FACTORS WHICH DETERMINE THE SUCCESS OF REGREENING IN GUNUNG KIDUL, CENTRAL JAVA

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ISHEMAT SOERIANEGARA & MANSURI. 1994. Factors which determine the success of regreening in Gunung Kidul, Central Java. This investigation was carried out in 39 sample villages located in 13 districts of Gunung Kidul Regency, Yogyakarta Province, Central Java. Tree species used in the regreening programme were *Tectona grandis, Acacia auriculiformis, Paraserianthes falcataria, Anacardium occidentale* and *Swietenia mahagoni*. The highest percentage of success was reached by *Tectona grandis* (54.6%), followed by *Acacia auriculiformis* (51.6%), *Anacardium occidentale* (49.9%) and *Swietenia mahagoni* (44.6%). The least successful species was *Paraserianthes falcataria* (36.5%). The species most preferred by the villagers were *Tectona grandis* and *Acacia auriculiformis* (each preferred by 37.8% of villagers sampled), followed by *Paraserianthes falcataria* (13.9%) and *Swietenia mahagoni* (10.3%). No villagers expressed a preference for *Anacardium occidentale*. A multiple linear regression analysis showed that success in the regreening programme was influenced by the following factors: elevation, slope, effective soil depth, rockiness, the productivity of the degraded land, the percentage of regreened land, distance to the regreening site, road density, volume of fuelwood collected, and the per capita income of the villagers.

Key words: Regreening - Indonesia - plantations - *Tectona grandis* - *Acacia auriculiformis* - *Swietenia mahagoni* - *Anacardium occidentale* - *Paraserianthes falcataria*

ISHEMAT SOERIANEGARA & MANSURI. 1994. Faktor-faktor yang menentukan kejayaan penghijauan di Gunung Kidul, Java Tengah. Kajian ini dijalankan di 39 kampung sampel di 13 daerah di Gunung Kidul Regency , Wilayah Yogyakarta, Java Tengah. Spesies pokok yang digunakan dalam program penghijauan semula ialah *Tectona grandis, Paraserinthes falcataria, Anacardium occidentale* dan *Swietenia mahagoni*. Peratus kejayaan yang paling tinggi dicapai oleh *Tectona grandis* (54.6%), diikuti dengan *Acacia auriculiformis* (51.6%), *Anacardium occidentale* (49.9%) dan *Swietenia mahagoni* (44.6%). Spesies yang paling tidak berjaya ialah *Paraserianthes falcataria* (36.5%). Spesies yang paling disukai oleh penduduk-penduduk kampung ialah *Tectona grandis* dan *Acacia auriculiformis* (setiap satu disukai oleh 37.8% dari sampel penduduk), diikuti dengan *Paraserianthes falcataria* dan *Swietenia mahagoni* (10.3%). Tiada penduduk yang menunjukkan keinginan untuk *Anacardium occidentale* . Analisis regresi linear berganda menunjukkan bahawa kejayaan dalam program penghijauan semula telah dipengaruhi oleh faktor-faktor berikut: ketinggian, kecerunan, kedalaman tanih yang efektif, keadaan tanih yang berbatu-bata , produktiviti tanah ternyahgred, peratus

tanah yang dihijaukan semula, jarak kawasan penghijauan semula, densiti jalan, isipadu kayu api yang dipungut dan pendapatan per kapita penduduk kampung.

Introduction

The Gunung Kidul Regency is an area of 148 513 ha in Central Java. Before 1975 55% of the Regency was classified as highly degraded due to land clearing and erosion which led to high levels of sedimentation of the rivers. Between 1976 and 1984 a total area of 77 659 ha was planted with about 31 million trees.

This study investigated the following questions:

- What is the percentage of survival of each species used in the regreening programme?
- What factors determine the percentage of success of each species?

Materials and methods

The study area

The Gunung Kidul Regency is situated southeast of the city of Yogyakarta, between latitude 7 ° 46' - 8 ° 09' S and longitude 110 ° 30' - 110 ° 50' E. The Regency encompasses 13 districts and 144 villages.

Climate

Average monthly rainfall in the area is shown in Figure 1. In general the area experiences five or six wet months (> 200 mm rainfall/month) and five or six dry months (<100 mm rainfall/month). Average annual rainfall is 1991 mm, with most rain falling between November and April.

