BIODIVERSITAS ISSN: 1412-033X
Volume 18, Number 2, April 2017 E-ISSN: 2085-4722
Pages: 765-772 DOI: 10.13057/biodiv/d180246

Tengkawang cultivation model in community forest using agroforestry systems in West Kalimantan, Indonesia

BUDI WINARNI[1,♥], ABUBAKAR M. LAHJIE[2,♥♥], B.D.A.S. SIMARANGKIR[2], SYAHRIR YUSUF[2], YOSEP RUSLIM[2,♥♥♥]

[1]Department of Agricultural Management, Agricultural Polytechnic of Samarinda.Jl. Samratulangi, Sei Keledang, Samarinda 75131, East Kalimantan, Indonesia. Tel.: +62-541-260421, Fax.: +62-541-260680, ♥email: bwinarni14@gmail.com.

[2]Faculty of Forestry, Mulawarman University. Jl. Ki Hajar Dewantara, Gunung Kelua, Samarinda 75116, East Kalimantan, Indonesia. Tel.: +62-541-735089, Fax.: +62-541-735379. ♥♥email: prof_abudir@yahoo.com, ♥♥♥ yruslim@gmail.com

Manuscript received: 2 November 2016. Revision accepted: 19 April 2017.

Abstract. *Winarni B, Lahjie AM, Simarangkir B.D.A.S, Yusuf S, Ruslim Y.2017. Tengkawang cultivation model in community forest using agroforestry systems in West Kalimantan, Indonesia. Biodiversitas 18: 765-772.* Tengkawang is the flora mascot of West Kalimantan and has long been supporting the life of people around the forest. Its fruit can be processed into fat which traded as 'green butter', 'borneo tallow', or 'tengkawang oil', which used as cocoa butter substitutes and the material for manufacturing lipstick, candle and drugs. Its wood was used as raw material for sawmill and plywood industries. Today, tengkawang tree existence is endangered and has been replaced with rubber plantations. The purposes of this research were to: (i) analyze the maximum growth increment of tengkawang; (ii) analyze the maximum production of tengkawang fruits and latex; (iii) analyze the financial feasibility of tengkawang cultivation and tengkawang combined with rubber; and (iv)formulate tengkawang cultivation model. The research used a descriptive method in survey form and interview technique by using questionnaire. The research result showed that the maximum growth increment of tengkawang which cultivated in monoculture (model 1) and tengkawang combined with rubber (model 2) were achieved at the age of 40 years. The maximum production of tengkawang fruit in model 1 and model 2 were achieved at the age of 64 years, while the maximum production of latex (model 2) was achieved at the age of 17 years. The cultivation of tengkawang by model 1 produced IRR of 12.3% and model 2 produced IRR of 12.9%. Financially, both cultivation models of tengkawang were feasible to be cultivated. Financially, tengkawang cultivation by using rubber in an agroforestry system was more profitable than tengkawang cultivation in monoculture.

Keywords: Financial analysis, increment, production analysis, tengkawang

INTRODUCTION

Tengkawang (*Shorea* spp.) is a name of tree species from genus *Shorea* that is long known in Indonesia. This tree belongs to a Dipterocarpaceae family (Kettle 2010). The natural distribution area for tengkawang includes India, Thailand, Malaysia, Indonesia, Sarawak, Sabah, and The Philippines (Kettle 2010; Saner et al. 2012; Widiyatno et al. 2014). In Indonesia, the tengkawang tree can be found in Kalimantan and Sumatera islands (Purwaningsih 2004; Kettle 2010). The largest tengkawang-producer region is located in the Province of West Kalimantan, specifically in Sanggau, Kapuas Hulu, Sintang, Pontianak, Sambas, and Ketapang Regencies. The tree has been familiar among people of the Dayak tribe owing to a long history of its traditional utilization and its field rotation plantation (*gilir balik*) system (Crevello 2004; Mulyoutami et al. 2009).

Tengkawang tungkul is a Dipterocarps tree whose seeds can serve as a source of plant-based fat. The seeds of tengkawang tungkul contain the highest fat content compared with those of other Merantispecies (*Shorea* spp.). Tengkawang tungkul fruit contains 40-60% edible fat (Jahurul et al. 2013). Furthermore, tengkawang tungkul is preferable by people in West Kalimantan because it produces bigger fruits. The harvested tengkawang fruits are processed in tengkawang fat factories in Pontianak to be exported to Japan and Europe as substitutes for chocolate butter in the chocolate industry (Purwaningsih 2004).

The presence of tengkawang trees in the natural forest becomes very less. According to Prasetyo et al. (2015), one of the underlying causes of this phenomenon has been the ever-increasing illegal logging and the exploitation done by permit holders of Timber Products Utilization Permits in Natural Forests (*Izin Usaha Pemanfaatan Hasil Hutan Kayu dalam Hutan Alam*, IUPHHK-HA). Recently, many of tengkawang trees have been cut down because of the low price of the fruit and the increasing demand for the timber as the hardwood tree becomes increasingly depleted in Kalimantan Island. Data from IUCN (2013) indicated that tengkawang tungkul is facing a high risk of extinction in nature (endangered).

Latest data from Statistics Indonesia showed that commercial transaction of tengkawang fat reached 1,072,104 kg in 1998 with a total export of US$ 3,997,560. Japan was the largest market for tengkawang fat (US$ 2,073,223), followed subsequently by Italy (US$ 663,925), Netherland (US$ 296,460), and Singapore (US$49,952) (Zulnely et al. 2012).

