coconut (and to a lesser extent that of cloves) during that period. As mentioned earlier, it was these species that the farmers in Gunung Kidul planted.

In the foregoing, it was concluded that the price of fuelwood is too low to encourage farmers to plant trees primarily to supply fuelwood. This low price may also be partly caused by the price subsidy on kerosene. Kerosene can also be used for cooking and thanks to this subsidy it is a cheap substitute for fuelwood. Dick (1980) estimates that in 1980 in Yogyakarta cooking on charcoal or fuelwood was almost twice as expensive as cooking on kerosene. Therefore in urban areas kerosene not only has the advantage of being a cleaner and more reliable source of energy for cooking, but it is also cheaper. Although there had earlier been a subsidy on kerosene, it was not until the late 1970s that it was argued that a higher kerosene price would encourage the use of wood-based fuel and hence would aggravate the deforestation problem (Dick, 1980). If abolishing the price subsidy on kerosene would cause its cost per unit of energy to be higher than that of fuelwood, it seemed probable that poorer people in urban areas would switch to fuelwood for cooking, resulting in an increase in the demand for fuelwood. If this demand could be met from increased collection from state-owned land, the influence on the fuelwood price would be limited, but accelerated deforestation of state-owned forests would be a consequence, at least in the short run. But in the long run, if the timber stock in state-owned forests had been exhausted, the increased demand could lead to a higher price of fuelwood which could induce farmers to grow fuelwood on private land (see Dick, 1980).

– Infrastructure.

It can be expected that a good infrastructure has a favourable effect on marketing of bulky and perishable products such as fruits and that this will stimulate tree planting. Results of research on tree density in three hamlets that varied in their accessibility and distance to a market illustrate this positive effect (Table 4). Mertelu has only been accessible by car for some years, since the construction of a bridge, and is fur-

Table 4. Size, number of (tree and other plant) species and number of trees per hectare (with a diameter of five cm or more) in home garden, upland dry fields and wet rice fields in three hamlets in the Nglipar subdistrict of Gunung Kidul; number of respondents within brackets.

Hamlet	Home garden			Upland dry fields			Wet rice fields			Total		
	size in ha	no. of species	trees per ha	size in ha	no. of species	trees per ha	size in ha	no. of species	trees per ha	size in ha	no. of species	trees per ha
Watugajah(26)	0.13	170	1190	0.51	62	652	0.05	12	203	0.69	175	343
Banyu(24)	0.31	182	1033	0.54	88	532	0.19	51	349	1.04	188	701
Mertelu(50)	0.25	232	791	0.41	90	279	0.41	73	321	1.07	247	392

thest from markets. Watugajah is situated close to towns with a market and is linked to them by an asphalted road. Banyu can also be reached over an asphalted road but is further from towns. Table 4 shows that the hamlets with a better infrastructure (Watagajah and Banyu) have a higher tree density than the hamlet with a poor infrastructure, both in the home garden and *tegal*. The question of whether this higher tree density may be wholly ascribed to a better infrastructure and not, for instance, to the larger area with *sawah* in Mertelu, is difficult to answer.

In table 4, the difference in the number of species is also striking. This number is lower in the hamlets with a better infrastructure. The reason for this difference may be that species with a low commercial value are removed. Especially the number of tree species that have only a wood production function is lower in Watugajah (39) than in Banyu (65) and Mertelu (77).

The physical infrastructure has improved considerably in recent decades in the Gunung Kidul district and consequently the number of cars has increased. But the road density (km/km^2) is still low compared to other districts within the Yogyakarta Special Province (Anonymous, 1989). However, a relatively large proportion of the roads in the Gunung Kidul district are paved (asphalt or macadam). The results of the abovementioned research suggest that improvement of the road network is necessary for the further development of commercial agroforestry in this district.

Discussion

Various studies have demonstrated that the growing of trees on private land by the generally very poor farmers in the Gunung Kidul district has increased in recent decades. This trend is apparent both in home gardens and on the *tegal*. Nowadays, the tree density on the *tegal* is often considerable too. However, research findings suggest that the increase in tree growing was least in areas that most need protection against erosion. Similar trends have been observed for other erosion control measures too (De Graaff & Wiersum, 1992).

