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FOSTERING THE SUSTAINABILITY OF COMMUNITY FORESTRY PROGRAM: CASE STUDY IN LAMPUNG-SUMATRA

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Abstract

Community Forestry Program in Indonesia (called HKm: *Hutan Kemasyarakatan*) as the scheme for recovering forest degradation from encroachment has been operating for 13 years now, but until nowadays there is no available guideline for fostering its sustainability (SUST). HKm Authority, however, still have 22–24 years remain to foster the program before the scheme due. It is in needing both economic and tree biodiversity indicators of every HKm's member land as the guidance for sustaining the program. The income as the economic indicator itself is commonly affected by the endogenous and exogenous variables. This research aimed at determining the roles of: (i) endogenous and exogenous variables on income agroforestry yield (INCM), (ii) INCM on tree biodiversity performance (BIODV), and (iii) BIODV on the HKm's SUST. Data collected by interviewing 230 members of HKm Jaya Lestari located in Way Kanan Regency-Lampung, Indonesia in February-May 2018. These HKm members consisted of four ethnic groups which the two are as the native (Semendonese and Lampungese) that more adaptive to agroforestry cultivation, whereas the remains (Javanese and Sundanese) are the offspring of people moved from Java Island under colonization program by Dutch Administration since 1905. We employed Ordinary Least Square regression postulate model to investigate the first purpose and Loglinear Regression to examine the second and the third purposes. Minitab Version 16 software was applied for the models' goodness-fits test and parameter optimization at 90 and 95% confident level. The research suggests: (i) endogenous variables with positive effect on INCM were the family size, participation in extension activities, land holding acreage, the tribes whose Sundanese and Semendonese were higher than Javanese, and with negative effect was the land elevation; whereas the exogenous variable affected negatively the rural facility construction and nursery demonstration plot activities; (ii) the higher INCM the higher BIODV, but (iii) the better BIODV the lower SUST will be. For the sake of pursuing SUST, it recommends to continue fostering HKm members by managing the endogenous variables in order to rise up INCM, and then multiply BIODV as well as to broaden HKm members' awareness on voluntary planting some wooden trees that have been adaptive or endemic at local region such as iron wood (*Fagraea fragrans* Roxb), cinnamon (*Cinnamomum verum* J. Presl), and *Shorea javanica.*

Key words: agroforestry, biodiversity, forest recovery, income, sustainability.

Introduction

Sustainability still remains a major theme in every development process since the Malthusian pessimism aroused in the early 19th century (Gleditsch 2021, Meiring 2020), including in the agrarian sectors (Pawlak and Kołodziejczak 2020, FAO 2017) that commonly susceptible to the socio-demographical dynamics, market pricing commodity shock, environmental disturbances, as well as macroeconomic or international policy changes as in Indonesia (Putra et al. 2021). The phenomena is also experiencing by almost all forest management programs in Indonesia including forest recovery from encroachment called HKm scheme (Wulandari and Inoue 2018). Forest encroachment itself was rampant during Indonesia underwent governmental reformation from authoritarian to democratization regime followed by forest decentralization to local government in the period of 1998 to 2001. According to Kelman (2013) during the period, especially in areas controlled by central government, such as protected forest areas, people perceive that they were free to act without any lawsuit of punishment. Besides, the poverty, meanwhile, accompanied by lacking of land holding as well as the limited government apparatus for controlling state own forest region were the major triggering on the encroachment phenomenon.

According to Sanudin et al. (2016) deforestation reached 54.56 % in Lampung Province, the province which most severely experienced deforestation in Indonesia during reformation and governmental decentralization period. So that this province was the first established HKm scheme. Under the schem, forest encroachers recruited as HKm member for 35 years, permitted to manage their claimed land by applying agroforestry gradually, forbidden cutting tree woods instead of non-wood products such as sap, latex, rattan, coffee fruit, vegetable, food crops, etc. This scheme can be considered as an incremental planning instead of radical planning due to limited resource or power. HKm schemes contribution on forest recovery can be indicated by the improved coverage forested area in Lampung Province.

According to Seno et al. (2018) in this province there has been forest cover improvement from 39,380 to 129,136 ha between 2001 and 2014. This improvement occurred particularly in the state own production forest and protected forest areas. Whereas the conservation forests or national parks were almost free from encroachment due to very tightly guarding activities. The improvement of forest coverage areas, further can contribute to the environmental services performance including microclimatic amenity, enhance ecological equilibrium, and at least to reduce infectious or zoonosis diseases incidence such dengue hemorrhagic fever (Seno et al. 2018, Mustika et al. 2016), malaria (Wigaty et al. 2016), pulmonary tuberculosis (Rosari et al. 2017), pneumonia (Adhyaksa et al. 2017), and avian influenza (Rohayati et al. 2018).