In addition to cultivating tengkawang, almost all Sanjan people in the research location cultivate rubber plant. In 2010, through a community forestry development program, almost all people of Sanjan in the research location have planted about 20,000 timber and latex-producing trees on the land area of 90 ha outside of the customary forest. From that total planted trees mentioned above, as much as 40% were rubber trees.In 2011, the local planted additional 50,000 endemic woody tree seeds in a land area of 125 ha, in which 20,000 of those trees were rubber tree seeds (Rufinus 2012). According to Statistics Indonesia (2016), in 2011, the smallholder rubber plantation area in West Kalimantan was 583,287 ha with a total production of 248,013 tons. In 2015, the area increased to 592,844 ha with a total production of 257,896 tons.

To stimulate people's interest to conserve trees, quantitative data on tengkawang cultivation in a community forest using agroforestry system is needed. Agroforestry is one of the suggested methods used for conserving biodiversity, producing food crops, and providing other ecosystem services such as, climate change and carbon deposition, owing to its land utilization system that consists of a mixture of hard plants with or without annual plants (Beenhouwer et al. 2016; Wiryono et al. 2016).

This study aimed to: (i) analyze the maximum growth increment of the tengkawang tree; (ii) analyze the maximum production of tengkawang fruit and rubber latex; (iii) analyze the financial feasibility of tengkawang cultivation and tengkawang-rubber tree combined plantation; (iv) formulate the model for tengkawang cultivation.

MATERIALS AND METHODS

Location and object of research

Sanggau District is a region in the province of West Kalimantan well known for its tengkawang fruit production. This study was conducted from January to November 2016 in Dusun Sanjan, Sungai Mawang Village, Sanggau District, Province of West Kalimantan, Indonesia (Figure 1). The research location was selected deliberately (purposive sampling), within which tengkawang tungkul trees were present and utilized by the locals. The potential of the tengkawang tree in the research location was still well-maintained because the locals upheld a local wisdom in managing the utilization of tengkawang trees.

The research object in this study included: (i) local community who cultivates tengkawang and rubber tree (as respondents); (ii) tengkawang tree that bear fruit and rubber tree that already been harvested; (iii) institution or agencies that provided information for this research, including, traditional leaders, the head of village and the head of district, as well as Department of Forestry and Plantation Sanggau District, West Kalimantan.

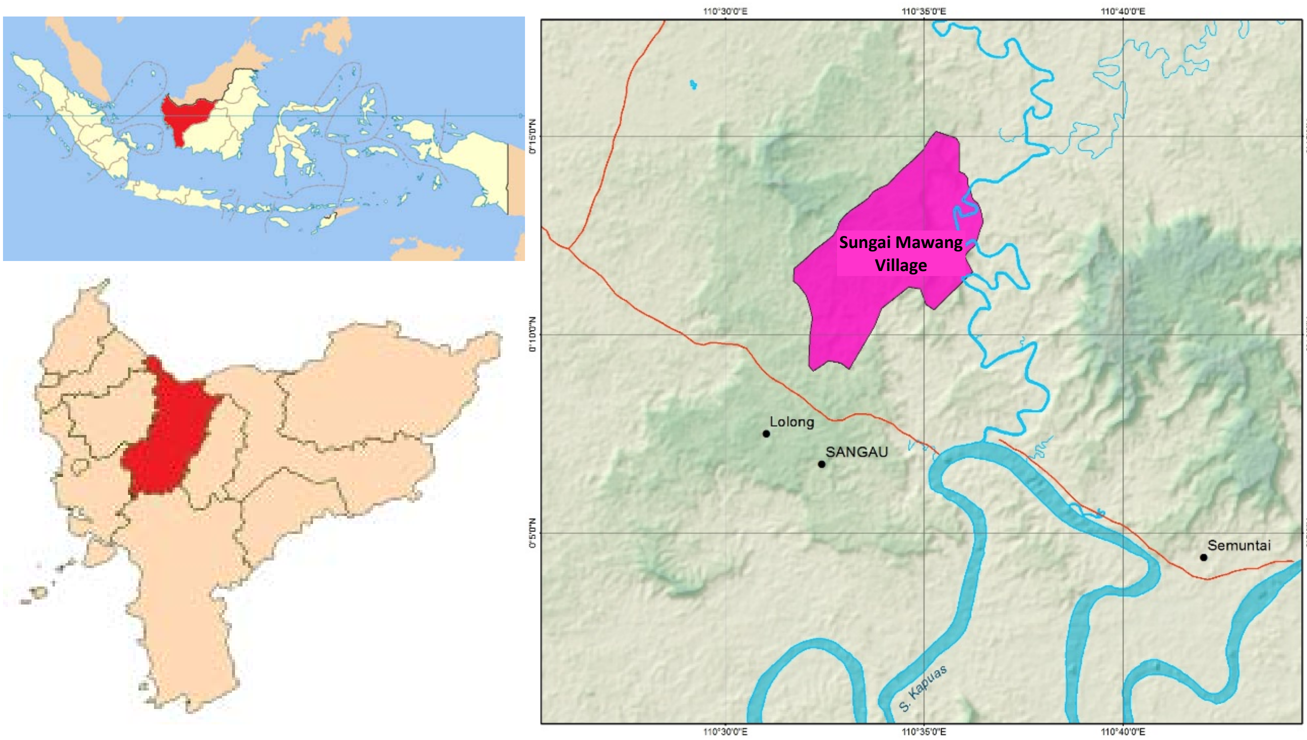

Figure 1. Research location in Dusun Sanjan, Sungai Mawang Village, Kapuas Sub-district, Sanggau District, West Kalimantan Province, Indonesia