Relief and soils

Elevation varies from sea level to 831 m a.s.l.; however, most of the study area (90.3%) lies between 100 and 500 m a.s.l. Slopes in the study area are given in Table 1. In the northern part of the region there are a number of parallel ridges of andesitic and dacitic conglomerates, tuffs, sandstones, marine sandstones and shales. To the south are limestone hills. Between the two hill regions lies the Wonosari valley, a transition region of alternating strata of andesitic tuff-sandstones, vitreous tuffs, tuffaceous marls and clays, limestone breccias and conglomeratic limestones (Dames 1955). Lithosols cover 68% of the Regency, followed by Red-Yellow Mediterranean (17.4%), Grumusol (7.4%), Latosol (3.7%) and Renzina (3.3%). Other soils types such as Alluvial and Regosol cover only 0.05% and 0.03% of the area respectively (Directorate of Land Use 1984).

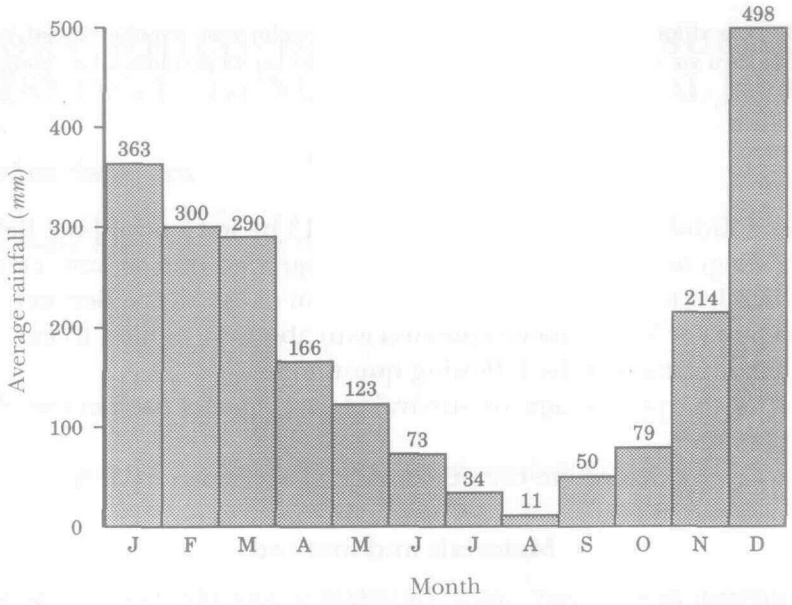

Figure 1. Average monthly rainfall at Gunung Kidul

Table 1. Slopes of the study area

Slope (%)	Extent (ha)	% of total area
0 - 2	28 623	19.3
2 - 15	38 941	26.2
15 - 40	57 293	38.6
> 40	23 656	15.9
Total	148 513	100.0

Source: Directorate of Land Use 1984.

Land use

Because of the rockiness of the area, only one third of the Regency is cultivable (Soedarwono 1975). Annual as well as perennial corps are planted between the rocks.

Hypotheses

Two hypotheses were proposed, namely:

1. Level of success of the regreening programme is determined by the choice of species;
2. Level of success of the regreening programme is determined by physical as well as socio-economic factors.

Data collection

Tree species used in the regreening programme were *Tectona grandis, Acacia auriculiformis, Paraserianthes falcataria, Anacardium occidentale* and *Swietenia mahagoni.* Plantations were established in 1981 and 1982. Data collection was carried out between May and August 1987. Three sample villages were chosen from each of the thirteen Districts, giving a total of 39 sample villages. Villages were chosen on the basis of the diversity and extent of plantations. In each village, 10% of the families participating in the regreening program were sampled. Families were first grouped according to the tree species planted, then 10% of each group were randomly selected. A total of 272 families were selected. Variables collected are summarised in Table 2.

