インドネシア・中部ジャワのチェプー森林区におけるトゥンパンサリ法式によるチーク造林の評価

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An Assessment of Teak Planting under Tumpangsari System in Cepu Forest District, Central Java, Indonesia

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Abstract: This research was conducted to assess teak plantations establishment by *tumpangsari* system in Cepu Forest District, Central Java. Tumpangsari system has been adopted in Java for a long period of time. In this system, landless farmers surrounding teak plantation areas are given chance to plant cash crops between the young teak stands. Cepu Forest District which was predominated by teak plantations has a total growing stock of about 21,615 ha. During eleven years, 11,760 ha teaks were planted, 72.16% of which is planted by *tumpangsari* system. Teak plantation establishment by hired workers or *banjar harian* was only implemented in areas where has a high elevation or no farmers want to use the site for agricultural crops. The planting cost of teak by *tumpangsari* system is lower rate than *banjar harian.* The total cost for teak plantation establishment by stump on *tumpangsari* system was about Rp 947,540 per ha, while *banjar harian* was about Rp 1,642,490 per ha. *Tumpangsari* system provides better condition to the young teak plantations and therefore gave a high planting survival and growth rates of the teak stands. Planting survival of teak by stump on the *tumpangsari* plots ranged from 92.86% to 97.05%, while on the *banjar harian* ranged from 77.16% to 90.05%. The average tree height on the *tumpangsari* plots ranged from 3.05 m to 3.92 m, while on the *banjar harian* plots ranged from 2.75 m to 2.95 m.

Key words: Teak plantations, *tumpangsari* system, planting cost, Cepu Forest District, Java.

Introduction

For hundreds of years, teak (Tectona grandis Linn.) has been recognized as valuable commodity. The demand for teak is so great that it exceeds supply and, therefore, has been one of the most expensive timbers of the world. To meet the ever increasing and insatiable demand, teak is now being planted in many countries within and beyond its natural habitat in the tropical countries. In 1995, about 94% of global teak plantations were in tropical Asia among which India and Indonesia share were about 44% and 31%, respectively (Bhat and Ma, 2004; Pandey and Brown, 2000). Teak plantations in Indonesia are widespread throughout Java Island mainly in Central and East Java. They were initially established within the second half of the 19th Century (MoF, 1987a; Kartasubrata, 1992; Peluso, 1992). Starting in 1972, Forest in Java including teak plantation, protected forest, recreation forest, *etc.* has been managed by Perum Perhutani (PP), a state forest corporation established by Ministry of Forestry of Indonesia (MoF, 1987b). The latest data inform that teak plantation in Java was about 650,000 ha which more than 470,000 ha have best growing stock for producing timber with an average yield of 100 m^3/ha. The annual timber production is about 500,000 m^3 (Perum Perhutani, 2005).

To manage teak plantation and others forest in Java, PP has three units in province level i.e. Unit I Central Java, Unit II East Java, and Unit III West Java and Banten. Each unit is divided further into forest districts. On whole Java Island, PP has 57 forest districts, some of which mainly plant teak. One famous forest district which produces a large amount and good quality of teak wood is KPH Cepu or Cepu Forest District (CFD).