Data collection

Data collection was done as follows (Linger 2014): (i) direct observation of the biophysics condition in the field regarding the operation of tengkawang and rubber tree cultivation, which included the type of activity, production cost, and revenue; (ii) literature review, which included data collection through studying the literatures and reports obtained from the agencies that were related to tengkawang and rubber tree cultivation in Sanggau District, Province of West Kalimantan, Indonesia; and (iii) in-depth interview and focus group discussion (FGD) and visitation to tengkawang oil factory in Pontianak to understand the prospect of tengkawang seeds processing as the raw material for tengkawang fat.

The collected primary data included production cost and revenue in tengkawang and rubber trees cultivation, and their marketing. The data sources from the field included local public figures, such as the traditional leaders, the head of the village, and the executive of related agencies, meanwhile, other informants were the locals who were, intentionally and unintentionally, met in the field (case informants). Primary data collection was conducted by a survey, observation, or structured interview using questionnaire, discussion, and direct interview with local tengkawang and rubber farmers. The in-depth interview was also carried out on regional government officers to dig up about the programs of the regional government related to tengkawang and rubber tree cultivation. The secondary data included the general condition of tengkawang and rubber tree management collected through literature review or reports from related agencies, including Department of Forestry and Plantation, Department of Industry and Commerce, and Statistics Indonesia.

Data analysis

Data analysis was including production analysis and financial analysis. There were two models analyzed in community forestry for tengkawang cultivation, (i) a monoculture cultivation of tengkawang, henceforth called model 1; and (ii) tengkawang in combination with rubber tree cultivation using an agroforestry technique, henceforth called model 2.

Maximum timber production was calculated by analyzing the growth increment of the tengkawang tree in a particular measurement time span (cycle), which included mean annual increment (MAI) and current annual increment (CAI). The increment is defined as an increase in the dimensional growth (height, diameter, base plane, volume) or an increase in the standing stock of a tree, in relation to the tree age or a particular period (Van Gardingen et al. 2003).

$$V = \frac{1}{4}\pi\, d^2\, h\, t\, f$$

In which: V = standing volume, d = diameter at breast height, h = branch-free height, f = form factor

$$MAI = \frac{V_t}{t}$$

In which: MAI = mean annual increment, V_t= total standing volume at age t, t = tree age

$$CAI = \frac{V_t - V_{t-1}}{T}$$

In which: CAI = current annual increment, V_t = total standing volume at age t, V_{t-1} = total stand volume at age t-1, T = time interval between each measurement age.

Analysis of maximum production of tengkawang fruit and rubber tree latex production for a particular measurement period (cycle) was done by calculating the average product (AP) and marginal product (MP) (Van Gardingen et al. 2003).

$$AP = \frac{P_t}{t}$$

In which: AP = average product, P_t = total production at age t, t = tree age

$$MP = \frac{P_t - P_{t-1}}{T}$$

In which: MP = marginal product, P_t = total production at age t, P_{t-1} = total production at age t-1, T = time interval between each measurement age.

The criterion used in evaluating the business feasibility was the internal rate of return (IRR). IRR is a mean annual return derived from an investment and expressed in percentage (Graves et al. 2007). IRR value indicates an interest rate that can be paid by a business, or in other words, the ability to gain income from the cost invested.

$$IRR = i_1 + \frac{(i_2 - i_1)(NPV_1)}{(NPV_1 - NPV_2)}$$

In which: NPV_1 = positive NPV, NPV_2 = negative NPV, i_1 = interest rate when NPV is positive, i_2 = interest rate when NPV is negative.

RESULTS AND DISCUSSION

Research location profile

Dusun Sanjan is administratively located in Sungai Mawang Village, Kapuas Subdistrict, Sanggau District, West Kalimantan Province. The geographical location of Sanggau District was 1°10' N-0°30' S and 109°49'-111°03' E. From Sanggau City, Dusun Sanjan can be reached in 20 minutes by motor vehicles. The total area of Dusun Sanjan is about 5,260 ha which consists of the settlement area, forest estate, and people's farm and orchard. The population of Dusun Sanjan was 416 people or 121 families. The majority of the population in Dusun Sanjan was Dayak Kodatn people and the main livelihood of the people came from dryland farming and rubber tapping.

Dusun Sanjan borders Dusun Ngkalet to the North, Dusun Sei Mawang and Dusun Rantau Prapat to the South, Dusun Nyandang to the East and Dusun Senunuk to the West. Topographically, Dusun Sanjan was dominated by hills and in it, there are a couple of rivers: Solang, Fang, Sabal, Sanjan, and Awik Rivers. Communally-held forest in Dusun Sanjan only consists of one tengkawang tree species, i.e. tengkawang tungkul.

