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Increasing Land Cover by Promoting Agroforestry-Based Tree planting to Sustain Community Livehood under Various Social Forestry Schemes in Indonesia

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Abstract

The high challenges and expectations in the management of Indonesian Tropical Forests to achieve the community welfare, forest sustainability and sustainable development goals, demands proper management in optimizing the use of forest resources to meet the high dependence of community needs on the forest. The pressure on forests is reflected in the deforestation that occurs as an indication of the various dependencies of the community on forests to meet their daily needs. In this regard, Agroforestry is a potential silvicultural recipe as a solution to restore degraded land and forest that can gain balance ecological, economic and social benefits. This paper aims to provide information on plant growth performance and survival rate in the establishment of agroforestry plot for a total 34 hectares in three schemes of Social Forestry in Indonesia, namely Paru Village Forest (VF)–West Sumatra, Cempaka Forestry Partnership (FP)–Lampung, Tuar Tana Community Forestry (CF)–East Nusa Tenggara, in collaboration between Forestry and Environment Research, Development and Innovation Agency with the Asian Forest Cooperation Organization (AFoCO). It was conducted by planting 26 plant species (both of forest tree and fruit tree/multipurpose tree species) included 5 seasonal crops species by applying Intensive Artificial Regeneration with planting distance of 8x8 m and 5x5 m depend on plant species. The collected data covered for survival rate and height measurement. Growth Percentage was observed at ages 1, 6, 12 and 18 months after planting. Survival rate in Paru VF shows the best result which is good for 12 months and still good enough for 18 months after planting, respectively 93.5% and 78.9% supported by community participation which looks high in maintaining their crops while survival rate in Tuar Tana CF was low enough only 43,2% due to the drough in this semi-arid region which affect the plant growth, eventhough the farmers have high effort in maintaining their crops.

Keywords: Mixed Tree planting, Reforestation, Community Forestry, Village Forest, Forestry Partnership

Introduction, scope and main objectives

Proper management is necessary in optimizing the use of forest resources with limited land availability to meet the increasing needs of society and the state for forests as the population increases. The conversion of forest land into agricultural land or other uses cannot be denied causing many environmental problems, such as decreasing soil fertility, increasing erosion, flooding and drought, decreasing species diversity to the extinction of flora and fauna and even triggering global climate change. This problem is getting worse in line with the ongoing deforestation which is a reflection of the pressure on the forest as an indication of the various dependence of the community on the forest to meet their needs.

One of these forest management policies is Social Forestry, which is a manifestation of the paradigm shift in forest management from the concept of timber-based forest management to community-based forest management by involving the community and other parties in forest management to achieve sustainable forest management. Community Based Forest Management (CBFM) is a strategy that emphasizes on the importance

of community's involvement to support forest conservation. Social Forestry (SF) as a scheme of CBFM has significant role in providing alternative sources of income and employment for forest communities.

Through FS schemes and policies, the government has opened access to local communities, especially those who live within or around forest areas to manage and utilize the surrounding forest areas. However, the realization of successful development of the SF program is still low so far, even far below the target set, even though it has been supported by various legal policies in the form of Government Regulations, Ministerial Regulations and Director General Regulations. The realization of the achievement of the Social Forestry program until August 2021 is around 4.7 million hectares from the target of 12.7 million hectares up to 2024 (Supriyanto 2021). Therefore, strategic steps are needed to support the acceleration of the realization of the Social Forestry Program, including through a pro-active approach from the management and permit holders to initiate the development of SF schemes, including promoting agroforestry-based tree planting for increasing land cover to sustain community livelihood under various Social Forestry schemes as well as development of forest-based agribusiness that has backward and forward linkages.