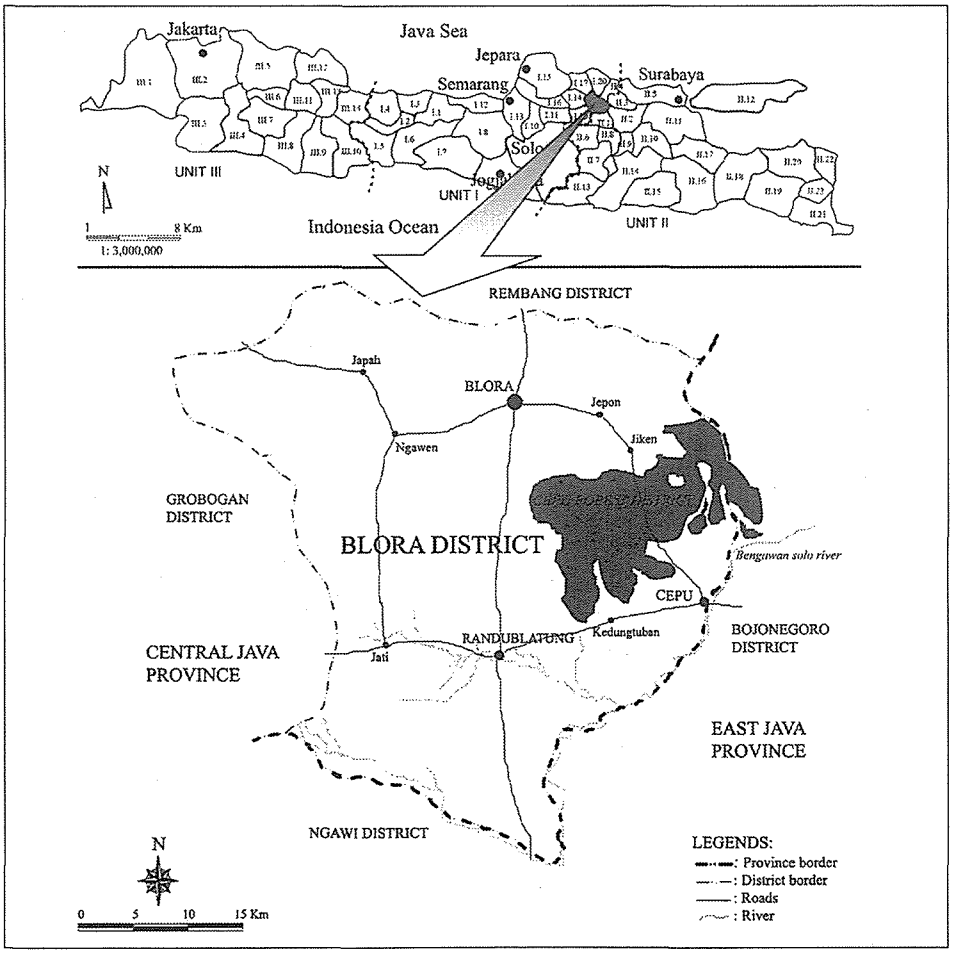
To establish teak plantations, *tumpangsari* (Agroforestry) and *banjar harian* systems were practiced. *Tumpangsari* is a system planting of agriculture crops between teak-rows during two years. It has been practiced for long period of time, which was introduced for the first time in 1873 by Buurman van Vreede, the Germany forester (Kartasubrata, 1992). After that time, the *tumpangsari* technique was soon broadly applied in the establishment of plantation forest in Java. Meanwhile, *banjar harian* is a planting system of teak plantation establishment by hired workers who is paid on wages bases. It is implemented on planting site where no farmers want to use the site for agricultural crops due to the poor and stony soil, or being far from their home.

Tumpangsari appeared to be a sound silvicultural method, and met the needs of population for agricultural land. The *tumpangsari* was increasingly popular because the system could decrease the cost for planting and maintaining on tree plantation and provided access to poor people nearby to plant agriculture crops in forest area. The management of *tumpangsari* in Indonesia has a long tradition. Consequently, there is an extensive body of empirical knowledge on the use and management of the teak trees and associated crops. The economic productivity of the cash crops on *tumpangsari* system is relatively well documented, but the cost and success of teak planting are lacking. Therefore focusing study to these aspects should be undertaken. This research was conducted to investigate the trend and recent situation of teak plantation establishments by *tumpangsari* system in Java using CFD as a case study. The research was stressed on planting system, planting cost, and success of plantation establishment.

Research Site and Methods

According to the provincial administration, CFD is situated between two state districts, namely Blora District, Central Java Province and Bojonegoro District, East Java Province (see Fig.1). According to geographical area, the forest area is located between 111° 16' and 111° 33' East longitudes, and between 06° 528' and 07° 248' South latitudes. This forest district has an altitude ranging from 30 to 250 m above sea level, with undulating to hilly terrain. The soil type is grey-alluvial with lime deposit as base materials. The climate is monsoonal with two distinct seasons: a dry season (May-September) and rainy season (October-April). Air temperature is relatively stable throughout the year with mean daily temperatures of 28oC. Mean annual precipitation is 1.636 mm. On Whitmore's map of rainfall types for tropical Far East, the area is classified into C and D or as a seasonal type (Whitmore, 1984).

Data were collected from a direct observation, interviews, and secondary data collection. Based on the different planting systems (*tumpangsari* and *banjar harian*), nine compartments (six *tumpangsari* compartments and three *banjar harian* compartments) of 2-year-old teak plantations were chosen. From those compartments were made sixty sample plots with size 20 m x 20 m (0.04 ha per plot) to inventory the survival rate of teak planting. Interviews with forest officers, farmers,



Source: Perum Perhutani (2005)
Notes: I.1, II,2, etc. are number of forest district in Java.