Maximum production potential of tengkawang wood

Community forestry model using monoculture tengkawang tree plantation (model 1) was done using a plant spacing of 5 m x 4 m. The tree numbers decreased because of natural death. The growth increment potential of the model 1 (Table 1) and model 2 (Table 2) tengkawang showed that the mean annual increment (MAI) began to decrease at the age of 40 years.Based on Table 1 and Table 2, the graph of tengkawang tree standing volume increment was shown which was a relationship between the mean annual increment (MAI) and current annual increment (CAI), which can be seen in Figure 1 and 2. The graph exhibits certain characteristics, as follows: CAI curve rapidly reached the peak and from there decline immediately, whereas MAI curve both climbed and declined slowly (Dinga 2014; Muliadi 2017). Timber cutting rotation followed the biological cycle of the tree stand, in which the stand will be harvested when MAI is equal to CAI, i.e. the intersection point of MAI and CAI curves.

From the graph of the tengkawang tree standing volume increment in Figure 1 and 2, it was revealed that in the beginning, MAI was lower than CAI, and that CAI reached the peak preceding MAI. After reaching the peak, CAI decline and at a particular point intersected with MAI. The intersection point of the MAI and CAI occurred at the age of 40 years. After the intersection point, both MAI and CAI declined, indicating a decreasing trend in the volume increment. At the age of 40 years, the mean annual standing volume increment of the tengkawang tree has reached the maximum, indicating that the timber maximum production potential has been attained and the tree was ready to be cut down.

In model 2, tengkawang cultivation was combined with rubber tree using an agroforestry system. Both tree species were planted in a community forest estate. The plant spacing for tengkawang trees was 5 m x 4 m, while rubber trees were planted in between that tengkawang, making the plant spacing in model 2 narrower. According to Pompelli et al. (2010), there was a correlation between the tree density, the light intensity, the photosynthesis and the tree growth. The standing volume increment depended on the tree density constituting the standing (Muliadi et al. 2017). This correlation can be seen at the harvest age of 40 years, the MAI of model 1 (9.52 $m^3.ha^{-1}.year^{-1}$) was bigger than the MAI of model 2 (5.59 $m^3.ha^{-1}.year^{-1}$).

Maximum production potential of tengkawang fruit and rubber latex

Tengkawang bears fruit at the age of 8 years. The production potentials of model 1 and model 2 were presented in Table 3 and Table 4, respectively. Based on those tables, the maximum annual production (AP) did not increase at the age of 64 years. Tengkawang tree can still bear fruit until the age of 96 years. The production of tengkawang fruit was presented in Figure 3 and Figure 4. The intersection point between AP and marginal production (MP) indicates an AP maximum. In model 1 (Figure 3) and model 2 (Figure 4), tengkawang reached its maximum fruit production at the age of 64 years, with eachAP for model 1 and model 2 of 2.45 $tons.ha^{-1}.year^{-1}$ and of $1.30ton.ha^{-1}.year^{-1}$, respectively. These data also suggested that tree density affected fruit production.

Table 1. Growth increment potential of the model 1

Age (year)	n	d	h	f	V	MAI	CAI
8	400	9.5	9	0.87	22.19	2.77	-
12	370	13.0	12	0.85	50.07	4.17	6.97
16	350	16.6	14	0.83	87.98	5.50	9.48
20	340	20.3	15	0.81	133.63	6.68	11.41
24	300	24.2	17	0.79	185.22	7.72	12.90
28	280	28.0	18	0.77	238.84	8.53	13.40
32	250	32.1	19.3	0.75	292.71	9.15	13.47
36	230	35.5	21	0.72	344.04	9.56	12.83
40	**200**	**39.4**	**22**	**0.71**	**380.69**	**9.52**	**9.16**
48	177	44.0	23	0.70	433.09	9.02	6.55
56	128	51.4	25.5	0.69	467.08	8.34	4.25
64	99	58.0	27.3	0.68	485.32	7.58	2.28
72	79	64.0	29	0.67	493.55	6.85	1.03
88	70	72.8	30	0.58	506.73	5.76	0.82
96	60	79.8	31	0.55	511.39	5.33	0.58

Note: n = number of trees ($tree.ha^{-1}$), d = tree diameter (cm), h =branch-free height (m), f = tree form factor, V= total volume ($m^3.ha^{-1}$), MAI = mean annual increment ($m^3.ha^{-1}.year^{-1}$), CAI= current annual increment ($m^3.ha^{-1}.year^{1}$)

Table 2. Growth increment potential of tengkawang combined with rubber tree cultivation (model 2)

Age (year)	n	d	h	f	V	MAI	CAI
8	400	9	9	0.87	19.91	2.49	-
12	370	11	12	0.85	35.85	2.99	3.98
16	350	14	13	0.82	57.41	3.59	5.39
20	310	17	14.5	0.81	82.60	4.13	6.30
24	280	20	16	0.79	111.13	4.63	7.13
28	260	23	17	0.77	141.33	5.05	7.55
32	240	26	18	0.75	171.93	5.37	7.65
36	220	29.2	19	0.72	201.44	5.60	7.38
40	**200**	**32.6**	**20**	**0.67**	**223.58**	**5.59**	**5.54**
48	180	36.3	21	0.66	258.06	5.38	4.31
56	130	42	24.3	0.65	284.34	5.08	3.28
64	100	48.2	26	0.64	303.47	4.74	2.39
72	90	51.5	27	0.63	318.74	4.43	1.91
88	80	56	28	0.62	341.89	3.89	1.45
96	70	60	29	0.61	349.94	3.65	1.01