This significant progress of forest recovery that also contributed by HKm scheme, however, has never been examined for sustainability yet. It is important to note that the sustainability indicator is dynamic, always changes and even move down. The sustainability HKm program, therefore, must be nurtured, managed, and pursued by fostering some of determined variables. The important and relevant ones commonly used are both economic and tree biodiversity performance of every parcel of forest land as the indicators of sustainability of HKm programs in Batutegi and Liwa Forest Management Unit (Ruchyansyah et al. 2018, Wulandari et al. 2018). According to some researchers both indicators are trade off in a forest ecosystem. That condition was true for conventionally forest management in past, but not for agroforestry system currently.

Agroforestry system actually can afford both economic and biodiversity at once. The strata of vegetation are stake, pole, and seedling can be grown bellow the wood stumpages in it. This stratified tree trunk system means to compose tree biodiversity on one hand and can afford economic benefit for the farmers (Puspasari et al. 2017). Among them that can afford a highly economic benefit is for example cinnamon (*Cinnamomum verum* J. Presl), coffee (*Coffea canephora* Pierre ex A. Froehner) or cocoa (*Theobroma cacao* L.) for the stake and pole stratum respectively. There are so many vegetation species of seedling stratum that can afford highly economic benefit as well as to contribute the biodiversity enhancement, i.e. soybean, peanut, some vegetables, aromatic or medical herbs, etc. (Bakri et al. 2018).

Applying agroforestry system for HKm members, therefore, is a prominent way to meet their obligation for forest recovering besides providing for their family income. But, the farmers' ability certainly will be constrained by some endogenous and exogenous variables. Their stock of knowledge and skills, their physical capital, or productive asset available are the endogenous variables that are possibly controlled internally by HKm management. The skills and knowledge level, however, are commonly affected by their socio-demographic variables including age, sex, family size, education, culture or ethnicity, group involvement, participation in extension, access to information, and distance to market place (Idayanti et al. 2019). Besides, the skills and knowledge land acreage, the ownership of hand phone, grocery, fishpond, and motorbike will become productive capital that determines their productivity and will shed out in the form of their income later on. Additionally, the exogenous variable including the availability of rural public investment as well as the social safety net maybe impact to their income.

Triggering by some incentive that possibly could be generated by the economic benefits from miscellaneous agroforestry yields, it is normal to expect that the farmers will add various tree wood species voluntarily on their land, particularly whenever their income can be promoted by fostering the HKm authority. In line with this background, it is needed to build model prediction of farmer income as the function of both the endogenous and exogenous variables and then the income needs to predict tree biodiversity performance as well as the control HKm program sustainability. This research, therefore, was conducted with the aims of: (i) Modeling HKm members' INCM based on their endogenous and exogenous variables, (ii) Modeling BIODV performance based on INCM, and (iii) Modeling HKm sustainability program as the function of BIODV. These three series model will become reliable tools in planning to foster HKm Schemes sustainability endeavor in Indonesia.

Material and Methods

This study consists of field survey and data analyses, from February to May 2018. The field survey was conducted at Talang Mangga Village, Banjit District, Way Kanan Regency, Lampung Province, Indonesia (Fig. 1). Data were collected