Fig. 1. Cepu Forest District in Central Java

and forest workers who establish teak plantations were also conducted to investigate the cost. Secondary data were obtained from statistical data of Unit I Central Java in Semarang and CFD office in Cepu town. To support the analysis, various official documents including policies, programs, and technical guides on teak plantation management were reviewed.

Results and Discussion

1. Teak resources and the trend of planting

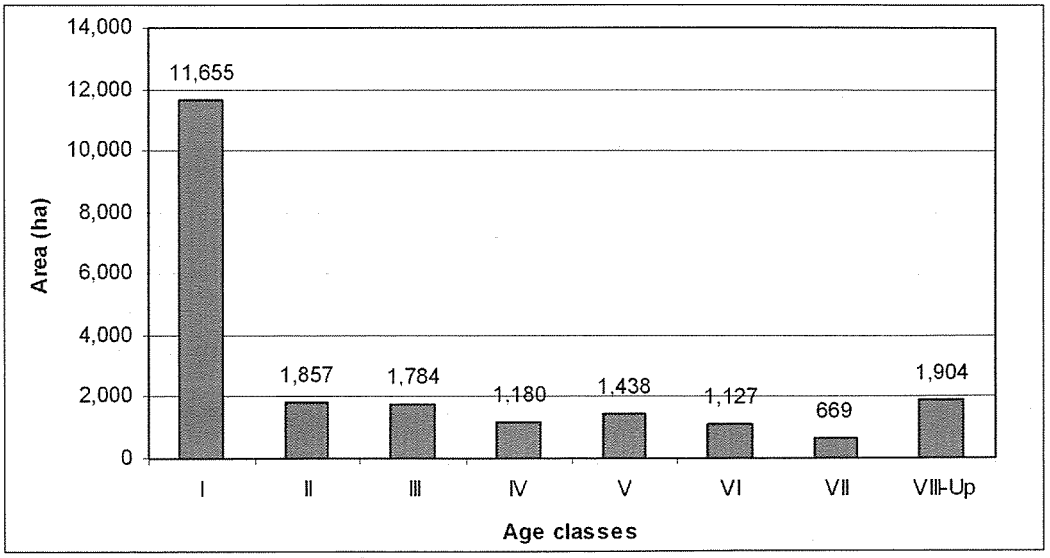
As presented in Table 1, CFD has an area of 33,047.07 ha which comprises of 90.45 % (29,891.70 ha) as production forest and the remaining land as non-production forest (monument forest, seed orchard, protection forest, recreation forest and other purposes). Teak plantation dominates that forest with contribution was about 72.19% of the total production forest. The latest data inform that CFD has productive teak plantation of about 21,615 ha which consisted of many age classes. The cutting rotation of teak plantation is designed on a 50 to 80 years of cutting cycle. Therefore, CFD arranges their teak plantations to have growing stock consisting of eight age classes (I to VIII-up) in which each class consists of 10-year-old trees. An age class distribution system is used to guarantee stable production. The silvicultural system applied is clear-felling with artificial regeneration. Fig. 2 shows growing stock of teak was about 21,615 ha which is distributed on eight age-classes of stands. The stands on age-class I (age 1 to 10 years) dominate the growing stock with share 53.92% of the total teak stands. This indicates that CFD established teak plantation on a large area in the last eleven years.

To ensure sustainability of that teak plantation, Forest Planning Section of PP conducts a "Sustained Yield Regulation Plan" for CFD which the main activities consist of planting, maintaining & thinning, harvesting, and forest protection. This plan is arranged for 10 years and then it is subdivided into Five-year Plans and Annual Technical Operational Plans. Technical

Table 1. Management of forest area in Cepu Forest District, Central Java in 2005

No.	Management of forest area	Area (ha)	Percentage to total area (%)
1.	Production forest area:		
a.	Productive teak plantations	21,615.00	65.41
b.	Low productive teak plantation (non age classes)	2,240.90	6.78
c.	Non-teak plantations	1,956.70	5.92
d.	Degraded land & logged over areas	4,079.10	12.34
	Total production forest area	29,891.70	90.45
2.	Non-harvest area: monument forest, seed orchards	1,038.20	3.14
3.	Protection, conservation, and recreation forests	713.20	2.16
4.	Other purposes: roads, buildings, log-yards, etc.	1,403.97	4.25
	Total area	33,047.07	100.00

Source: Perum Perhutani KPH Cepu (2006)
Note: Non-teak plantation including mahogany (Swietenia macrophylla), rosewood (Dalbergia latifolia), and suren (Toona sinensis), etc.