Note: n = number of trees ($tree.ha^{-1}$), d = tree diameter (cm), h =branch-free height (m), f = tree form factor, V= total volume ($m^3.ha^{-1}$), MAI = mean annual increment ($m^3.ha^{-1}.year^{-1}$), CAI= current annual increment ($m^3.ha^{-1}.year^{1}$)

Table 3. The production potential of tengkawang fruit in model 1

Age (year)	P	AP	MP
8	7.7	0.96	-
12	12.6	1.05	1.23
16	18.2	1.14	1.40
20	24.5	1.23	1.58
24	32.2	1.34	1.93
28	41.3	1.48	2.28
32	51.8	1.62	2.63
36	64.4	1.79	3.15
40	79.1	1.98	3.68
48	109.2	2.28	3.76
56	137.2	2.45	3.50
64	**156.8**	**2.45**	**2.45**
72	171.5	2.38	1.84
88	191.1	2.17	1.23
96	198.1	2.06	0.88

Note: P = total product ($ton.ha^{-1}$), AP = average annual production ($ton.ha^{-1}.year^{-1}$), MP= marginal annual production ($ton.ha^{-1}.year^{-1}$)

Table 4. The production potential of tengkawang fruit in model 2

Age (year)	P	AP	MP
8	6	0.75	-
12	9.6	0.80	0.90
16	13.4	0.84	0.95
20	17.4	0.87	1.00
24	21.8	0.91	1.10
28	26.8	0.96	1.25
32	32.5	1.02	1.43
36	39	1.08	1.63
40	46	1.15	1.75
48	60	1.25	1.75
56	73	1.30	1.63
64	**83**	**1.30**	**1.25**
72	91	1.26	1.00
88	104	1.18	0.81
96	110	1.15	0.75

Note: P = total product ($ton.ha^{-1}$), AP = average annual production ($ton.ha^{-1}.year^{-1}$), MP= marginal annual production ($ton.ha^{-1}.year^{-1}$)

Table 5. Latex production potential of rubber trees

Age	P	AP	MP
5	300	60.00	-
7	460	65.71	80.00
10	740	74.00	93.33
13	1090	83.85	116.67
15	1320	88.00	115.00
17	**1490**	**87.65**	**85.00**
20	1650	82.50	53.33
25	1750	70.00	20.00

Note: TP = total production ($kg.ha^{-1}$), AP = average annual production ($kg\ ha^{-1}.year^{-1}$), MP = marginal annual production ($kg.ha^{-1}.year^{-1}$)

A rubber tree is ready to be tapped for its latex at the age of 5 years and it continued to produce latex until the age of 25 years. The production potential of the rubber latex was shown in Table 5. From the AP and MP graphs shown in Figure 5, it was known that the maximum latex production was acquired at the age of 17 years, with an AP of87.65 $kg.ha^{-1}.year^{-1}$.