Table 2. Variables which might influence the success of the regreening programme in Gunung Kidul Regency

No.	Variable	Symbol	Unit
1	Success of regreening plantation	Y	%
2	Elevation above sea level	X_{01}	m
3	Average annual rainfall	X_{02}	mm
4	Slope	X_{03}	%
5	Effective soil depth	X_{04}	cm
6	Rock coverage	X_{05}	%
7	Cattle density	X_{06}	no. ha^{-1}
8	Population density	X_{07}	persons km^{-2}
9	Size of land holding	X_{08}	ha $family^{-1}$
10	Productivity of non-plantation land	X_{09}	Rp ha^{-1} y^{-1}
11	Plantation land as a proportion of total land owned	X_{10}	%
12	Distance between plantation & village	X_{11}	km
13	Road density	X_{12}	km km^{-2}
14	Fuelwood collection per villager	X_{13}	m^3 y^{-1}
15	Distance between plantation & demonstration plot	X_{14}	km
16	Population size	X_{15}	% of total
17	Security of income	X_{16}	% of pop. in Govt. service
18	Income per capita	X_{17}	Rp y^{-1}

The percentage of success was calculated as follows:

1. The number of surviving plants was counted using a hand counter;
2. The percentage of success was obtained by dividing the number of surviving plants by the total number of seedlings planted.

Levels of success were determined as follows:

> 80%: very successful (vs)
60 - 79%: successful (s)
40 - 59%: rather successful (rs)
20 - 39%: less successful (ls)
< 20%: unsuccessful (us)

Results and discussion

Level of success of the regreening programme

The results of the inventory of the regreening plantations are presented in Table 3.

Table 3. Level of sucess of the regreening programme in each sample village

Village	*Paraserianthes falcataria*		*Swietenia mahagoni*		*Anacardium occidentale*		*Acacia auriculiformis*		*Tectona grandis*	
	A	B	A	B	A	B	A	B	A	B
1	12.5	us	-	-	22.5	ls	71.8	s	-	-
2	87.5	vs	-	-	90.0	vs	91.3	vs	-	-
3	38.3	ls	-	-	57.6	rs	59.3	rs	-	-
4	50.5	rs	-	-	40.3	rs	77.5	s	-	-
5	70.0	s	-	-	39.5	ls	58.3	rs	-	-
6	72.8	s	-	-	47.5	rs	75.0	s	-	-
7	55.0	rs	25.5	ls	32.9	ls	25.0	ls	-	-
8	18.0	us	42.0	rs	52.5	rs	80.0	vs	-	-
9	-	-	38.8	ls	45.0	rs	-	-	-	-
10	12.0	us	-	-	43.8	rs	39.8	ls	-	-
11	28.5	ls	-	-	49.2	rs	50.0	rs	-	-
12	14.0	us	-	-	38.5	ls	-	-	-	-
13	18.0	us	52.0	rs	63.3	s	53.0	rs	26.0	ls
14	68.0	s	43.9	rs	56.8	rs	46.7	rs	59.8	rs
15	27.5	ls	30.3	ls	60.3	s	34.4	ls	35.2	ls
16	27.5	ls	-	-	48.5	rs	33.3	ls	-	-
17	43.8	rs	-	-	55.0	rs	27.5	ls	-	-
18	15.0	us	-	-	25.0	ls	38.0	ls	-	-
19	-	-	-	-	-	-	40.2	rs	35.7	ls
20	-	-	76.0	s	-	-	46.0	rs	58.3	rs
21	-	-	-	-	-	-	27.8	ls	42.5	rs
22	-	-	80.0	vs	-	-	-	-	83.3	vs
23	-	-	52.5	rs	-	-	-	-	71.0	s
24	-	-	55.5	rs	-	-	-	-	85.4	vs
25	-	-	34.0	ls	-	-	43.2	rs	43.2	r
26	-	-	40.6	rs	-	-	33.4	ls	30.0	ls
27	-	-	40.3	rs	-	-	59.5	rs	45.5	rs
28	-	-	50.0	rs	-	-	72.6	s	62.2	s
29	-	-	25.3	ls	-	-	62.9	s	55.8	rs
30	-	-	75.0	s	-	-	52.4	rs	49.7	rs
31	-	-	49.7	rs	-	-	75.0	s	50.0	rs
32	-	-	43.8	rs	-	-	60.0	s	50.0	rs
33	-	-	43.8	rs	-	-	-	-	63.4	s
34	62.5	s	14.0	us	65.0	s	20.0	us	75.0	s
35	16.7	us	22.5	ls	46.4	rs	25.8	ls	50.0	rs
36	5.0	us	45.0	rs	69.9	s	32.5	ls	35.0	ls
37	-	-	27.0	ls	-	-	39.9	ls	62.5	s
38	-	-	28.5	ls	-	-	59.9	rs	48.2	rs
39	-	-	78.0	s	-	-	90.8	vs	87.6	vs

A = Survival rate (%);
B = Level of success: vs - very successful; s - successful; rs - rather successful; ls - less successful; us - unsuccessful.