The increase in tree growing on private land in recent decades in the Gunung Kidul district, in spite of population growth, has been described as an adaptive

process to a change in factor endowment, demand for products and institutional factors. The increased tree growing has partly to be considered as merely an adjustment of the product mix and the adoption of techniques of tree growing that are already known, but it has certainly involved technological change induced by changing resource endowments and by institutional innovation. Cultural factors may also have contributed to the increased interest in tree growing. E.g. some farmers give as their reason for tree planting that 'everybody does'. The latter may also have a political background. Beckford (1984) points to the lack of social and political dimensions as a shortcoming of the induced innovation model of development. One political factor that has certainly affected tree growing – the possible influence of the district head – has already been mentioned; the possible influence – whether positive or negative – of village heads can be added to this.

Although elements of the induced innovation model have been used as framework for analysis, it does not mean that the validity and reliability of this model has been tested. The difficulty of empirical verification is an important element of the criticisms levelled at this theory (Beckford, 1984; Olmstead & Rhode, 1993; Silvis, 1994). The factors that have affected the increase in tree growing have been studied more closely. Analysis of the results suggests that market trends and governmental trade/pricing policy have considerably influenced the farmers' decisions about tree growing. For many farmers, augmenting their cash income was an important reason for planting trees. This contrasts with what Gilmour (1987) suggests for Nepal, namely that farmers' subsistence need for tree products (fuelwood and fodder) induced them to grow trees. Trees planted on private land had to supply the tree products formerly supplied by the communal forest. Elsewhere, however, responses to market forces are also considered to be an important factor for tree planting on private land. Michon & Mary (1994) have described the increased specialization on commercially attractive elements of home gardens in West Java. In several parts of India farmers have replaced fruit species by Eucalyptus trees for pulp and poles, which has led to considerable economic and social problems (Saxena, 1992; Vandana Shiva *et al.*, 1982). No such development has taken place in the Gunung Kidul district. Here, the increased interest in tree growing will have led to a diversification of the sources of agricultural income, a diversification of the diet and increased food security. An adverse influence on employment could be avoided.

Although in general farmer's interest in tree growing in the uplands of Java is increasing, the factors that have triggered that interest may differ in nature and intensity from those influential in Gunung Kidul. Infrastructure is one factor – that is already a cause of difference within the Gunung Kidul district – site condition is another. Elsewhere on Java, e.g. in the Dieng Plateau which has more fertile soils, farmers have specialized in cash crops like vegetables and tobacco and removed trees (Berenschot *et al.*, 1988).

The increase in the supply of agroforestry products to the market in this area could have led to investment in small-scale forest-based industries, through which 'agroforestry is a key sector for rural diversification' (Barghouti *et al.*, 1990). Manning (1988) concludes for Java that 'the spinoff in employment creation in rural areas as a consequence of the green revolution has probably been remarkably small'.

Observations in the Gunung Kidul districts show that there is a small-scale forest-based industry, but that its development is hampered by competition with substitute raw materials and a lack of managerial skills. Its development may further be hampered by institutional aspects. To discourage illegal cutting, private conversion of teak into furniture or boards is not permitted within nine miles of the forest borders and in villages enclosed by the forests (Peluso, 1992). It has been mentioned that in several villages farmers have planted a large number of teak trees.

Lastly, the question arises of whether the results of this research support the conclusion reached by Pearce and Warford (1993) that '... poverty does not necessarily in and of itself lead to environmental degradation'. On one hand, it has been concluded that the increased interest in tree growing on private land in this very poor district will have reduced erosion. On the other hand, it has been observed that the development of agroforestry in the more accessible hamlets has reduced the number of tree species on private land. In addition, although soil erosion will have been reduced, it is still a serious problem in the Gunung Kidul district. Therefore, research is necessary on interventions that contribute to a further reduction of the environmental degradation resulting from land use and management. Policies that aim at increasing tree planting by farmers should be based not only on socio-economic aspects resulting from farming system analysis, but also on the study of the farmers' knowledge system and their behaviour with respect to tree planting, since farmers have to be recognized as an important source of innovation.

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