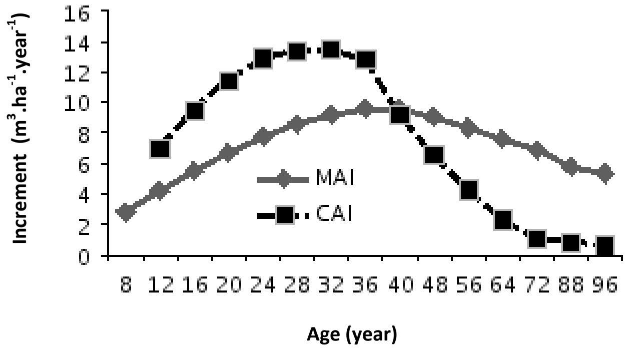

Figure 1. Standing volume increment of tengkawang tree of the model 1

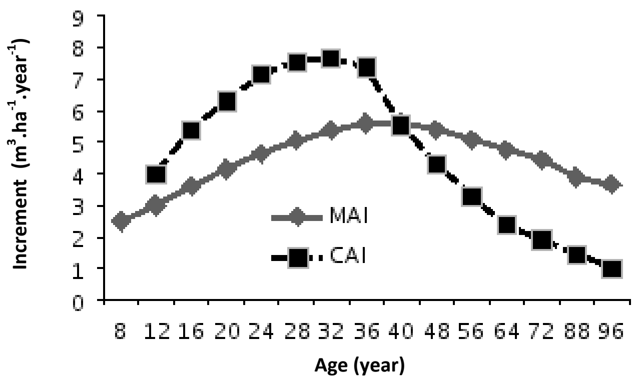

Figure 2. Standing volume increment of tengkawang tree of the model 2

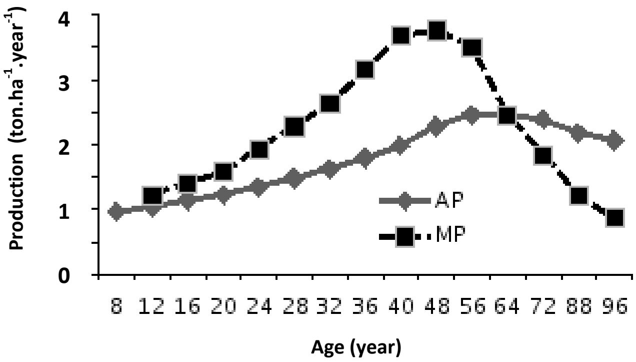

Figure 3. Tengkawang fruit production in model 1

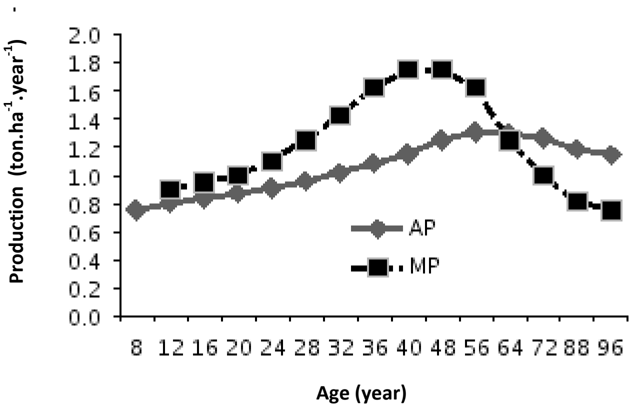

Figure 4. Tengkawang fruit production in model 2

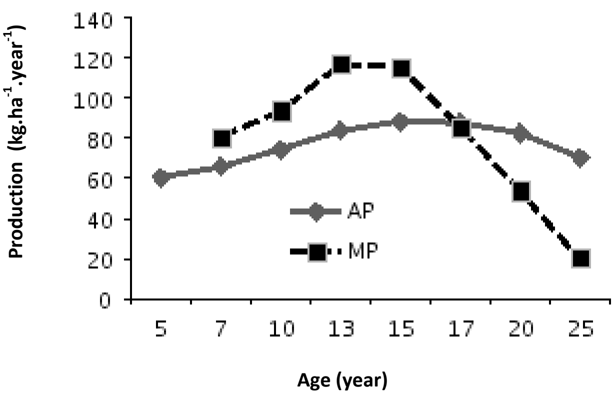

Figure 5. Rubber latex production in model 2

Tengkawang and rubber plants interacted each other to form a population of vegetation that resembles a forest condition. Currently, the locals still prefer cultivating rubber to tengkawang. This is because rubber latex can be tapped anytime, whilst tengkawang fruit can only be harvested once a year; the time for selling the collected rubber latex can be scheduled, thereby the farmers can sell it whenever the market price is high, whereas tengkawang fruit does not last long and often time its price falls during the harvest period; rubber tree can be tapped for as early as 5 years, while the harvesting of tengkawang fruit only starts when the tree reaches 8 years.

Financial feasibility of tengkawang cultivation model

In performing the financial analysis, data analyses on each activity step of tengkawang cultivation, cost component analysis, revenue from tengkawang cultivation business, and feasibility analysis using IRR parameter is necessary. According to Florian (2014), the cost for the forest cultivation was including the starting cost for preparing the field up to the cost of harvesting. Activities done in the tengkawang cultivation consisted of planning, field preparation, supplying seeds, planting, stitching, maintenance, and harvesting. Activities such as planning, field preparation, supplying seeds, and planting were done in the first year. Plant stitching was only conducted in the second year. The maintenance of the growing plants was done once every year, while the harvesting was started in the eighth year for tengkawang, and the fifth year for rubber tree.

The income source from tengkawang and rubber tree cultivation came from the tengkawang fruits, the rubber latex, tengkawang timber, and firewood. According to Martins et al. (2014), trees played important roles for people, as a source of firewood, wood for house construction, and medicine. The cash flow data was calculated from the cash outflows i.e. cost for tengkawang cultivation and the cash inflows i.e. tengkawang timber, firewood and fruits, and rubber latex sales which were all according to the market prices when this study was conducted. The local market prices of each commodity were: tengkawang timber Rp. 1,000,000 per m^3, firewood Rp. 100,000 per m^3, tengkawang fruits Rp. 2,750 per kg, rubber latex Rp. 6,500 per kg.

The financial analysis of tengkawang cultivation in the community forest used an internal rate of return (IRR) criterion, which is a discount rate that gives the result to a net present value (NPV) of zero. A feasible cultivation business is indicated by the IRR value that is bigger than the interest rate applied at the time when the investment taking place (Graves et al. 2007). The interest rate at the time of this study was 6% per year.

According to this calculation, the IRR at 96 years plant cycles of model 1 and 2 were 12.3% and 12.9%, respectively (Table 6). This result indicated that both of cultivation models were feasible to be undertaken because the profit was still far higher than the actual bank interest rate (6%). From this result, it showed that the tengkawang agroforestry (model 2) was a promising alternative to conserve tengkawang tree and to sustain the economy of the locals. The utilization of non-timber forest products contributed significantly to the economy of people settling around the forest (Jensen 2009; Rist et al. 2012; Dawson et al. 2014). Wood product consumption will keep increasing. Thus a method to reduce wood harvesting was necessary to be developed for the biodiversity in the tropical forest to be preserved (Ruslim et al. 2016). A well-conserved forest will benefit the people, economically and ecologically (Mönkkönen et al. 2014).