The Indonesian government issued the Minister of Environment and Forestry Regulation No. 24 year 2020 which gave new opportunities for social forestry areas to become food estate development areas. The regulation is in line with regulation of Minister of Environment and Forestry No. 8 year 2021 concerning forest management and preparation of forest management plans, as well as forest utilization in protection forests and production forests, which encourage increased productivity of forest land through the implementation of agroforestry practices and Forestry Multi-business. In this regard, Agroforestry is a potential silvicultural recipe as a solution to restore degraded land and forest that can gain balance ecological, economic and social benefits. This paper aims to provide information on plant growth performance and survival rate in the establishment of agroforestry plot for a total 34 hectares in three schemes of Social Forestry in Indonesia, namely Paru Village Forest (VF)–West Sumatra, Cempaka Forestry Partnership (FP)–Lampung, Tuar Tana Community Forestry (CF)–East Nusa Tenggara, in collaboration between Forestry and Environment Research, Development and Innovation Agency with the Asian Forest Cooperation Organization (AFoCO).

Methodology/approach

Time and Location

Development of agroforestry demonstration plots carried out in three pilot site of Social Forestry areas in Indonesia, located in Paru Village Forest (VF) under Sijunjung forest Management Unit (FMU), Paru Village, Sijunjung District, Sijunjung Regency, West Sumatra Province; Cempaka Forestry Partnership (FP) under management of Batutegi FMU, Sumber Bandung Village, Pagelaran Utara District, Pringsewu Regency, Lampung Province; and Tuar Tana Community Forestry (CF) under management of Sikka FMU, Hikong Village, Talibura District, Sikka Regency, East Nusa Tenggara Province. The research was conducted in February 2018 - March 2020 (Figure 1).

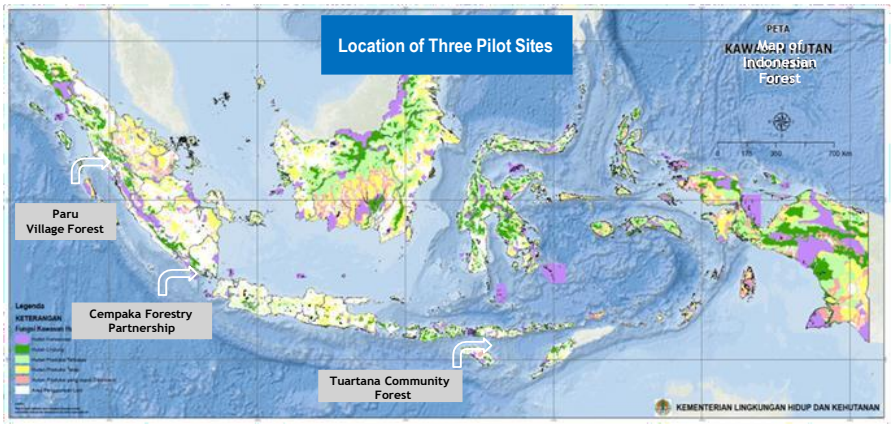

Fig. 1: Three pilot site in Indonesia under three Social Forestry schemes

Materials

Materials used in this study were seedling of forest trees, various multipurpose tree species and seasonal crops, manure, fertilizers, bamboo stick for planting pole, herbicides, blank tally sheets. Tools used were Global Positioning System (GPS), compass, Suunto Clinometer, measuring tape 50 m, rope, and stationery.

Methods

Planting Technique. In Paru VF, planting sites were classified into 2 land use categories, which were Protection Forest area and other land uses area (Areal Peruntukan Lain/APL). Protection forest indicated to those areas within Paru Vilage Forest while APL indicated to those owned privately. Different planting technique were applied into these two land status types. Planting technique in gap was applied for Protection Forest within Paru VF amounting 6 hectares while for other land use (APL) status area amounting 3 hectares we applied Intensive Artificial Regeneration (IAR) with planting distance of 8 m x 8 m. Line clearing was practiced along the planting track (around 2 m in width). Planting poles were used which is made from bamboo stick with 1.2 m in height. The same planting technique was conducted in Cempaka FP (distributed into eight sub group area) and Tuartana CF (distributed into three bloks area in 21 land manager). Demonstration plot in each pilot sites was shown in Figure 2.

