Promoting agroforestry model in increasing land cover to sustain community livelihood in Paru Village Forest

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Abstract. In forestry sector, social forestry gained more concern nowadays and subjected to create new economic growth. Agroforestry is a silviculture practice that is suitable to be applied in areas with social forestry schemes. In this condition, Agroforestry is one of solution to restore degraded forest and other form of landscapes which can cover ecological, economical, and social aspect. This paper aim to gain information of plant survival rate in the establishment of agroforestry plot for a total 8 hectares in Paru Village Forest under Sijunjung Forest Management Unit, West Sumatra by planting 9 tree species (both of forest tree and fruit tree/multipurpose tree species) and 3 seasonal crops species. We applied different planting technique for two types of land status. For protection forest was applied by gap planting technique while for other land status area was applied Intensive Artificial Regeneration (IAR) with planting distance of 8 m x 8 m. Data collection covered for survival rate and initial height measurement. Growth percentage was observed at ages 1, 6 and 12 months after planting, respectively 95.2%; 94.5% and 93.5%. Survival rate is good enough for 12 months after planting, supported by community participation which looks high in maintaining their crops.

1. Introduction

Ecosystem restoration is one of the positive critical responses in reacting to environment quality depletion. Ecosystem restoration has been conducted to maintain the essential function of a landscape for human, plant and animals living on it. Restoration technique has long been developed that first only focused on ecological aspect to that of the needs for integrating it with socio economic aspect. Indonesia deforestation trend in 2016 to 2017 still 0,48 million hectare per year [1].

This current trend should require outputs that the benefit of restoration program can be directly disperse for increasing economic aspect on local community surroundings the landscape. Choosing species with high ecological function and economically accepted by the community is one way to creating the successful restoration story. Integrating both ecological aspect and economical acceptance is needed to increase the participatory of local community involvement in restoration activities. It can be realized by agroforestry practice.

Valuing forest from only ecological aspect is currently no more appropriate. In this condition, Agroforestry which is suitable to be applied in areas with social forestry schemes is one of solution to restore degraded forest and other form of landscapes which can cover ecological, economical, and social aspect. Social forestry gained more concern nowadays and subjected to create new economic growth especially among the infrastructure-connected areas. Social forestry policy provides solutions to unemployment, to poverty, to land conflicts, for the rehabilitation of lands and restoration of landscapes, and provide a sense of security and peace of mind to communities by providing them with legal of access

to forest resources and the Forest Area. It has 5 schemes and Paru Village Forest is one of the social forestry schemes in Indonesia under the management of Sijunjung Protected Forest Management Unit - Forestry Service of West Sumatra Province. The recorded achievements of the social forestry program have increased significantly over the past three years (2015 to 2018). Over this period, permits issued to enable communities to manage forests have increased 1,272,540.83 hectares, of which 821,412.61 hectares are for HD, 267,178.07 hectares are for Community Forest (Hutan Kemasyarakatan/HKm); 70,742.78 hectares are for Plantation Forest (Hutan Tanaman Rakyat/HTR); 72,318.13 hectares are for Forestry Partnerships; 16,510.90 hectares are Social Forestry Utilization Permits; and 24,378.34 hectares are Customary Forests [1].

This paper aim to gain information of plant survival rate and plant growth performance in the establishment of agroforestry plot for a total 8 hectares in Paru Village Forest under Sijunjung Forest Management Unit, West Sumatra by planting 9 tree species (both of forest tree and fruit tree/ multipurpose tree species) and 3 seasonal crops species. This activity is in collaboration between Forestry and Environment Research, Development and Innovation Agency (FOERDIA) and the Asian Forest Cooperation Organization (AFoCO).

2. Material and Methods

2.1. Time and Location

The study was conducted in Paru Village Forest area in Mach 2018-March 2019. Administratively, the Paru Village Forest area is located in areal block of Bukik Mandi Angin, Sungai Sirah. It is 33 km away from the capital of the Sijunjung Regency, West Sumatera Province. Geographically, the Paru Village Forest area is located between $101^0$5'0"-$101^0$10'3" E longitude and $0^0$35'10"-$0^0$40'13" S latitude. Based on the distribution of watershed areas, the Paru Village Forest area is located in the Batang Binuang sub-watershed, Indragiri watershed [2]. The area of the Paru Village Forest is around 4,430 ha.