Table 6. Financial analysis recapitulation of tengkawang cultivation

Model	Commodity	Cycle (year)	NPV (Rp)		IRR (%)
			10%	15%	
1	Tengkawang	96	18,188,000	-20,242,000	12.3
2	Tengkawang and rubber	96	28,790,000	-20,146,000	12.9

Note: NPV = Net Present Value, IRR = Internal Rate of Return

Tengkawang cultivation using agroforestry system was adopted by the people West Kalimantan in the ex-areal of settlement (*kampung*) and farm field (*gupung*). In reality, the Dayak people were aware of the importance of tengkawang for their life, hence, they have essentially implemented a type of agroforestry practice by planting tengkawang, either in their yard or the field (Ibrahim 2012). The traditional agroforestry system is a centuries-old agricultural practice and has become an important agricultural model in the world, especially in the tropical and sub-tropical area, which is, from the economic, ecological, and socio-cultural viewpoints, profitable to the community who runs it (Weiwei et al. 2014). Agroforestry can be used as a strategy to prevent deforestation and land degradation (Minang et al. 2014); and as a strategy to reduce the CO_2 level in the atmosphere by increasing the C deposit in agricultural land (Hergoualch et al. 2012; Astiani and Ripin 2016). Agroforestry is a form of local wisdom coming from the local community to preserve biodiversity, in particular, tengkawang tree (ITTO 2011). Local wisdom is a value which is believed to be true by the locals and becomes a reference for those people to act upon in their daily life (Sumarniasih 2015; Muliadi et al. 2017). Local wisdom plays a pivotal role in the civilization development of society because it embodies elements such as intelligence, creativity, and local knowledge which are given by the society (Lokers et al. 2016).

The conclusions that can be derived from this study were that the maximum annual growth increment of tengkawang from model 1 and 2 was attained at the age of 40 years, namely as much as 9.52 $m^3.ha^{-1}.year^{-1}$and 5.59 $m^3.ha^{-1}.year^{-1}$.The maximum annual productions of tengkawang fruit from model 1 and 2 were 2.45 $ton.ha^{-1}.year^{-1}$and 1.30 $ton.ha^{-1}.year^{-1}$, respectively, which were achieved at the age of 64 years. Maximum production of latex rubber from model 2 was reached at the age of 17 years, which was 87.65 $kg.ha^{-1}.year^{-1}$. Tengkawang cultivation, either done by a monoculture system like the model 1 (IRR 12.3%) or carried out in combination with rubber tree like the model 2 (IRR 12.9%) were feasible to be implemented. Tengkawang and rubber cultivation model using agroforestry system were financially more profitable than monoculture tengkawang cultivation.

ACKNOWLEDGEMENTS

This study was supported by Kaltim Cemerlang Scholarship from the Local Government of East Kalimantan Province, Indonesia. The authors wish to thank Rufinus, Head of Sungai Mawang Village Consultative Body of Kapuas Sub-district, Sanggau District, West Kalimantan, who helped author's activities in the field.We thanks also to Umbar Sujoko for his contribute to creating the map of the study site.

REFERENCES

Astiani D, Ripin. 2016. The roles of community fruit garden (tembawang) on maintaining forest structure, diversity and standing biomass allocation: an alternative effort on reducing carbon emission. Biodiversitas 17 (1): 359-365.

Beenhouwer MD, Geeraert L, Martens J, Geel MV, Aerts R, VanderHaegen K, Honnay O. 2016.Biodiversity and carbon storage co-benefits of coffee agroforestry across a gradient of increasing management intensity in the SW Ethiopian highlands. Agric Ecosyst Environ 222:193-199.

Crevello S. 2004. Dayak land use systems and indigenous Knowledge. J Hum Ecol 16 (2): 69-73.

Dawson IK, Leakey R, Clement CR, Weber JC, Cornelius JP, Roshetko JM, Vinceti B, Kalinganire A, Tchoundjeu Z, Masters E, Jamnadass R. 2014. The management of tree genetic resources and the livelihoods of rural communities in the tropics: non-timber forest products, smallholder agroforestry practices and tree commodity crops. For Ecol Manag 333: 9-21.

Dinga E. 2014. On a possible predictor of the cyclical position of the economy. Procedia Econ Financ 8: 254-261.

Fischer J, Abson DJ, Butsic V, ChappellMJ, Ekroos J, Hanspach J, Kuemmerle T, Smith HG, Wehrden H. 2014. Land sparing versus land sharing: moving forward. Conserv Lett 7: 149-157.

Florian V. 2014. Priority ecosystems: risk and economic-social opportunities management strategies. Procedia Econ Financ 8: 320-326.

Graves AR, Burgess PJ, Palma JHN, Herzog F, Moreno G, Bertomeu M, Dupraz C, Liagre F, Keesman K, Van der Werf W, De Nooy AK, Van den Briel JP.2007.Development and application of bio-economic modelling to compare silvoarable, arable, and forestry systems in three European countries.Ecol Eng 29 (4): 434-449.

Hergoualch K, Blanchart E, Skiba U, Henault C, Harmand JM.2012. Changes in carbon stock and greenhouse gas balance in a coffee (*Coffea arabica)* monoculture versus an agroforestry system with Inga densiflora, in Costa Rica.J Agric Ecosyst Environ148: 102-110.

Ibrahim, Setiawati, Herlambang H, Burhan N, Fahrian F, Al-Hani F, Syamsiah N. 2012. Sustainable Harvest Level of Tengkawang Seed. ITTO Project PD 586/10 Rev.1 (F).

ITTO. 2011. Tengkawang potential in the land of local people in West Kalimantan. ITTO Brief Info 4: 1-2.