Data Collection and Analysis. Tree survival rate and growth were recorded at the interval 6 months. Survival rate was recorded as number of trees survived divided by total number of planted seedlings. Growth parameters were seedling height and seedling diameter for those exceeding 1.3 m in height.

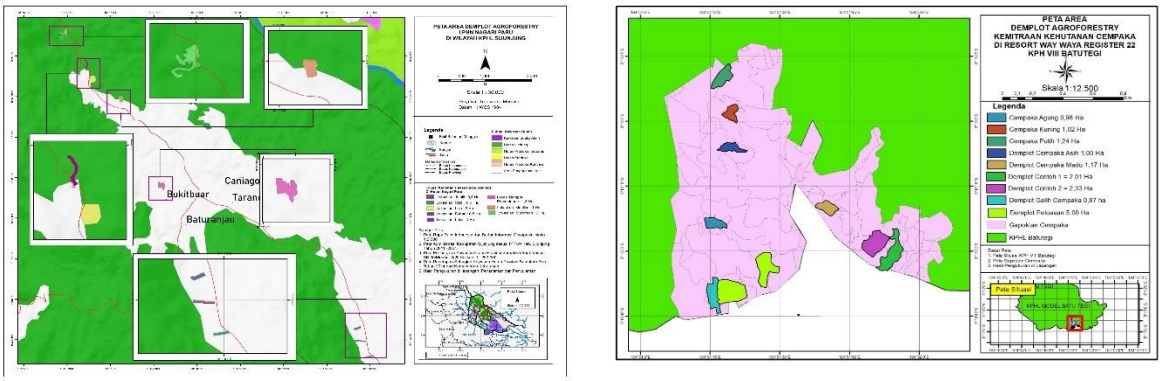

Fig. 2: Demonstration plot in Paru VF (left) **and Cempaka FP** (right) Source: Octavia *et al.* 2020

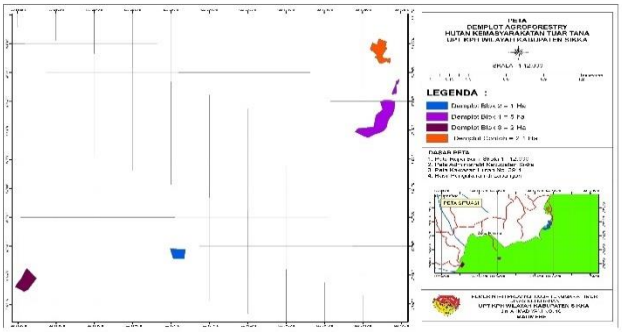

Fig. 3: Demonstration plot in Tuar Tana CF Source: Octavia *et al.* 2020

Results

Species selection

In Cempaka Forestry Partnership (Batutegi FMU), establishment of agroforestry plot was conducted for a total 15 hectares by planting 9 tree species (both of forest tree and fruit tree/ multipurpose tree species) and 4 seasonal crops species. The species selection was stated in Memorandum of Understanding for plantation activity. They are nutmeg (*Myristica fragrans*), champaca (*Michelia champaca*), Damar Mata Kucing (*Shorea javanica*), clove (*Syzygium aromaticum*), marmalade (*Crescentia cujete*), candlenut (*Aleurites moluccana*), mangosteen (*Garcinia mangostana*), banana (*Musa* Sp.), shrub pepper (*Piper albi*), Gamal (*Gliricidia sepium*), ginger (*Zingiber officinale*), Temulawak (*Curcuma zanthorrhiza*), lemongrass (*Cymbopogon nardus*).