Paru Village Forest was achieved its recognition status and working area legalized by Forestry Minister Decree No. SK. 507/Menhut-II/2014 dated on June 4th 2014 for 4.500 Ha, followed by (Letter of Permit for Paru Forest Management/*Hak Ijin Pengelolaan Hutan* Paru) HIPHP issued by West Sumatera Province Governor No. 522.4-501-2015 on June 2015 for another 4.500 Ha. The role of Paru Village Forest in forest management has been confirmed through Law No. 10 concerning Communal/Customary Land and Regional Regulation No. 2 year 2007 concerning Basic Principles of Village Administration.

2.2. Materials

Materials used in this study were blank tally sheets (Annex 1). Establishment of agroforestry plot for a total 8 hectares at Paru Village Forest by planting 9 tree species (both of forest tree and fruit tree/multipurpose tree species) and 3 seasonal crops species (Figure 1). Those are seedling of 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*), cinnamomum (*Cinnamomum burmanii*), ginger *(Zingiber officinale),* galangal (*Alpinia galanga*), and bulrush (*Pennisetum purpureum*).

Tools used were Global Positioning System (GPS) receiver, Suunto Clinometer, measuring tape 50 m, rope, and stationery.

Figure 1. Agroforestry plot area at Paru Village Forest

2.3. Methods

2.3.1. Planting technique

Planting sites were classified into 2 land use categories, which were Protection Forest (*Hutan Lindung*) and other land uses (*Areal Peruntukan Lain*/APL). Protection forest indicated to those areas within or inside Paru Vilage Forest area while APL indicated to those owned privately.

Different planting technique were applied into these two land status types. For Protection Forest within Paru Village Forest amounting 5 hectares we applied gap planting technique 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. Detail information as shown in Table 2.

Line clearing was practiced (of about 2 m in width) along the planting track. Planting poles were made from bamboo stick with 1.2 m in height. In the case of Paru Village Forest, planting poles used fallen branches.

2.3.2. Data record and parameter measured

Survival and growth (height) data record has been taken for each of the plot site at 1,6 and 12 months after planting while data on diameter will be taken after the average height of the planted seedlings reaching above 1.0 m (commonly at around 12 MAP).

3. Result and discussion

Protection Forest inside the scheme of Village Forest in West Sumatera has rather different management with those of Protection Forest in other provinces. Since traditionally the forest has been managed in very long time by local community, in certain area of so called Protection Forest status which lied inside Village Forest. There will be someone or a group of community who are responsible for managing the use and the management of forest itself. This situation may give insight that even Protection Forest will have “the owner”. Very different situation is reflected in other provinces where Protection Forest strictly managed by Ministry of Forestry through Directorate General of Ecosystem and Forest Resource Conservation or Directorate General of Watershed Management and Protection Forest, both under Ministry of Environment and Forestry. Each type of land status divided into several ownership of land, as in detail can be seen in annex 2.

3.1. Plant growth and survival rate

Data collection in this research covered for survival rate, and initial height measurement. Data on survival rate and average height growth of 1, 6, and 12 month(s) old seedling is presented in Table 1, 2 and 3, respectively.

Table 1. Survived seedling 1 months after planting and its average height for each plot.

Owner/managed by, land status	Area (Ha)	∑ of species planted	∑ of seedling planted	Survival rate (%)	Average height (cm)
Mualim, NPF	1,0	9	230	100	47,0
Madirman, NPF	2,0	9	338	94,1	46,6
Suherman Lelo, NPF	2,0	9	364	100	45,7
Iskandar, APL	1,5	9	282	80,6	37,0
Jamili, APL	0,5	5	110	86,4	23,7
Rizal, APL	0,5	5	113	93,0	19,7
Buhari, APL	0,5	6	99	100	40,0
Average Survival rate				95,2	

Note: NPF = Nagari Paru Forest (Paru Village Forest); APL = Areal Penggunaan Lain (other land use)

Table 1 indicated that all plots showed high survival rate (>80%) showing planting activities achieved good result until its first evaluation by one-two months after planting. It is a hope that this positive trend would be maintained at least for the first two year of planting when this is the crucial time for the survival of the planted seedling at most of the cases.