IUCN. 2013. International Union for Conservation of Nature.IUCN Red List of Threatened Species. Version 2013.2.

Jahurul MHA, Zaidul ISM, Norulaini NAN, Sahena F, Jinap S, Azmir J, Sharif KM, Omar AKM. 2013. Cocoa butter fats and possibilities of substitution in food products concerning cocoa varieties, alternative source, extraction methods, composition, and characteristics. J Food Eng1 17: 467-476.

Jensen A. 2009. Valuation of non-timber forest product value chains. For Pol Econ 11: 34-41.

Kettle CJ. 2010. Ecological considerations for using dipterocarps for restoration of lowland rainforest in Southeast Asia. Biodiv Conserv 19: 1137-1151.

Linger E. 2014. Agro-ecosystem and socio-economic role of home garden agroforestry in Jabithenan District, North-Western Ethiopia: Implication for climate change adaptation. SpringerPlus 3: 154.

Lokers R, Kanpen R, Janssen S, Van Raden Y, Jansen J. 2016. Analysis big data technologies for use in agro-environmental science. J Environ Model Software 84: 494-504.

Martins MB, Xavier A, Fragoso R. 2014. A bioeconomic forest management model for the Mediterranean forests: a multicriteria approach. J Multi-crit Decis Analysis 21: 101-111.

Minang PA, Duguma LA, Bernard F, Mertz O, Van Noordwijk M. 2014. Prospects for agroforestry in REDD+ landscapes in Africa. Environ Sustain 6:78-82.

Mönkkönen M, Juutinen A, Mazziotta A, Miettinen K, Podkopaev D, Reunanen P, Salminen H, Tikkanen OP. 2014. Spatially dynamic forest management to sustain biodiversity and economic returns. J Environ Manag 134: 80-89.

Muliadi M, Lahjie AM, Simarangkir BDAS, Ruslim Y. 2017. Bioeconomic and environmental valuation of dipterocarp estate forest based on local wisdom in Kutai Kartanegara, Indonesia. Biodiversitas 18 (1): 401-408.
Mulyoutami E, Rismawan R, Joshi L. 2009. Local knowledge and management of simpukng (forest gardens) among the Dayak people in East Kalimantan, Indonesia. For Ecol Manag 257: 2054-2061.
Pompelli MF, Martins SC, Antunes WC, Chaves AR, DaMatta FM. 2010. Photosynthesis and photoprotection in coffee leaves is affected by nitrogen and light availabilities in winter conditions. J Plant Physiol 167 (13):1052-60.
Prasetyo E, Hardiwinoto S, Supriyo H, Widiyatno. 2015. Litter production of logged-over forest using Indonesia selective cutting system and strip planting (TPTJ) at PT. Sari Bumi Kusuma. Procedia Environ Sci 28: 676-682.
Purwaningsih. 2004. Ecological distribution of Dipterocarpaceae species in Indonesia. Biodiversitas 5 (2): 89-95.
Rist L, Shanley P, Sunderland T, Sheil D, Ndoye O, Liswanti N, Tieguhong J. 2012. The impacts of selective logging on non-timber forest products of livelihood importance. For Ecol Manag 268: 57-69.
Rufinus. 2012. Sanjan Ompuk Tomawakng indigenous forests awaits recognition. In: Santosa A, Murhananto, Bintang S (eds).Community Forestry Communication Forum, Bogor.[Indonesia]
Ruslim Y, Sihombing R, Liah Y. 2016. Stand damage due to mono-cable winch and bulldozer yarding in a selectively logged tropical forest. Biodiversitas 17 (1): 222-228.
Saner P, Loh YY, Ong RC, Hector A. 2012. Carbon stocks and fluxes in tropical lowland dipterocarp rainforests in Sabah, Malaysian Borneo. PLoS ONE 7 (1): e29642. DOI: 10.1371/journal.pone.0029642
Statistics Indonesia. 2016.West Kalimantan in Figures. Badan Pusat Statistik Provinsi Kalimantan Barat, Pontianak. [Indonesia]
Sumarniasih MS. 2015. Erosion prediction for determination soil and water conservation based local wisdom in Ayung Watershed Bali, Indonesia. Agric Sci Res J 5 (5): 85-91.
Van Gardingen PR, McLeish MJ, Philips PD, Fadilah D, Tyrie G, Yasman I. 2003. Financial and ecological analysis of management options for logged-over dipterocarp forest in Indonesia Borneo. For Ecol Manag 183: 1-29.
Weiwei L, Wenhua L, Moucheng L, Fuller AM. 2014. Traditional agroforestry systems: one type of globally important agricultural heritage systems. J Resour Ecol 5 (4): 306-313.
Widiyatno, Soekotjo, Naiem M, Purnomo S, Setiyanto PE. 2014. Early performance of 23 dipterocarp species planted in logged-over rainforest. J Trop For Sci 26 (2): 259-266.
Wiryono, Puteri VNU, Senoaji. 2016.The diversity of plant species, the types of plant uses and the estimate of carbon stock in agroforestry system in Harapan Makmur Village, Bengkulu, Indonesia. Biodiversitas 17: 249-255.
Zulnely R, Gusti EP, Kusmiyati E. 2012. Utilization of Tengkawang. FORPRO 1 (2): 1-5.[Indonesia]