Paraserianthes falcataria

Survival percentage ranged between 5.0% in a region of drier climate (six dry months, Red-Yellow Mediterranean soil) to 87.5% in a village with a wetter climate (four dry months, Red Latosols).

Swietenia mahagoni

Survival ranged from 14.0% (six dry months, Red-Yellow Mediterranean soil) to 80.0% (five dry months, Red-Yellow Mediterranean soil).

Anacardium occidentale

Survival percentage ranged from 22.5% (four dry months, Grumusol) to 90.0% (four dry months, Red Latosol).

Acacia auriculiformis

Percentage survival ranged from 20.0% (six dry months, Red-Yellow Mediterranean soil) to 91.35 (four dry months, Red Latosol).

Tectona grandis

Percentage survival ranged from 26.0% (six dry months, Grumusol) to 87.6% (five dry months, Red-Yellow Mediterranean soil).

Table 4 presents average success rate over the whole Regency for the various species. The Table shows that *Tectona grandis* had the highest percentage of survival, and *Paraserianthes falcataria* had the lowest. *P. falcataria* grew faster than the other species and hence was harvested earlier. Trees planted on slopes and hill tops grew more slowly than did trees planted at the foot of hills and on relatively flat areas. This was probably due to the shallower effective soil depth on slopes and hill tops.

Table 4. Average success rate of the regreening species over the whole study area

Species	Average percentage of success/survival	Level of success
Tectona grandis	54.6	rs
Acacia auriculiformis	51.6	rs
Anacardium occidentale	49.9	rs
Swietenia mahagoni	44.6	rs
Paraserianthes falcataria	36.5	ls

Factors which determine the success of plantations

A multiple linear regressions analysis between the percentage of survival and the 17 independent variables (Table 2) showed multiple colinearities among the variables. Therefore a principal components analysis was conducted to group the highly correlated independent variables. This produced five principal components (Table 5). These components became the new independent variables.

A multiple linear regression analysis was carried out to check the relationship between the principal components and the percentage of success. The following equations were produced:

(1) For *Paraserianthes falcataria*:

$$Y = 35.531 + 18.607\ P1^* - 1.436\ P2 + 0.042\ P3 + 1.215\ P4 - 3.541\ P5$$

with a coefficient of determination (r^2) = 0.5845. The first principal component (P1) was correlated positively and significantly (at 1% level) with the percentage of survival.

(2) For *Swietenia mahagoni*:

$$Y = 44.573 + 20.261\ P1^* - 2.488\ P2 + 2.246\ P3 - 2.862\ P4 + 3.414\ P5$$

with $r^2 = 0.6582$.

(3) For *Anacardium occidentale*:

$$Y = 49.972 + 21.907\ P1^* - 0.513\ P2 + 0.896\ P3 + 0.466\ P4 - 1.248\ P5$$

with $r^2 = 0.8386$.

(4) For *Acacia auriculiformis*:

$$Y = 51.603 + 19.026\ P1^* - 6.790\ P2 + 0.236\ P3 + 5.791\ P4 - 0.968\ P5$$

with $r^2 = 0.6486$.

(5) For *Tectona grandis*:

$$Y = 54.601 + 26.558\ P1^* - 0.272\ P2 + 4.613\ P3 - 3.126\ P4 + 1.175\ P5$$

with $r^2 = 0.8138$.

From the above five equations, it is obvious that only the first principal component (P1) correlated positively and significantly with the survival percentages of the trees. The principal component P1 consists of (see Table 5): elevation (m.a.s.l.), slope (%), effective soil depth (cm), rock cover (%), the productivity of the ungreened land (Rp $ha^{-1}y^{-1}$), the percentage of the ungreened land (% of land

owned by the villager), the distance from the regreened area to the village (km), road density (km/km^{-1}), fuelwood collection per villager ($m^3 y^{-1}$), and the villager's income (Rp y^{-1}). The ten variables, as a group, determined the survival rate of the five tree species planted.

A multiple linear regression was conducted to investigate the relationship between each independent variable and survival rate. The result is presented in Table 6.