Source: Perum Perhutani KPH Cepu (2006)

Fig 2. Teak growing stock on different age classes in Cepu Forest District

operational plan for silvicultural practice is documented in annual technical plan, which consists of three components i.e., plantation, maintenance and production. Included in plantation plans are plans for nursery operation, preparation for planting, and planting implementation.

Basically, sustainability of teak plantation is strongly depends on effort of replanting of logged over area. There are two types of teak planting activity which are conducted by CFD to replant log over areas, namely routine planting and rehabilitation planting. Routine planting is replanting of logged over areas of final clear-felling, while rehabilitation planting is replanting of bare lands or logged over areas of unplanned clear-felling. PP will cut immature teak stands in areas where the stands could not be maintained until mature because of low productivity. It may occur due to some disturbances such as illegal logging, land encroachment, and firing, *etc.*

Table 2. Annual establishment of teak plantations based on planting type and planting system in Cepu Forest District from 1995 to 2005

Year	Planting type					Planting system				
	Routine		Rehabilitation		Total	Tumpangsari		Banjar harian		Total
	(ha)	(%)	(ha)	(%)	(ha)	(ha)	(%)	(ha)	(%)	(ha)
1995	295	51	280	48.74	575	575	100.00	0	0.00	575
1996	289	60	196	40.42	485	437	89.95	49	10.05	485
1997	251	36	439	63.66	689	560	81.19	130	18.81	689
1998	355	62	218	38.04	573	508	88.66	65	11.34	573
1999	308	32	645	67.68	953	834	87.57	118	12.43	953
2000	193	11	1,619	89.36	1,812	1,026	56.63	786	43.37	1,812
2001	155	12	1,084	87.52	1,239	762	61.53	477	38.47	1,239
2002	113	10	1,023	90.03	1,137	1,097	96.49	40	3.51	1,137
2003	81	6	1,225	93.80	1,306	1,025	78.50	281	21.50	1,306
2004	202	12	1,492	88.06	1,695	434	25.61	1,261	74.39	1,695
2005	285	22	1,012	78.04	1,297	358	27.63	939	72.37	1,297
Total	2,526		9,234		11,760	7,616		4,144		11,760
Average	230	29	839	71.40	1,069	692	72.16	377	27.84	1,069

Source: Perum Perhutani Unit I Jawa Tengah (2000, 2003, 2006)

Table 2 shows the trend of teak plantation establishment from 1995 to 2005. This table shows that rehabilitation planting dominated planting type in CFD. The average annual planting of teak in this forest district was about 1,069 ha including 230 ha of routine planting and 839 ha of rehabilitation planting. From that data, it can be indicated that many degraded teak plantations during the last eleven years which have be replaced by new plants. A high rehabilitation planting occurred especially after 1990 when planting rate increased almost twice bigger than before. The contribution of rehabilitation planting was about 81.5% of the total planting. The routine planting which conducted on areas of final cutting was relatively constant during eleven years. It can be understood that final cutting was conducted based on Annual Allowable Cut (AAC) which is decided on rate as same as possible. Generally, soil and climate conditions in CFD are favorable for teak and therefore tree planting is still dominated (86%) by teak species. Non-teak including mahogany (*Swietenia macrophylla*), rosewood (*Dalbergia latifolia*), and *suren* (*Toona sinensis*), *etc.* contributed for only 14.2% of the total planting. Non-teak commonly is planted in areas which the land is unsuitable for teak and for clear cutting. It especially occurred in a high topography and along a riverside.

Based on planting system, teak planting can be divided to *tumpangsari* and *banjar harian* (hired labour on daily wage bases). Table 2 shows that the *tumpangsari* dominated the teak planting in CFD with contribution more than 72% of the total planting. This indicated that *tumpangsari* gained a highly attention from local people surrounding teak plantation in CFD. However, in the two-last years (2004-2005), the condition was opposite, which *banjar harian* was dominated in teak planting. Based on our field observations and interviewing some forest rangers in CFD, there are some reasons why *tumpangsari* was not interesting for local people in two recent years. Firstly, location of planting areas is far from the local residents and therefore it is not easy to be accessed by farmers to conduct *tumpangsari*. Most forest areas where are nearest local residents were planted first. Secondly, many landless farmers are still being *tumpangsari* farmers in other teak plantation areas which were planted before in a large scale. Thirdly, young generations in village do not be interested to conduct *tumpangsari* due to low income rate which is provided from t *umpangsari*. They are also more interested to get in come in cash. For most people, *tumpangsari* is actually viewed as last income source when there is no alternative job which can be reached by people in the village.