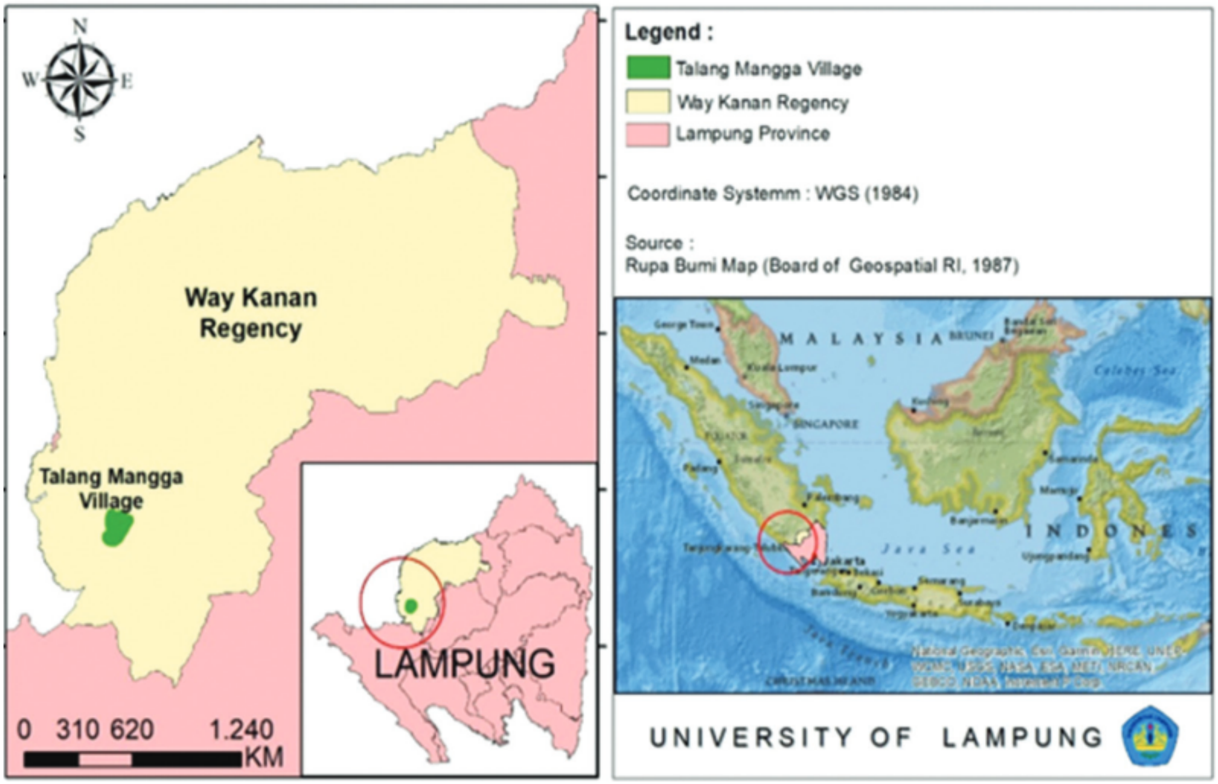


Fig. 1. Research location (GWKR 2016).

through interviews using questionnaires guidance to 230 HKm members. The cluster random sampling method on a population of HKm Mangga Jaya group members totaling 697 households and composed of 9 sub-groups. The sub-grouping was based on block area that may consist of one or more villages. The division followed the list that has been made since the beginning of HKm membership was formed. Each sub-group had about 73 to 76 households as members. Each one was treated as cluster.

We randomly drew samples of 25–26 households in each sub-group as potential respondents so total samples were 230 households, and we named this 230 respondents. As to the decision about 25–26 respondents as the minimum size of sample per sub-group is intended of having normal data distribution. According to the Central Limit Theorem (Johann Karl Gauss 1777–1855 as cited by Lunsford et al. 2006, Dinov et al. 2008, Ghasemi and Zahediasl 2012, Sang and Hae 2017) if the sample data size is large enough, it will follow a normal distribution regardless population distribution form. Sang and Hae (2017) and also Ghasemi and Zahediasl (2012) have proven a sample size of >30 is the golden rule to meet normal distribution, while according to Lunsford et al. (2006) and Dinov et al. (2008) the golden number of minimum size is 25 members.

Model approach and testing hypotheses

In accordance with the aim of this research there are three measured response variables: 1) farmers' income of agroforestry yield (INCM), 2) tree biodiversity indices (BIODV), and 3) sustainability of HKm program indices (SUST). As for the surrogate of three are explained in the following.

Model I: Farmer income

Farmer INCM is intended to depict their welfare under HKm program. In this research, ECNM is measured by using the total income per family per annum, the income from cultivation on HKm land only, such as latex (rubber sap), coffee bean, areca nut, etc. Increased INCM is expected to become an important variable in determining the improvement of BIODV of every land parcel which belongs to HKm members. BIODV itself is a good indicator of the forest ecosystem recovery process particularly agroforestry system instead of monoculture cropping pattern.

According to Idayanti et al. (2019), INCM is significantly influenced by age, sex, and number of dependents. While as reported by Puspasari et al. (2017), there are no real differences between ethnicities in earning income. Setiawan et al. (2014), however, proved that in this study area Javanese ethnicity was more resilient in increasing their income than ethnic Lampung and others in making the living. Meanwhile, in the local forestry institution namely KPH Bukit Punggur (2014) Strategic Plan document, it is stated that the HKm members in this research area are composed of Javanese, Sundanese, Lampung, and Semendo ethnic groups. The first two are immigrants while the others are native who are very adaptive to agroforestry cultivation legacy from their ancestor. The ethnicity can be considered as the surrogate of a traditionally cultural bundle that have accumulated day by day along history. The different ethnicity can be utilized for contrasting skills and local knowledge in relation to their productivity in agroforestry cultivation. This variable, therefore, should be counted on every community development plan included in the fostering to behave more efficiently in earning from agroforestry yields (INCM). The earning, in turn, will be the basic for stimulating HKm member to plant wooden tree crops other than rubber. INCM modeling functioning as the endogenous and exogenous variables of household in detailed is summarized in Table 1. Model I as the INCM prediction is expressed in formula (1):

$$INCM_i = \alpha_o + \alpha_1 AGE_i + \alpha_2 SEX_i + \alpha_3 FMLSZ_i + \alpha_4 VDAM_i + \alpha_5 GADM_i + \alpha_6 AJOB_i + \alpha_7 CLVTN_i + \alpha_8 D1\_ELS_i + \alpha_9 D1\_JHS_i + \alpha_{10} D2\_SND_i + \alpha_{11} D2\_SMD_i + \alpha_{12} D2\_LPG_i + \alpha_{13} LHLD_i + \alpha_{14} UPLN_i + \alpha_{15} RICEF_i + \alpha_{16} GOAT_i + \alpha_{17} FPOND_i + \alpha_{18} MBIKE_i + \alpha_{19} GCERY_i + \alpha_{20} TVOW_i + \alpha_{21} HPOW_i + \alpha_{22} EXTN_i + \alpha_{23} ELVT_i + \alpha_{24} DLND_i + \alpha_{25} DVLM_i + \alpha_{26} DDST_i + \alpha_{27} RINVT_i + \alpha_{28} SCNET_i + \alpha_{29} NURSY_i + €_i, \quad (1)$$

where: INCM is income from agroforestry yield of respondents; $\boldsymbol{\alpha}_0$ is intercept; $\boldsymbol{\alpha}_{1\text{-}29}$ are parameter Model I; € is residual error Model I; i=1, 2, …, 230 are respondent numbers; the other symbols correspond to the symbols in Table 1.