From Table 6 it is obvious that the ten variables of the principal component P1 are significantly correlated with the survival rate. The role of each variable may be explained as follows:

(1) Elevation above sea level (X01)

At higher elevations population density is lower and sites are more difficult to access, hence the plantations are less likely to be disturbed.

(2) Slope (X03)

Steeply sloping land is not favoured for agriculture, hence there is less competition between agricultural crops and the tree plantations.

(3) Effective soil depth (X04)

Deeper soils are a more favourable medium for plant growth.

(4) Rock cover (X05)

Rocky areas are not in demand for crop growing and hence there is less competition for the land.

(5) Productivity of the ungreened lands (X09)

Higher productivity from non-plantation land means that the villager is not pressured to convert the plantation land to agriculture.

(6) Percentage of land which is regreened (X10)

The smaller the percentage of regreened land the higher the success of regreening because the villager has more land for crop growing and hence has sufficient income to leave the plantations undisturbed.

(7) Distance to the village and the location of the plantation (X11)

The further the distance from the village,the less interest the villager has in growing crops and thus competition between agricultural crops and the plantations is reduced.

(8) Road density (X12)

Higher road density means that villagers can readily travel to other areas to work and so the plantations are less disturbed.

Table 5. Grouping of 17 independent variables into five principal components

Principal component	Tree species used for regreening				
	P. falcataria	*S. mahagoni*	*An. occidentale*	*Ac. auriculiformis*	*T. grandis*
P1	X01 (+0.89809)	X01 (+0.85612)	X01 (+0.92373)	X01 (+0.71609)	X01 (+0.90401)
	X03 (+0.96683)	X03 (+0.94497)	X03 (+0.98160)	X03 (+0.86557)	X03 (+0.97271)
	X04 (+0.88244)	X04 (+0.56565)	X04 (+0.62425)	X04 (+0.84436)	X04 (+0.86623)
	X05 (+0.92870)	X05 (+0.93477)	X05 (+0.95130)	X05 (+0.73159)	X05 (+0.96072)
	X09 (+0.74562)	X09 (+0.74276)	X09 (+0.94990)	X09 (+0.86605)	X09 (+0.95435)
	X10 (-0.95495)	X10 (-0.83723)	X10 (-0.92654)	X10 (-0.76674)	X10 (-0.92128)
	X11 (+0.83970)	X11 (+0.73804)	X11 (+0.92781)	X11 (+0.62168)	X11 (+0.92216)
	X12 (-0.88870)	X12 (+0.83742)	X12 (-0.92327)	X12 (-0.53722)	X12 (-0.76240)
	X13 (+0.95829)	X13 (+0.94824)	X13 (+0.98146)	X13 (+0.87439)	X13 (+0.94921)
	X17 (+0.95849)	X17 (+0.92010)	X17 (+0.97748)	X17 (+0.82241)	X17 (+0.96041)
P2	X07 (+0.73886)	X07 (+0.72475)	X07 (+0.72403)	X07 (+0.73595)	X07 (+0.66435)
	X08 (+0.89583)	X08 (+0.86576)	X08 (+0.88679)	X08 (+0.85696)	X08 (+0.89487)
P3	X02 (+0.77936)	X02 (+0.81714)	X02 (+0.84198)	X02 (+0.84104)	X02 (+0.79796)
	X14 (-0.70851)	X14 (-0.68474)	X14 (-0.62718)	X14 (-0.64174)	X14 (-0.67949)
	X15 (+0.63447)	X15 (+0.59396)	X15 (+0.60871)	X15 (+0.56965)	X15 (+0.64403)
P4	X16 (+0.95427)	X06 (+0.75402)	X16 (+0.91651)	X16 (+0.90944)	X06 (+0.94073)
P5	X06 (+0.94783)	X16 (+0.90733)	X06 (+0.95100)	X06 (+0.84119)	X16 (+0.95806)

Note: For the explanation of the 17 variables, see Table 2.