2. Tumpangsari system

As mentioned before that more than 72% of the total teak planting in CFD were conducted by *tumpangsari* system. In this system farmers around the plantation area are allowed to plant agricultural crops in the planting site. However, there are some requirements to apply *tumpangsari* system; i.e. the soil should be fertile enough to grow agricultural crops, the land slope is not more than 40% and enough number of farmers who are willing to participate in *tumpangsari*. When these requirements are not fulfilled, the planting is done by hired workers on daily wage bases. Crops which are allowed to be planted together with the main forest crop (teak) in *tumpangsari* system are agricultural crops such as rice, corn, tobacco, chili, ground nut, and soybean. However, certain crops such as cassava, potato, banana, and climber (liana) plants are not allowed mainly due to their competitive effect with the forest crop.

Tumpangsari is carried out according to the following basic guidelines. A farmer is given usufruct rights to an area where they then plant with teak. The farmers are allowed to plant agricultural crops between rows of teak with the agreement that they will nurture and protect that teak stands. At the time before the *tumpangsari* is begun, the forest ranger announced availability of land at the site via forest overseers and several appointed community members. The announcement was spread through meetings and house to house visits. The overseer and appointed community members were designated as the person who is responsible for selecting participants for *tumpangsari*. Participant selection was carried out in many ways. Some people declared their interest to the overseer in order to be registered as candidates for selection, and others were approached individually by him through house visits. For the most part, *tumpangsari* plots were allocated through a lottery system. Each farmer will be designated a tract of forest land, which will be shared equally among them. Land shares amount to 0.25 to 0.5 ha, depending on land availability and the capability of the farmer in providing labor and/ or time.

Farmers plant agriculture crops during the first two years (or before shaded out by teak) such as rice, peanut, and corn. The planting season starts in October-November, coinciding with the start of the rainy season. PP provides the seeds/seedling (depending on the agroforestry system adopted). Farmers provide labor for land clearing, weeding (which they would do for their inter-planted crops) and pruning, and are held accountable for timber theft. The farmers are responsible for achieving a certain seedling survival rate, which is evaluated after the first year. If they fall short of this rate, they are required to supplement teak planting until the rate is achieved. Pruning is done on the third year, and farmers are allowed to use the waste for firewood.

Because the *tumpangsari* was in part justified as a poverty alleviation strategy, the PP proposed guidelines in 1986 aimed at prioritizing the involvement of the landless and the land-poor in *tumpangsari*. The PP's Guide states that candidate members from the nearby forest village will be prioritized according to the following criteria: low level of income, insufficient farmland, landlessness, ability to work in the forest, possession of special skills, and other criteria based on agreement.