The working hypothesis Model I is expressed in the following:

- *Ho*: $\alpha_1 = \alpha_2 = \alpha_3 = \ldots = \alpha_{29} = 0$ (among the 29 variables enlisted in Table 1, there is no variable that affect the family's income significantly);

- H_1: $\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \ldots \neq \alpha_{29} \neq 0$ (among the 29 variables enlisted in Table 1, at least there would be one variable that affects the family's income significantly).

The testing hypothesis and optimization parameters process for Model I was conducted by applying Minitab 16. The Fisher statistic employed to examine the goodness fits test for the Model I at confi-

Table 1. The endogenous and exogenous variables of family head and their data scoring in model employed as well as the expected sign in regression result.

Group of variable and the variables	Symbol	Unit or data scale measured	Scoring	Expected Sign in Regression: Brief explanation in relation to the income per family	
Social demographic*					
1. Age	AGE	year	integer number	-	: the older the lessen their productivity will be
2. Sex	SEX	categorical	=1 if man; =0 if other	+	: man more powerful in cultivation than woman
3. Family size number	FMLSZ	person	integer number	+	: the more person the more income
4. Role in village administration	VADM	-	=1 if village administrator	+	: will earn more access to information and power
5. Role in HKm group	GADM	-	=1 if administrator of HKm	+	: will earn more access to information and power
6. Additional job	AJOB	-	=1 if any	+	: will bring other source of income
7. Cultivation applied	CLTVN	-	=1 if agroforestry; =0 if monoculture	+	: who applied agroforestry have miscellaneous yield so that more secure from cropping failure as well as from pricing market shock
Education level* (0 = never schooling)					
8. Dummy elementary school	D_1_ELS	dummy	=1 if elementary; =0 if others	+	: graduate ELS more innovative then who never schooling
9. Dummy junior high school	D_1_JHS	dummy	=1 if junior high sch.; =0 if others	+	: graduate JHS more innovative then who ELS
Ethnicity* (0 = Javanese tribe)					
10. Sundanese	D_2_SND	dummy	=1 if Sundanese; =0 if others	-	: Sundanese less adaptive in agroforest than Javanese
11. Semendonese	D_2_SMD	dummy	=1 if Semendonese; =0 if others	+	: Semendonese more adaptive than Javanese
12. Lampungnese	D_2_LPG	dummy	=1 if Lampungnese; =0 if others	+	: Lampungeses the most adaptive in agroforest
Productive assets*					
13. Total land holding acreage	LHLD	ha	rational number	+	: the more total land holding the more income
14. Up land acreage inside HKm area	UPLN	ha	rational number	+	: the more up land in HKm area the more income

Group of variable and the variables	Symbol	Unit or data scale measured	Scoring	Expected Sign in Regression: Brief explanation in relation to the income per family	
15. Rice field inside HKm area	RICEF	ha	rational number	+	: the more rice field in HKm area the more income
16. Goat number ownership	GOAT	ha	integer number	+	: the more number goat the more income
17. Fish pond ownership	FPOND	categorical	=1 if own; =0 if other	+	: who owe fishpond will earn more income
18. Motorbike ownership	MBIKE	categorical	=1 if own; =0 if other	+	: who owe motor bike will earn more income
19. Small grocery shop ownership	GCERY	categorical	=1 if own; =0 if other	+	: who owe small grocery will earn more income
Information and physical accessibility*					
20. TV ownership	TVOW	categorical	=1 if own; =0 if other	+	: who own TV will have more productive information
21. HP ownership	HPOW	categorical	=1 if own; =0 if other	+	: who own HP will have more productive information
22. Extension participation	EXTN	-	=1 if active =0 if other	+	: who participate in extension have more productive
23. Elevation of land area	ELVT	m a.s.l.	rational number	-	: the higher the more effort and the less income
24. Distance to land area	DLND	minutes by bike	rational number	-	: the farther distance the more time or transportation cost needed
25. Distance to village market	DVLM	minutes by bike	rational number	-	: the farther distance the more time or transportation cost needed
26. Distance to subdistrict centre	DDST	minutes by bike	rational number	-	: the farther distance the more time or transportation cost needed
Beneficiary from rural facility investment**					
27. Rural facility investment	RINVT	-	=1 if any; =0 if other	-	: public investment activities project such as rural road improve will make trade off time and negatively impact to agroforestry activities
28. Social safety net	SCNET	-	=1 if any; =0 if other	+	: social safety net also will affect positively to income
29. Nursery demonstration plot	NURSY	-	=1 if any; =0 if other	+	: the plot will affect positively to the farmers skill and their income

Note: * endogenous variables, ** the exogenous variables.

dent level of 90 and 95 %. Then to depict every parameter of predictor variables we employed the T statistic at confident level of 90 and 95 % as well.