In Paru Village Forest (Sijunjung FMU), establishment of agroforestry plot was conducted for a total 9 hectares by planting 9 tree species (both of forest tree and fruit tree/ multipurpose tree species) and 3 seasonal crops species. The species selection was stated in Memorandum of Understanding for plantation activity. They are dragon's blood (*Daemonorops draco*), mangosteen (*Garcinia mangostana*), durian (*Durio zibethinus*), agarwood (*Auricularia malaccensis*), dog fruit (*Archidendron pauciflorum),* stink bean/bitter bean (*Parkia speciosa*), areca nut (*Areca catechu*), rubber (*Hevea brasiliensis*), cinnamon (*Cinnamomum burmanii*), ginger *(Zingiber officinale),* galangal (*Alpinia galanga*) and bulrush (*Pennisetum purpureum*).

In Tuar Tana Community Forestry (Sikka FMU), establishment of agroforestry plot was conducted for a total 10 hectares by planting 10 tree species (both of forest tree and fruit tree/ multipurpose tree species) and 2 seasonal crops species. The species selection was stated in Memorandum of Understanding for plantation activity. They are nutmeg (*Myristica fragrans*), clove (*Syzygium aromaticum*), candlenut(*Aleurites moluccana*), jackfruit (*Artocarpus heterophyllus*), durian (*Durio zibethinus*), mahoni (*Swietenia mahagoni*), stink bean/bitter bean (*Parkia speciose)*, *cashew (Anarcadium occidentale), pinang/areca nut (Areca catechu),* Gamal *(Gliricidia sepium)*, ginger *(Zingiber officinale)* and galangal (*Alpinia galanga*).

Formulation of incentive scheme also was outlined in memorandum of understanding (MOU) which was prepared participatively involving three related parties in the partnership i.e. AFoCO, related FMU and the community. Some main points stated in the MOU mainly concerned with rights, obligations and responsibilities of each party in managing and maintaining the established agroforestry demonstration plots (Suharti and Octavia 2020).

Survival Rate

Survival rate were evaluated at six months interval. The physical count enabled estimation of the actual number of surviving trees out of total planted ones. The percentage of survival rate at interval of six months evaluation at agroforestry plot shown at Table 1, Table 2, and Figure 4.

Table 1. Survival rate of each species at certain periodical observation in Cempaka FP

No.	Species planted	Number of plant	Survival rate (%)			
		Initial planting	1 map	6 map	12 map	18 map
1	Nutmeg	1073	94.11	79.26	68.87	57.99
2	Clove	746	93.03	63.84	66.62	46.14
3	Champaca	214	94.01	75.00	63.08	52.27
4	Shorea javanica	220	94.95	75.43	86.36	56.47
5	Marmalaide	311	97.19	80.66	72.99	46.53
6	Mangosteen	34	100	80.56	94.12	69.44
7	Candlenut	27	100	37.93	81.48	31.03
	Total	2625	96.18	73.92	70.17	52.49

Note: map (months after planting)

Table 2. Survival rate at both land management type at certain periodical observation in Paru VF

Land management type	Survival rate at 6 months interval (%)		
	6 map	12 map	18 map
Paru Village Forest (PVF)	98.6	92.7	85.3
APL	91.4	76.5	71.5

Note: map (months after planting)