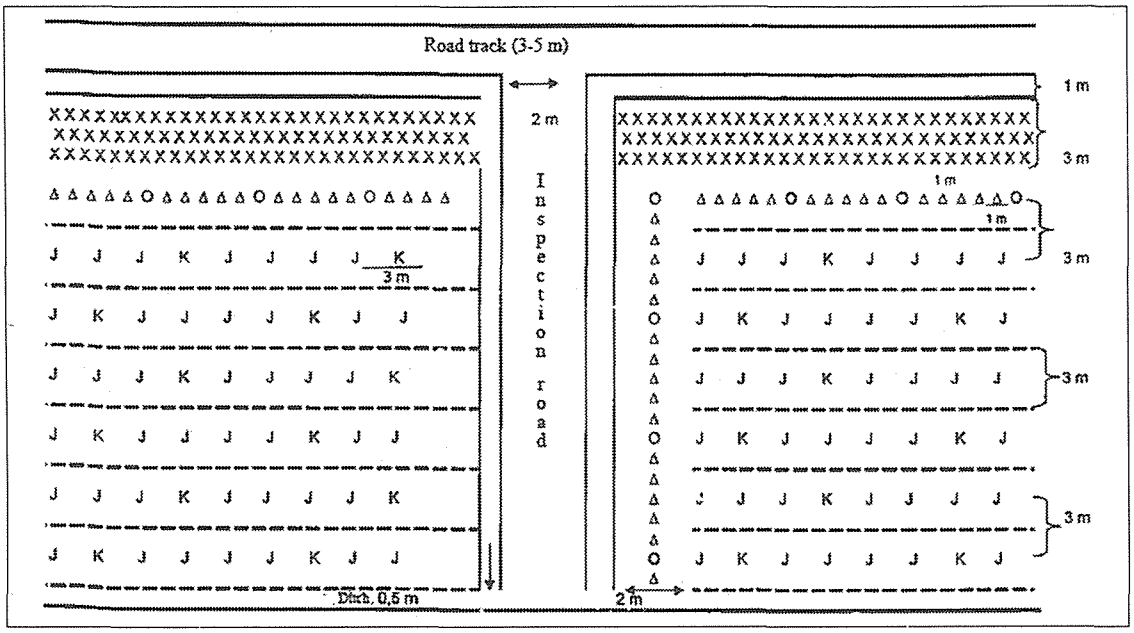
3. Planting layout

Beside the main tree (teak), there are also other forest trees planted together with the main tree with specific function, namely intercrop tree, edge crop tree, filled crop tree, and hedge crop tree. Intercrop tree such as leucaena (*Leucaena leucocephala*) is planted, which functioned mainly to reduce erosion. Edge crop tree such as mahogany, randu (*Ceiba pentandra*), and *johar* (*Casia seamea*) are planted, mainly to mark the boundary of planting area. Filler crop tree such as *kesambi* (*Schleichera oleosa*) and fruit trees are planted primarily to increase tree diversity in plantation forest and to obtain some products (such as fruit) before wood is harvested. Hedge crop tree such as *secang* (*Caesalpinia sappan*) functions to prevent the entry of animal to teak plantation. In this case *C. sappan* is thorny, and is effective enough to deter the entry animal (especially farm animal). The planting design (layout) of those trees is presented in Fig. 3. Based on our observation, however, when *leucaena* grows more than 1 m, then the farmers cut the tree for feeding animal (buffalo or cow) or even it was removed to expand the space for agricultural crops practices. Therefore, we could not find the intercrop tree after one year of teak planting.

There are several aspects which should be considered in determining spacing in teak planting including soil fertility, type of planting stock, silvicultural techniques to be adopted and economical consideration. On fertile soil, planting distance tend to be wider because plant growth is expected to be more rapid. Spacing which are usually used for teak planting are $2 \times 2m^2$, $3 \times 1m^2$, $3 \times 3m^2$, $4 \times 2m^2$ and $4 \times 4m^2$, depending on site condition. In CFD, the common spacing is $3 \times 1m^2$ and $3 \times 3m^2$.

Teak is usually planted by seeds which are directly planted in the field, or by using stumps. Planting with direct seedling is conducted usually on October (at the beginning of rainy season) or being conducted before the first rain come when soil temperature is still hot. Teak seeds are planted at 2 cm depth (below the soil surface) and are afterwards covered with fine soil. On each planting point, four teak seeds are planted to get the opportunity to obtain best seedling. In direct seeding, seeds are directly planted in the planting site. This technique has long been done in Indonesia. However, direct seeding is only suitable for tree species with abundance seed and seeds

have high viability and rate of germination. Planting using stump is conducted by taking stumps from 1-year-old teak seedling. The stump is made by uprooting the teak seedling from the seedling bed, prunes the root laterals and cut the main stem at a certain height.



Sorce: Perum Perhutani (1974)
Note: J=main crop tree (teak), K= filled crop tree (kesambi), X= hedge crop (secang), △○= edge crop tree (mahogany, johar, or randu), ---= intercrop tree= leucaena

Fig. 3. General layout (design) of teak planting

4. Analysis of teak planting cost

Tree planting cost per hectare will vary according to species, planting system, source of planting stock, area size, location, and topography, etc. To investigate the cost of teak planting, we analyze planting cost data which were supplied by CFD office. We chose planting cost data of tree compartments which were planted in same year and have relatively similar condition (distance, topography, and size, etc.) to eliminate variation by those conditions. Those three compartments were selected in order to compare planting cost based on planting system (*tumpangsari* versus *banjar harian*) and type of planting stock (seed versus stump). Based on the availability of data which was supplied by CFD office, we divided plating cost to five components including land preparation, seedlings, planting and maintaining, fertilizing, and miscellaneous. Complete result of comparing planting cost of teak plantation establishment can be seen in Table 3.