Model II: Tree biodiversity prediction model

As mentioned before Model II is intended to predict the probability of tree biodiversity improvement of every land parcel belonging to HKm members. Model II is predicted by single variable of INCM. It is expected to express that HKm members will add more tree species voluntarily at their land whenever their INCM is risen up. In order to depict this objective, we employed the Loglinear Regression or Logistics Regression that expressed in the formula (2):

$$Ln\frac{p(BIODVi)=1}{1-p(BIODVi)=1} =$$

$$= \beta_0 + \beta_1 INCM_i + \xi_i, \qquad (2)$$

where: *Ln* is logarithm operator using the natural number (e = 2,718...) as the basis; $p(BIODV_i) = 1$ are the probability of being succeeded in improving tree biodiversity of the respondent i^{th}; $1–p(BIODV_i) = 1$ are probability of being fail in improving tree biodiversity of respondent i^{th}; β_0 is intercept; β_1 is parameter Model II; ξ_i is residual error Model II; *i* = 1, 2, …, 230 are respondent numbers.

The working hypothesis of Model II is expressed in the following:

- H_0: $\beta_1 = 0$ (family income does not affect tree biodiversity performance significantly);

- H_1: $\beta_1 \neq 0$ (family income affects tree biodiversity performance significantly).

For H_1 above, a positive number of parameter β_1 was expected that would be produced later on through optimization process using statistical software of Minitab 16. Gald statistics was employed to test the goodness fits of model. Whereas the significance of parameter model was tested by employing Wald statistics. Both Gald test and Wald test were employed at confident levels of 90 and 95 %.

Model III: HKm program sustainability prediction model

Model III is intended to predict SUST by using single predictor variable of BIODV. The model III is expressed in the formula (3):

$$Ln\frac{p(SUSTi)=1}{1-p(SUSTi)=1} =$$

$$= £_0 + £_1 BIODV_i + \pi_i, \qquad (3)$$

where: *Ln* and *i* are as in formula (2); $p(SUST_i)=1$ is the probability of respondents – i^{th} succeeded to support HKm program sustainability; $1–p(SUST_i) = 1$ is the probability of respondents – i^{th} fail to support HKm program sustainability; $£_0$ is intercept; $£_1$ is a parameter Model III; π_i is residual error of Model III.

The working hypothesis Model III is expressed in the following:

- H_0: $£_1 = 0$ (tree biodiversity performance does not affect the sustainability program significantly);

- H_1: $£_1 \neq 0$ (tree biodiversity performance affects the sustainability program significantly).

Also in Model III, a positive number of parameter $£_1$ was expected that would be produced by optimization process using statistical software of Minitab 16. Gald statistics was employed to test the Goodness fits of the model. Whereas the significance of parameter model was tested by employing Wald statistics. Both Gald test and Wald test were employed at confident levels of 90 and 95 %.

Results and Discussion

Result in descriptive statistics

Very firstly we need to describe three variables that were used as the respond variables in the three models regression, namely [INCM], [BIODV], and [SUST]. Having displayed the descriptive statistics of their respond, the three modeling results will be provided consecutively later on. It is important to note from data gathered of the field survey, that lowest [INCM] was USD 10 and the highest was USD 1,608 per year. Briefly distribution of [INCM] is provided in Table 2. Based on this term, the dominant class [ICNM] was less than USD 300 per year, with the frequency of 143 families (62.2 %). This fact can be treated as the bench mark in planning to enhance INCM from agroforestry earning that have to be fostered by HKm scheme.

Table 2. Proportion of families based on their income (n=230).

No	Income class, USD/year	Frequency	Proportion, %
1	<300	143	62.2
2	301 - 600	38	16.5
3	601 - 900	31	13.5
4	901 - 1200	9	3.9
5	1201 - 1400	7	3.0
6	>1400	2	0.9
Mean= 351	Minimum =10	Maximum =1,608	Sd=340

As for [BIODV] is defined by addition the wooden tree crop that have planted and successful to grow, the number addition of wooden tree then are grouped in three classes BIODV namely: low, moderate, and high. The moderate class is defined in between 3 to 5 species added, while beyond both boundaries are low and high classes of BIODV respectively. The distribution BIODV is described in Table 3. From this table we can appraise for forestry workers, who have been striving their effort to recovery forest degradation (Bakri et al. 2018, Chamberlain et al. 2019). It is the fact that for 11 years HKm's program operating only did 1.7 % or 4 parcels of land covered by the high BIODV. The dominant is still 54.4 % (125 parcels) - low in tree biodiversity performance (BIODV). This fact can be treated as the bench mark in planning to speed up the forest recovery program under HKm scheme as well.