Average height written in Table 1 actually may show higher value when areca nut species excluded from the measurement. It is indeed the cause for the lower value of average height in Jamili and Rizal plot since *pinang* species planted in both plots were shorter/lower compare to other locations. However, since both plots are nearly complete bare land, smaller size may gave benefit in reducing seedling stress grow in open area. Bigger size seedlings would be better for plots that have more shade since bigger seedling size would experience more evapotranspiration due to their number and higher area of leaves. The results of plant growth evaluations aged 1, 6 and 12 months after planting, obtained that plant height in 1 month after planting were in range 19,7 up to 47,0 cm. Showed on Table 2, height gain of 12 months old of plant in 6 months is ranged 2,1 cm until 15,6 cm at various species.

Table 2. Average height for each species at 6 and 12 Months After Planting (MAP)

Species	Height (cm)		Average ΔT (cm)	Diameter
	6 months	12 months		at 12 months (mm)
Mangosteen	24.8	35.2	10.4	-
Durian	44.8	53	8.2	13.8
Stink bean	34.1	49.6	15.5	16.5
Dog fruit	35.5	48.9	13.4	11.1
Areca nut	59.9	73.4	13.5	16.2
Agarwood	21.9	37.5	15.6	11.5
Dragon's blood	72,2	74.3	2.1	13.8
Rubber	66.9	78.3	11.4	12.6
Cinnamomum	26,9	36.8	9.9	10.1

Note: - mangosteen could not be measured because the height less than 1 m

As conducted by previous activities, periodic visits has evaluated the plant growth and successful rate of planting activities at 6 and 12 months after planted as well. Based on communal consensus, percentage of survived seedlings will be the major verifier to determine how much each farmer may get

the compensation from their lands. There are incentives will be delivered based on farmer's performance of plant growth. Incentives are designed to give more spirit and support for farmers to take care their land and trees seriously. Based on memorandum, numbers of survived seedlings will become a basic consideration for the incentives that will be accepted for each farmer.

It was obtained a good survival rate as well, respectively 95.2%, 94.5% and 93.5% as shown in Table 3.

Table 3. Suvival rate for each plot/land holder at 1, 6 and 12 Months After Planting (MAP)

Land Owner	Survival Rate of Seedling (%)		
	1 month	6 months	12 months
Iskandar	80.6	79.9	79.9
Mualim	99	97.4	97.0
Sahirman lelo	100	99.4	97.6
Madirman	94.1	99.1	99.2
Rizal	93	97.7	94.2
Buhari	100	100	100.0
Jamili	100	87.9	86.4
Average Survival Rate	95.2	94.5	93.5

Planted tree seedling and annual crop in agroforestry composition in this study which consist of dragon's blood (*D. draco*), mangosteen (*G. mangostana*), durian (*Durio zibethinus*), agarwood (*A. malaccensis*), dog fruit (*Archidendron pauciflorum),* stink bean/bitter bean (*P. speciosa)*, areca nut (*Areca catechu*), rubber (*H. brasiliensis*), cinnamomum (*C. burmanii*), ginger *(Z. officinale)* and galangal (*Alpinia galanga*) will give more opportunity to gain more benefits and advantages for community in next short and long period. Other research results also show that agroforestry farming in Sesaot Community Forest in West Lombok, provides economic benefits to the community. Candlenut and coffee are suitable to be developed in all strata, cocoa is suitable to be developed in second strata [3]. Agroforestry is a pattern of agriculture which is widely applied in all regions with varying extent in each region. It was based on a geospatial analysis of remote sensing derived from global data sets that investigate correspondence and relationship among tree cover, population density and climate conditions in agricultural land with a resolution of 1 km [4].

3.2. Potency of planted agroforestry species to sustain community livehood

Jernang rattan/dragon's blood (*D. draco*), mangosteen (*G. mangostana*), durian (*Durio zibethinus*), agarwood (*A. malaccensis*), dog fruit (*Archidendron pauciflorum),* stink bean/bitter bean (*P. speciosa)*, areca nut (*Areca catechu*), rubber (*H. brasiliensis*), cinnamomum (*C. burmanii*) have economical potency to sustain community livelihood.

In Paru Village Forest, dragon's blood that can be used for medicine, crafts, dyes, and sap is the type of non timber forest products (NTFPs) producer with the highest score. This was mainly due to the high sale value and abundance of dragon's blood. As a priority NTFPs, the stem's price of dragon's blood per kilogram (kg) can reach Rp.40.000 and fruit's price can reach Rp. 400,000. This price is higher than other NTFPs just Rp.5000 – 15.000. It is stated in one of study that there is diversity of absolute income of jernang rattan to annual household economies. It varied from 386 US dollars per adult equivalent units (USD/aeu) for Jernang collectors through 1389 USD/aeu for Jernang cultivators, and up to 2106 USD/aeu for entrepreneurs. In this case, collector households were the poorest group, both in terms of land ownership and income. The high relative contribution of Jernang to the incomes of cultivator households may prevent conversion of rural agroforestry systems to monocropping [5]. Another study highlight the possible importance of Protected Areas and adjacent areas as reservoirs of wildlife as well

[6]. The higher dependencies and demands for NTFPs, the greater is the possibility of high impacts on the local environment [7].