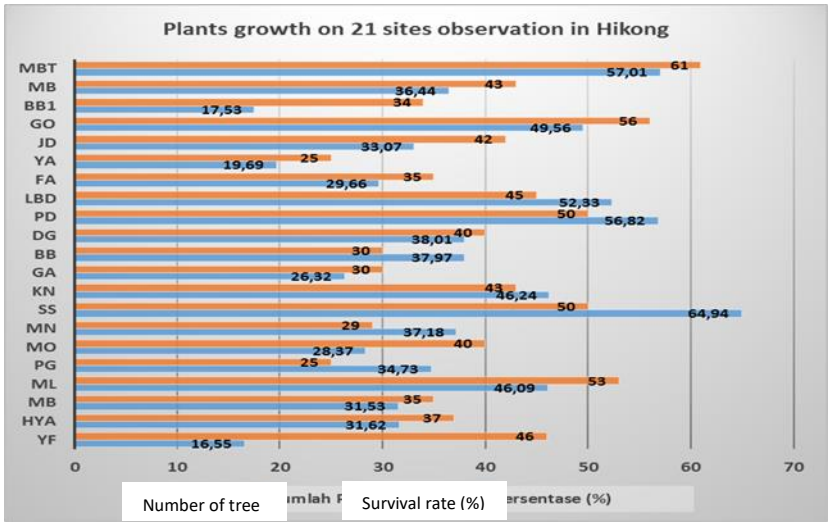

Fig. 4: Survival rate at agroforestry plot in Tuar Tana CF Source: Primary data 2020

Height and diameter growth

Height growth performance was evaluated at each plot at 6, 12 and 18 months after performance. Table 3 showed the growth performance at periodic observation interval Paru VF.

Table 3. Height and diameter growth at certain periodical interval by species in Cempaka FP

Species	Height (cm) at certain periodical interval							
	1 map		6 map		12 map		18 map	
	Diameter (mm)	Height (cm)	Diameter (mm)	Height (cm)	Diameter (mm)	Height (cm)	Diameter (mm)	Height (cm)
Nutmeg	4.03	30.43	5.08	30.43	6.19	43.67	9.81	66.66
Clove	2.43	22.90	3.13	22.90	3.97	36.72	9.33	68.47
Champaca	3.77	28.63	4.17	28.63	6.52	55.30	18.13	102.18
Shorea javanica	3.31	32.94	5.37	52.94	7.02	57.52	14.36	89.96
Marmalaide	5.00	19.50	6.67	30.5	8.07	47.42	18.85	115.72
Mangosteen	8.00	25.00	9.00	45.00	11.9	39.42	13.10	50.83
Candlenut	4.00	39.00	6.40	59.0	10.9	81.65	16.10	111.18

Table 4. Height growth at two land management type at certain periodical interval by species in Paru VF

Species	Height (cm) at certain periodical interval in two land management type					
	1 map		12 map		18 map	
	PVF	APL	PVF	APL	PVF	APL
Mangosteen	27.1	23.3	36.3	34.5	42.1	39.1
Durian	47.9	43.0	57.1	50.5	61.0	60.3
Stink bean	39.4	31.0	49.7	49.6	56.1	55.4
Dragon blood	61.4	57.6	73.7	73.0	83.4	84.2
Dog fruit	41.2	32.1	51.0	47.7	56.8	57.2
Rubber	70.9	60.9	82.1	72.6	87.6	87.1
Cinnamon	29.6	22.9	37.9	35.0	43.0	44.1
Agarwood	71.6	73.1	80.1	77.5	83.3	85.1
Areca nut	31.7	16.0	44.7	24.1	55.6	50.7

Height and diameter growth at certain periodical interval by species in Tuar Tana CF can be seen at Figure 5.

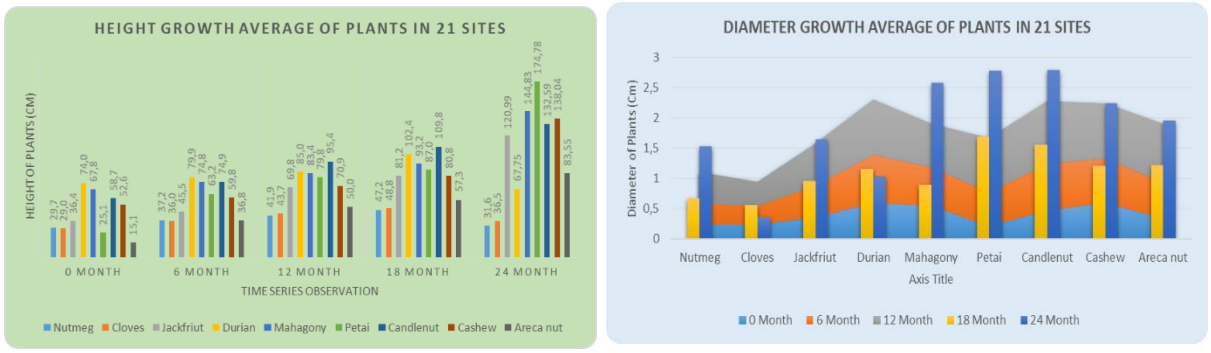

Fig. 5: Height and diameter growth at agroforestry plot in Tuar Tana CF Source: Primary data 2020