Table 3. Proportion of families based on tree biodiversity.

No	Tree biodiversity class	Frequency	Proportion, %
1	Low	125	54.4
2	Moderate	101	43.9
3	High	4	1.7

The third respond variable is classified as *yes* or *no* in supporting HKm's SUST. The distribution of this data is provided in Table 4. It is important to note that the criterion for separating into two classes (*yes versus not*) is the compliance of HKm's members to plant the additional wooden tree crops on their land even though without any financial assistant from HKm authority or from other sources. In case a member comply is '*yes*' – to support the probability of HKm's sustainability program. The revers is as '*no*'. This distribution is depicted in Table 4. The table displays more than half of the families do not support yet the probability of HKm's SUST. This fact should be taken into account in developing programs to foster it.

For the sake of pursuing the guidelines to foster SUST, we need to examine the relationship among the three variables consecutively in series models regression. Having known which ones among both endogenous and exgenous variables (Tabel 1) that significantly affect INCM, we then can estimate or predict BIODV performance. We, furthermore, use the predicted BIODV to examine the SUST. The three regressions model is presented below.

Table 4. Proportion of families who support the probability of HKm's sustainability program.

No	Family who support	Frequency	Proportion, %
1	Yes	87	37.8
2	No	143	62.2

Result of the regression models

Model I is to explain the role of both the endogenous and exogenous variables in determining family income from agroforestry yield (INCM) in HKm land. The goodness of fits test result for Model I applied is provided in Table 5. Meanwhile the optimization parameter of variables affecting INCM can be seen in Table 6.

By referring to *P* = 0.000 (Table 5), it means that we have had no enough facts to reject H_1 (that also means there is no enough facts to accept H_0). In other words, Model I is valid or robust predictor model of INCM based on both endogenous and exogenous variables of every family at the study area. In addition, *P* = 0.000 does not mean that this predictor model can predict 100% correctly or without any making miss prediction, but only below 1 % and maximum 0.04 % (=0.0004) miss prediction. It is important to realize that there is no breaking any mathematical rules in case we write this *P* = 0.0004 because this number is approximately the same with the original number namely *P*=0.000 as the output of Minitab process. But *P* = 0.0004 can help the interpretation about the robustness Model I obtained. It tells us that if we applied the model for predicting INCM based on the 29 predictor (Table 1, the endogenous and exogenous) variables to predict 10,000 families, we will get very high precision of predicted INCM, i.e. there will be maximum 4 families that miss predicted than the actual ones. Briefly, the confident level of Model I is more than 99 %.

Table 5. Analysis of variance of role independent variables on family income.

Source	Degree of freedom	Sum square	Mean square	F	*P*
Regression	33	18354608	632918	15.60	0.000
Residual error	195	8073640	40571		
Total	228	5404.31			

Note: *S* = 201.423; R^2 = 69.5 %; R^2-adj. = 65.0 %. *S* = root square of total variances, R^2-adj= R^2 adjusted to sample size; F = Fisher statistic value; *P* = Probability to miss prediction.

Table 6. Parameter optimization of socioeconomic variables that affected family income.

Predictor	Symbol	Coeff.	SE Coeff.	T	P
Constant	-	330		1.24	0.215
Social demography					
1. Age	AGE	-0.413	1.203	-0.34	0.731
2. Sex	SEX	27.350	55.049	0.50	0.620
3. Family size number	FMLSZ	29.441	9.692	3.04	**0.003**
4. Role in village administration	VADM	-0.503	60.294	-0.01	0.993
5. Role in HKm group	GADM	-855.245	1283.217	-0.67	0.506

Predictor		Symbol	Coeff.	SE Coeff.	T	P
6.	Additional job	ADJOB	-4.385	46.455	-0.09	0.925
7.	Cultivation applied	CLTVN	841.259	1134.266	0.74	0.459
Education level (0 =never schooling)						
8.	Dummy elementary school	D_1_ELS	71.545	54.972	1.30	0.195
9.	Dummy junior high school	D_1_JHS	7.965	57.951	0.14	0.891
Ethnicity (0 = Javanese tribe)						
10.	Sundanese	D_2_SND	114.448	41.203	2.78	**0.006**
11.	Semendonese	D_2_SMD	130.476	48.189	2.71	**0.007**
12.	Lampungese	D_2_LPG	51.818	1108.392	0.47	0.640
Productive assets						
13.	Total land holding acreage	LHLD	278.203	18.748	14.84	**0.000**
14.	Up land acreage in Hkm area	UPLN	9.874	47.755	0.21	0.836
15.	Rice field inside HKm area	RICEF	-64.881	61.776	-1.05	0.295
16.	Goat number ownership	GOAT	-4.154	33.112	-0.13	0.900
17.	Fish pond ownership	FPOND	18.559	33.580	0.55	0.581
18.	Motorbike ownership	MBIKE	-35.692	37.804	-0.94	0.346
19.	Small grocery shop ownership	GCERY	-24.622	40.105	-0.61	0.540
Information and physical accessibility						
20.	TV ownership	TVOW	-12.063	39.797	-0.30	0.762
21.	HP ownership	HPOW	-34.566	45.140	-0.77	0.445
22.	Participation in Extension	EXTN	166.790	35.622	4.68	**0.000**
23.	Elevation of land area	ELVT	-0.503	0.175	-2.88	**0.004**
24.	Distance to land area	DLND	-1.601	5.175	-0.31	0.758
25.	Distance to village market	DVLM	-1.601	5.175	-0.31	0.758
26.	Distance to district centre	DDIST	-4.021	3.797	-1.06	0.291
Beneficiary from rural facility investment						
27.	Rural facility investment	FIVST	-171.825	45.531	-3.77	**0.000**
28.	Social safety net	SCNET	68.657	63.245	1.09	0.279
29.	Nursery demonstration plot	NURSY	-199.587	40.685	-4.91	**0.000**