The types of planted species that provide more than three benefits are areca nut, cinnamon, and dragon's blood. Based on observation, areca nut can be used as a food-producing plant, medicine, craft material, color producer and building material while Cinnamon can be used as a food-producing plant, medicine, and building material. Durian (*Durio zibethinus*) were categorized in multi purpose tree species which has very deep root and tolerant of high acidity levels. Besides as food-producing plants, dog fruit (*A. pauciflorum) and* stink bean (*P. speciosa)* have shallow roots and tolerant of high acidity levels as well [8]. Besides its function to soil conservation, its fruit generated more income economically as well. In Paru Village Forest, dragon's blood, areca nut, and dog fruit are types of NTFPs that have a high enough potential sale value of more than Rp. 20 million per year. In another area, the adoption of a relatively sustainable agroforestry system in the main river basin in Sumatra with the main components of cinnamon tree (*Cinnamomum burmanii*) and legume-type soil cover able to avoid soil erosion [9]. Diversification in an agroforestry models are desirable policy objectives because they give individuals and households more capabilities to improve livelihood security and to raise living standards [10].

4. Conclusion

Seedling performance up to 12 months after planting is relatively good with a high average survival rate above 90%. The high survival rate and good performance of plant growth is due to the awareness of farmer group members in well manage such as weeding, make shading plant and replanting. Multipurpose tree species planting in agroforestry technique provide more opportunity to gain benefit and advantages to sustain livelihood development, especially dragon's blood (*Daemonorops draco*), durian (*Durio zibethinus*), dog fruit (*Archidendron pauciflorum),* areca nut (*Areca catechu*), and cinnamomum (*Cinnamomum burmanii*).

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Annex 1. Blank tally sheet

TALLY SHEET

Date/month/year :
Latitude/longitude :
Name of farmer group :
Name of plot/land owner :
Location :
Name of surveyor :

No.	Species	Diameter (mm)	Height (cm)	Note

Annex 2.

Table 4. Planting sites in each of land status in Paru Village Forest

Land status	**Managed by/owner**	**Area planted (Ha)**	**Initial condition**
Protection Forest	Madirman (Head of Kerapatan Adat Nagari)	2	Good tree coverage, forest stand
	Sahirman Lelo (Local conservationist)	2	Good tree coverage, forest stand
	Mualim	1	Good tree coverage, forest stand
Other Land Uses	Bukhari	0.5	Unplanted garden with shrubs,10 % tree cover, adjacent to *Hevea brasiliensis* old plantation
	Jamali	0.5	Bare land, dominated by shrubs and tall grass
	Rizal	0.5	bare land with no significant cover crops/grass
	Iskandar (Head of Paru Village)	1.5	Nearly bare, 20% tree cover

Table 5. Planting technique for different land uses type

Land status	Planting technique	Description
Protection Forest/NPF	Gap planting	- Seedlings were planted in gap within each plot site. Gap determined as area within plot that having less number of tree coverage and thus became an open area within the site compare to its surrounding. - Planting distance !/for each seedling was not determined strictly, consideration was decided based on the size and openness of gap itself. One spot of gap may contain or planted with several trees from 5-15 trees. - Gap planting also considered because its initial vegetation condition that planting sites still showed good tree coverage and more likely to take a forest stand-alike. - Species to be planted: mangosteen, durian, stink bean, dog fruit, cinnamomum, agarwood, rubber, and dragon's blood.
Other land uses/APL	IAR	- Seedlings were planted by Intensive Artificial Regeneration (IAR), which means planted intensively within the similar and definite planting distance (8 m x 8 m) - IAR considered to be applied because all the plot sites are in very open condition so that it needs to be managed intensively. However wider planting distance was applied here to be combined later by agroforestry technique for cover crop whenever the owner want to practice agroforestry technique within their land. - Seedlings to be planted: mangosteen, durian, petai, dog fruit, cinnamomum, agarwood, and rubber.