Table 6. Multiple regression analysis between the percentage of success and the ten independent variables

	Tree species used for regreening				
	T. grandis (Y)	*Ac. auriculiformis* (Y)	*An. occidentale* (Y)	*S. mahagoni* (Y)	*P. falcataria* (Y)
Constants	9.58417	4.12486	6.08703	6.78532	16.22534
X01	+0.01729*	+0.01793*	+0.01151*	+0.01428*	+0.01153*
X02	+0.00329	+0.00223	+0.00020	+0.00013	+0.00115
X03	+0.09231*	+0.10175*	+0.09460*	+0.09059*	+0.09003*
X04	+0.14974*	+0.11041*	+0.06766*	+0.10910*	+0.06803*
X05	+0.08062*	+0.04820*	+0.08834*	+0.07842*	+0.06408*
X06	-3.44261	+2.40570	-3.72829	+0.58460	-9.92294
X07	-0.23934	-0.18755	-0.26673	-0.46622	-0.94595
X08	+0.00380	-0.00600	-0.00174	-0.00094	-0.00258
X09	+0.00025*	+0.00028*	+0.00024*	+0.00021*	+0.00023*
X10	-0.13379*	-0.06450*	-0.12432*	-0.13119*	-0.09350*
X11	+5.17344*	+6.10138*	+3.92839*	+2.30486*	+2.84637*
X12	+1.90633*	+1.06218*	+3.06523*	+1.97399*	+2.06636*
X13	+0.11673*	+0.11374*	+0.10774*	+0.10263*	+0.09596*
X14	-0.15954	+0.10780	+0.01565	-0.05329	-0.05713
X15	+1.29438	-0.49090	+0.21878	+0.91938	-0.59617
X16	-0.22216	+1.71407	-0.80243	-1.32584	-0.11498
X17	+0.00027*	+0.00031*	+0.00019*	+0.00024*	+0.00024*

Note: * Significant at 1% level;
For the explanation of the independent variables, see Table 2.

(9) The amount of fuelwood collection (X13)
Village people collect branches from the plantations for use as fuel. Hence, higher amounts of fuelwood indicate greater success of the plantations.

(10) Income per capita (X17)
A higher income means that the villager will not need to disturb the plantations.

The socio-economic conditions of the village people strongly influence their behaviour with regard to the regreening plantations. The plantations are on lands on which they depend for their livelihood. On average each family only owns 0.87 ha. They are therefore confronted with two options: to fulfil their basic needs by growing agricultural crops, or to grow the regreening plantations. It appears that villagers have recognised the importance of the regreening programme, because plantations have been well kept on steeper slopes, at higher elevations and on rockier soil. A compromise would be to promote agrisilviculture by identifying appropriate opportunities for plantations where the land is less suited to agriculture. This will require extension and training and the establishment of demonstration plots.

Tree species preference

Interviews were conducted with 272 sample families to identify their preferred tree species. The results are presented in Table 7.

Table 7. Preference of tree species by village families

Species	Number of families	%
Tectona grandis	103	37.8
Acacia auriculiformis	103	37.8
Anacardium occidentale	0	0
Swietenia mahagoni	28	10.3
Paraserianthes falcataria	38	13.9

The least preferred species was *Anacardium occidentale.* This species does not grow well and the fruit production may be as low as 12 kg ha^{-1} y^{-1}. The planting of this species was subsidised by the government and the plantations were undisturbed, thus the survival rate of this species was higher than that for *P.falcataria* and *S. mahagoni.*

Next least preferred is *S. mahagoni.* Although the wood is valuable for timber and furniture, growth is slow. *P.falcataria* is third in preference but its survival rate is the lowest because its rapid growth meant that it was harvested early. This species produces leaves for fodder (especially for goats and sheep) and wood for timber, furniture and fuelwood. The most preferred species were *A.auriculiformis* and *T. grandis.* Their survival rate was also highest. Village people like *A. auriculiformis*

because it grows well everywhere, even on poor soils, and it branches profusely. The wood is used for timber, furniture and fuelwood. *T. grandis* is highly preferred because of its valuable wood for construction timber and furniture, although its growth is slow. Growing of teak is considered to be a good investment which can be passed on to the next generation.

Conclusion

The first hypothesis that the percentage of success is determined by the choice of species is proven in the case of *T. grandis, A. auriculiformis* and *P. falcataria.*

The second hypothesis that the level of success is influenced by biophysical as well as socioeconomic factors has been proven by the multiple linear regression analyses.

To reduce population pressure on the regreening plantations, job opportunities outside agriculture need to be created.

The practice of agrisilviculture should be enhanced through extension, training and establishment of demonstration plots.

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