Note: the bold numbers are significant at level <1.0 %; T=the critical value of T statistic.

As for which ones among the 29 variables that affect ICNM significantly, we must examine their probability to miss (*P*) in Table 6. It connoted that there are eight variables affecting INCM significantly with *P* < 1 % (or confident level more than 99 %) namely the variables of the family number size (FMLSZ), the ethnicity where the Sundanese (D_1_SND) and Semendonese (D_1_SMD) compare to Javanese, land holding acreage (LHLD), participation in extension (EXTN), land elevation position (ELV), rural investment facility (FISVT) and nursery development plot project (NURSY). In other words, against these eight variables, there is no enough facts to reject H_1 (or all at once to accept H_0). Additionally, that the last two variables mentioned happen to be the exogenous variables where the others six are the endogenous variables. Fortunately the effect of the six endogenous ones are in the same direction with the INCM, the better quality of each variable the better

INCM will be. On the contrary, in case the activities of both FISVT and NURSY exist, the INCM will reduce significantly.

As for the 21 variables remain on the contrary, there is no enough facts to reject H_0 (or all at once to accept H_1). All these variables have any significant effect to INCM. As mentioned before, Model II is intended to explain BIODV based on INCM. The goodness fits test of Model II as well as the significance effect of INCM on BIODV is provided in Table 7. This table depicts that there is no enough facts to reject H_1 (and all at once to accept H_0). In other words INCM affects significantly BIODV. In case INCM at average rises up as much as one USD per year, BIODV will improve by 1.13 as indicated by its Odds Ratio and this improvement is very significant that indicated by its *P*-value = 0.000 or with confident level more than 99 %.

Developing Model III is motivated by seeking some clues to compose a guideline for fostering every HKm member in order to contribute the probability increase of HKm's SUST. The goodness fits test of Model III as well as the significance effect of BIODV as the predictor of SUST is provided in Table 8.

Table 7. Wald test of Model II: effect of income to BIODV.

Predictor	Symbol	Coefficient	SE Coeff.	Z	*P*	Odds Ratio	95% confident interval (CI)	
							Lower	Upper
Constant	-	-0.330442	0.200843	-1.65	0.100	-	-	-
Income	INCM	0.122602	0.034123	3.59	0.000	1.13	1.06	1.21

Note: Log-Likelihood = -149.873; Test that all slopes are zero: G = 15.685, DF = 1, *P*-value = 0.000. G = Gald statistic; *Z* = Coeff./SE coefficient; P = probability to miss of separately predicted β_0 or β_1 numbers; *P*-value = probability to miss of predicted BIODV using ECNM.

Table 8. Wald test of Model III: effect of BIODV to HKm SUST.

Predictor	Symbol	Coefficient	SE Coeff.	Z	P	Odds Ratio	95% confident interval (CI)	
							Lower	Upper
Constant	-	-0.138836	0.199487	-0.70	0.486	-	-	-
Tree Biodiversity	BIODV	-0.660920	0.275737	-2.40	0.017	0.52	0.30	0.89

Note: Log-Likelihood = -149.637; Test that all slopes are zero result: *G* = 5.801; *DF* =1; *P*-value = 0.016. *G* = Gald statistic; *Z* = Coeff./SE coeff. P = probability to miss of separately predicted $£_0$ or $£_1$ numbers; *P*-value = probability to miss of predicted SUST using BIODV.

Table 8 indicates that there is no enough facts to reject H_1 (all at once to accept H_0). It means that BIODV is a reliable variable to predict HKm's SUST. But unfortunately, in case the BIODV improve from low to moderate or to high levels, the probability HKm program become sustain (SUST) would be reduced by 0.52 as indicates by its Odds Ratio with confident level is more than 98.3% as indicated by its *P*=0.017.