Discussion

Species selection

In the three pilot sites, the species selection was mostly considered by community consensus where almost all were included in multi-purpose tree species when their non-timber product as their main product target (fruit, resin, bark). Among them, species producing fruit are: durian, dog fruit, stink bean, mangosteen and areca nut; species-producing resin are dragon blood, rubber, and agarwood; while species-producing beneficial bark is cinnamon. All species has important economic value and commercially traded among community in the market both at local and national scale. Fruit tree species are more preferable and widely accepted by the community in addition Asia continent itself is known to have more than 500 fruit trees used and consumed by their people (Paul and Duarte, 2011). Tree species planted were varying among site. Paru VF was planted by more tree species than those of APL. In general, in APL area, multipurpose tree species was more preferred than those of woody/timber trees only. Durian, dog fruit, stink bean, mangosteen were among the most preferable tree species to be planted under both type of land management.

Trees were planted in spacing of 8 x 8 m intercropped with previously available trees on each site. By this spacing distance, the estimated density was about 156 trees per hectare. At Paru VF when land coverage was higher than those of APL, the planted tree density may be lower. Intensive artificial planting was conducted at APL where concise spacing distance and numbers of tree are applied. In the other side, planting technique at Paru VF has more flexible pattern when planting may not be carried out to some points where tree canopy coverage is high. In general, the planting pattern in Paru VF may look more similar to those of gap planting.

Survival Rate

The average stand density at both land management type decreased in different value and correlated with the survival rate. Higher survival rate showed lower mortality thus owned higher density. When comparing the survival rate of the trees between those planted at PVF and CNL, PVF was considered to have better performance. The existing conditions of the plots were also rather different. Those located at APL generally showed higher openness area and several were consisted of bushes with very few standing uncommercial trees left. While those located at PVF which served as protection forest, showed more shaded environment. Condition in PVF was mild environment that support the early and critical stage in seedlings survival. More open area had more constraints considering the light intensity, soil compaction, cattle disturbance, and anthropogenic activities. In general, plots in CNL status were almost barely. Open area will receive excess sunlight during day time those making evapotranspiration rate became very high. During project period activities, a long dry season occurred with very extreme temperature fluctuation in three pilot sites. Those, plot at these conditions received very severe conditions that inhibit the seedlings growth and higher mortality. While those plot within Paru VF has milder condition even at the long period of dry season. Higher moisture also supports higher survival rate in Paru VF.

Animal (pest, cattle, intruders, etc) are known to have impact on the growth performance of the planted seedlings. There was no pest attack determined at every observation plot both at Paru VF and APL. Those, pest management were set as preventive step in managing the plots by doing regular and frequent evaluation. Surprisingly, cattle become the major cause at certain APL site that lowering the survival rate of planted seedlings. Along the period of planting activities, there were cattle (cow) that were raised near the certain plot. Condition was worsened by the fact that the cattle were set free to have their activities in the plot. Young planted seedlings were easiest food sources for the cattle. Higher mortality rate at APL plot were mainly caused by these cattle. Both at Paru VF and APL, wild boar attack become the major cause for seedlings mortality. General performance for this condition showed by the seedling destruction from mild condition of those only scathes on main stem to those of severe disturbance that caused seedling mortality. Similar to those of cattle disturbance, there is less effort to local community to handle and overcome these disturbances since the lands itself were in open access and will be not impossible to be fenced.