Table 3. Teak planting cost based on planting stock and planting system in rupiah per hectare

No.	Component of planting cost	Stump by tumpangsari		Seed by tumpangsari		Stump by banjar harian	
		(Rp*)	(%)	(Rp*)	(%)	(Rp*)	(%)
1	Land Preparation	115,580	12.20	111,960	18.09	765,360	46.57
2	Seed/Seedling & transport	209,890	22.15	99,100	16.01	215,000	13.08
3	Planting and maintaining	313,500	33.09	282,500	45.64	452,300	27.52
4	Fertilizing	206,800	21.82	0	0.00	136,500	8.31
5	Miscellaneous	101,770	10.74	125,410	20.26	74,330	4.52
	Total Cost	947,540	100.00	618,970	100.00	1,642,490	100.00

Source:Field observation in July 2006
Notes:*Rp= Indonesia rupiah, 1 US$ = Rp 9,500. Land preparation includes land clearing, soil tillage, and constructing inspection road, ditches and terraces. Maintaining includes substituting died seedlings, weeding, and pruning. Miscellaneous includes kind of tools, materials, and administrative costs.

The distribution of planting cost components provides an interesting comparison of planting operation. Table 3 shows this distribution by planting system and source of planting stock. Land preparation obviously varies significantly by planting system. Land preparation for teak plantation establishment by *banjar harian* was seven times bigger than *tumpangsari* systems. Activities included within land preparation are land clearing (slashing and burning the shrub, bush, herbs, and residual trees), soil tillage, and the construction of inspection road, ditches and terraces. Those

activities are generally conducted on both *tumpangsari* and *banjar harian* system. A much time with a hard working which is spent to those activities has a consequence to a high cost for land preparation. On the *banjar harian* system, the cost was dominant with contribution of about 46.57% of the total planting cost. On the *tumpangsari*, however, the cost was relatively small. It occurred due to in *tumpangsari* system, land preparation such as land clearing, soil tillage, and making terraces is conducted by farmers who plant agricultural crops. In those activities, farmers are paid in kind with the yields of the agricultural crops. Farmers were only paid on form " *tumpangsari*-contract fee" and unrelated planting activities such as constructing inspection road. Cost for planting stock depends on type. Stump was relatively higher than seed. Planting and maintaining teak stands differed by both planting system and source of planting stock. In general, planting and maintaining cost on *tumpangsari* were smaller than *banjar harian* because the farmers were paid at lower rate than hired workers. It occurred due to the farmers were given a chance to practice *tumpangsari*. Unfortunately, on *tumpangsari* system, miscellaneous cost was relatively high because many aspects were expended for this cost such as making *tumpangsari* contract, farmers meeting, and providing such subsidies for farmers.

This research calculated the total cost for teak plantation establishment by stump on *tumpangsari* system was about Rp 947,540 per hectare, while *banjar harian* was about Rp 1,642,490 per hectare. It means that establishment of teak plantation by *tumpangsari* system is nearly twice cheaper than *banjar harian*. Finally, we concluded that *tumpangsari* system has advantages not only for the farmers but also for the PP. Tumpangsari system provides chance to plant agricultural crops to increase income of the landless farmers in the surrounding teak plantation. In the other side, *tumpangsari* system gives low cost for teak plantation establishment. Therefore, *tumpangsari* system has mutual benefit for both farmers and PP.

5. Analysis of the planting survival

It is important to assess the success of planting efforts. Successful tree planting depends on site preparation, kinds of planting stock to be planted, planting methods and stands maintenance. To evaluate the success of teak plantations establishment, research was conducted at nine compartments of 2-year-old teak plantations which were planted by teak stumps and seeds through *tumpangsari* and *banjar harian* systems. Sample plots with size 20 x 20m^2 (0.04 ha per plot) were taken place based on proportional random sampling. This research compared characteristics of teak stands at those compartments including stand survival and stand growth as presented in Table 4.

Table 4. Planting survival of the 2-year-old teak plantations at nine compartments

Item	Stump by *tumpangsari* (TS)					Seed by TS	Stump by *banjar harian*		
Compartment number	4023a	1074b	1068a	1067a	1041c	1038b	1039b	1058a	1059
Size of compartment (ha)	32.8	5	18	15	3	12	9.3	9.8	10
Number of sample plots	16	3	9	8	3	6	5	5	5
Total area of sample plot (ha)	0.64	0.12	0.36	0.32	0.12	0.24	0.2	0.2	0.2
Average tree height on sample plot (m)	3.57	3.75	3.92	3.68	3.58	3.05	2.95	2.75	2.92
Planted trees on total sample plot (trees)	784	147	441	392	147	832	245	232	242
Survived trees on total sample plot (trees)	746	138	428	364	139	767	218	179	219
Planting survival (%)	95.15	93.88	97.05	92.86	94.56	92.19	88.98	77.16	90.50