Based on the evaluation, the survival rate in Tuar Tana CF ranged from 16.55% to 64.94%. It can be seen at the Figure 4, the plant growth trends shown an increasing trend in mortality in the last 2 years. Replanting efforts is

needed to increase the number of plants in each planting site. However, the climate factors influence very strongly, especially the limited of rainfall that just supported only along 3-4 months per year. This is the main factor that causes drought and the availability of soil water content for plant growth is very limited. In addition, intervention efforts to mitigate the effects of drought on plant growth have not yet generated optimal results. It was indicated by still occurred relatively high plant mortality rates reaching 65.39%. Community initiatives to regenerate and conserve NTFPs through agroforestry model need to be improved, especially for improving the rate of plant growth (Njurumana and Octavia 2020). In Tuar Tana CF, enhanced technology in managing farmland such as spatial planning for food crop cultivation and long-life plants for NTFPs by agroforestry model should be promoted, because the landscape is dominated by only a few plant species, one of which is candlenut (*Aleurites moluccana*), which covers 65% of CF management area. The irregular structure and composition of plants have implications for the nutrients' availability for plant growth. In this regard, assistance is needed for the spatial use of land and crop regeneration, including the possibility of increasing the available arable land area to farmers who have succeeded in carrying out rehabilitation and reforestation on critical CF land (Njurumana *et al.* 2020).

Overall, the average conditions of plant growth in the demonstration plots up to 12 months after planting in Cempaka FP were still quite good, at 70.17% (Danu and Octavia 2020). This is because the group members take care of their cultivated land area well. The high of plant survival rate is due to the awareness of members of farmer groups in tending plant such as clearing weeds, creating shade plants and providing replanted plant. As is the case in Tuar Tana CF, the decrease in growth percentage occurred at 18 months after planting due to a long drought.

Height and diameter growth

Fruit trees were the most species chosen by the community due to the fact that they would yield a large annual crop of fruit in the future and continuous yield (Tchiegang-Megueni *et al*. 2001). However, in the future, landholders need to conduct appropriate silvicultural action because typically fruit trees require wide spacing and full sun to bear productively. Spacing distance of 8 x 8 meter would be good enough for several sites in APL but may not really suitable in Paru VF when the density of trees much higher as the result of current standing stock. In APL, planted trees has less competitor due to less trees grown in the sites. But in PVC which was resembled a good forest stand, a closely spaced system was automatically formed by the current standing stock condition. However, in this early stage of growth, shaded environment seemed to support the tree growth as it has been lessening the very extreme drought happened during the project. In form of height increment, in general there seem no significant differences between these two lands management type.

In Cempaka FP, from observations up to 18 months after planting, maja, candlenut and cempaka produced the largest height growth, which was above 100 cm. In Tuar Tana CF, the highest growth was also found in candlenut and cashew plants, while in Paru VF, the best growth was seen in jernang, gaharu and rubber which reached more than 80 cm. These species have adapted well in the area.

Conclusions/ wider implications of findings

Handling and reversing deforestation and forest degradation requires communities based participatory forest management, especially in state forest areas, through several SF schemes offered. Survival rate of seedling in Paru VF shows the best result which are supported by strong/intensive community participation in maintaining the plants, meanwhile the factor influencing the rate of survival seedlings and growth performance in three pilot sites, are not only determined by the environment abiotic factors itself such as drought and light intensity, but also the existence of external factors like cattle disturbance, wild boar and other intruders. Micro condition related to abiotic factors attributed in Paru VF were considered to be the major cause for this result. Through three Social Forestry schemes (Village Forest, Community Forestry and Forestry Partnership model) implementation in the project, it was found that many species of multi-purpose tree species were adaptive to be planted at the 3 pilot sites (Sijunjung-West Sumatra, Batutegi-Lampung and Sikka_East Nusa Tenggara) in Indonesia.

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