Source: Field observation in July 2006

Notes: Spacing on teak planting by stump is 3 m x 3 m, by seed is 3 m x 1 m. Plot size is 20 m x 20 m (0.04 ha). Planting survival= (survived tree/planted trees) x100%

Table 4 shows that success of teak planting on each compartment is various. In general, however, it can be concluded that teak planting through *tumpangsari* system is better than *banjar harian* system. Planting survival of teak by stump on the *tumpangsari* plots ranged from 92.86% to 97.05%, while on the *banjar harian* ranged from 77.16% to 90.05%. Planting survival of teak by seed on the *tumpangsari* plots is also better than stump on the *banjar harian*. Furthermore, the growth of teak stands the *tumpangsari* plots which were planted by both stump and seed is higher than the *banjar harian* plots. The average tree height on the *tumpangsari* plots ranged from 3.05 m to 3.92 m, while on the *banjar harian* plots ranged from 2.75 m to 2.95 m. These results are not surprising because teak stands on *tumpangsari* got better treatments than *banjar harian* plots. Teak stands on *tumpangsari* plots under intensive-care for by farmers who are responsible to replant died teak stands during the *tumpangsari* contract (2 years). Soil work (tillage in site preparation) and weeding receive a high attention by farmers when they plant agriculture crops between teak stands. It has direct impact of better soil

condition on the surrounding young teak stands. As a consequence, young teak stands grow well because good soil condition can improve root-zone soil water supply and encourage more intensive root development (Flint and Child, 1987). Teak is a moderately fast growing species that grows fast in the initial years, but slows down afterwards (Jha, 1999). Comparing with other result in Madiun Forest District, East Java stands height of the 2-year-old teak plantations under the intensive *tumpangsari* system with planting space of 3 x 1 m2 ranged from 3.50 m to 5.14 m (Purwanto et al., 2003).

Conclusions

Teak plantations which predominates forest areas in CFD have a total growing stock of about 21,615 ha. During eleven years (1995-2005), CFD planted 11,760 ha teak of which 72.16% was planted by *tumpangsari* system. Tumpangsari is an agroforestry system which is practiced for limited period to encourage landless farmers surrounding forest area to plant cash crops between the young teak stands. Teak plantation establishment by hired workers or *banjar harian* system was only implemented in areas where has a high elevation or no farmers want to use the site for agricultural crops. The planting cost of teak by *tumpangsari* system has lower rate than *banjar harian* because many activities which were conducted by farmers were paid in kind with the yields of the agricultural crops. Furthermore, *tumpangsari* system provide better condition to the young teak plantations and therefore gave a high planting survival and growth rates of the teak stands. Finally, we concluded that *tumpangsari* system has mutual benefit for both farmers and PP.

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インドネシア・中部ジャワのチェプー森林区におけるトゥンパンサリ法式によるチーク造林の評価

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要約

この研究は中部ジャワのチェプー森林区におけるトゥンパンサリ(アグロフォレストリー)方式によるチーク人工造林の評価を行うことである。トゥンパンサリ方式は長年にわたり、ジャワで採用されてきた。この方式ではチーク人工造林地域周辺の土地なし農民は若齢のチーク立木間で現金作物を栽培する機会を与えられている。チーク人工材が優勢であるチェプー森林区の面積はおよそ21,615haである。11年間に11,760haのチークが造林され、その72.16%はトゥンパンサリ方式によって植えられた。雇用労働力による人工造林は標高の高い地域でのみ行われており、そこでは農民は農作物の場所を望んでいない。トゥンパンサリ方式によりチーク造林コストは雇用労働力よりも低い金額である。Ha当たりの苗木によるチーク人工造林の総コストはトゥンパンサリ方式では約947,540ルピアであるが、一方雇用労働力では1,642,490ルピ

アである。トゥンパンサリ方式は若齢チーク人工造林へよりよい条件を与えているので、チーク立木の高い植付け活着率と成長率をもたらした。各トゥンパンサリ方式区画での苗木の植付け活着は92.86～97.05%であったが、一方雇用労働力では77.16～90.05%であった。各トゥンパンサリ区画での平均樹高は3.05～3.92mであったが、一方各雇用労働力区画では2.75～2.95mであった。

キーワード：チーク人工造林、トゥンパンサリ方式、造林コスト、チェプー森林区、ジャワ