Discussion

Role of demographic variables on income

Among the demographic variables, only FMLSZ variable affects INCM, if the other variables are constant, a family who has more than one family member will have an increase in income around USD 29.441 per year. The effect of addition of labour supply (family members) to the region is very significant (P = 0.003). This phenomenon means that the marginal labour productivity in the region is still positive in stimulating INCM. Because the core business of HKm authority is to release this protected forest from human occupation, it is a must to employ policy to enhance labour skills by extension or training program instead of mobilizing labour from outside area (Idayanti et al. 2019). Training in silviculture techniques cycle from seedling to post harvesting will make labour augmented by knowledge and technology, in turn will increase their work productivity and then lessen the excess demand of traditional labour (Supriadi et al. 2018). This finding is congruence with the effect of LHLD that will be elaborated below.

The other variables of demographics, namely: age, sex, role in village administration, role in a HKm group, additonal job, and cultivation applied do not affect significantly INCM. As depicted in Table 5, there is no significant effect of SEX, as INCM is relatively the same. Similar to SEX is the variable of CLTVN, a family applying an agroforstry pattern indeed has a higher INCM than that using monoculture, but the difference is not significant (P = 0.459).

Another AGE variable shows that INCM will decrease with increasing age of the family heads each year, however, the effect is not significant (P = 0.731). This reflects the agricultural work in the region is resilient enough to change in age of the farmers. So are the effects of the variables of VADM, GADM, and ADJOB. INCM of the family heads involved VADM are commonly lower than those free from that affair, but the difference is not significant (P = 0.993). It is similar to GDAM, with P = 0.506. Both cases suggest that voluntary work does not significantly disturb families in making a living. An interesting fact there is the effect of ADJOB such as construction labour, pedicab drivers, etc. The families having ADJOB tend to lose their opportunity to intensify their agricultural work and have lower income than those not having ADJOB.

In short, FMLSZ is the only demographic variable that can enhance INCM. In development practice, allocating more manpower to this region can be the only opportunity available for forest planners to increase economic performance as a necessary condition for enabling sustainable development besides the biodiversity of any landholding plots. For the sake to find some opportunities in enhancing the economic performance, we need to examine other variables that give significant effects on INCM as also depicted in Table 3.

Effect of education level on income

It is normal to expect an educational background influence on people's productivity in economic sectors, and so is it in the agroforestry sector in the study area. The higher people's education background the higher their innovativeness, that will be accompanied by their higher productivity reflected in their income. This expectation, unfortunately, cannot be achieved in this study. As referring to Table 5, the level of education of family heads does not significantly affect ICNM. Family heads with an Elementary School education level (D_1_ELS) have an income of USD 71.545 compared to those who never schooling. The difference, however, is not significant (*P* = 0.195 = 19.5 % or > 5 %). The similar effect occurs with family heads categorized as Junior High School (D_1_JHSC). Although the family heads of D_1_JHS category have an extra of USD 7.965 per year also compared to those, the difference is not significant (*P* = 0.891).

In brief, the 3 levels of education background of the family heads have no significant impact on ICNM. It can be concluded that the education has not yet significantly stimulated innovativeness so that there are no significant effects on ICNM either. The phenomenon, however, will be very useful for forest planners eager to look for an INCM elevating strategy, at least that the forest planners will not need to separate the family heads based on the education level in conducting extension activities, etc. The extension program itself gives a significant effect on INCM, as discussed below.

Effect of ethnicity on income

Contrary to the educational level, the ethnicity affects INCM significantly. The family heads in the study area belong to 4 ethnic groups: Javanese, Sundanese, Semendonese, and Lampungese. In order to make a comparison of the magnitude effect among them, Javanese becomes the reference. The scoring applied for them equals to 0 in ICNM modeling (Table 1). The results, in Table 5 show that Lampungese (D_2_LGP) indeed have an average ICNM of USD 51.818 per year more than Javanese do. But the difference is not significant (*P* = 0.640 = 64 % > 5 %). On the contrary, INCM of Sundanese reaches USD 130.475 per year more than of Javanese. The difference is significant (*P* = 0.006 = 0.6 % or <1 %). It seems that Semendonese people are the most productive in the study area. The family income of Semendonese (D_2_SMD) is USD 114.448 per year more than of Javanese. The difference is also significant (*P* = 0.007 = 0.7 % or <1 %).

It is interesting to discuss the differences in INCM based on the ethnicity analysis. Setiawan et al. (2014) revealed that Lampungese and Semenodenese in the study area could be regarded as the native ethnic groups whereas Javanese and Sundanese were the newcomers. The natives commonly cultivate cash crops, including coffee, cocoa, cinnamon, and rubber through the agroforestry system. Meanwhile, according to Nurhaida et al. (2007) both Javanese and Sundanese migrated from Java Island (or their offsprings) started in 1905 under Dutch Colonization and last recurrent in between 1961 and 1965 under the National Reconstruction Scheme. Newcomers do not do much cash crop cultivation through the agroforestry system. Instead, they do the perennial crops cultivation especially rice. Many of them, in fact, have no background in any agricultural livelihood at all. From this background it is easily understood why Javanese come last in INCM from rubber agroforestry cultivation. Reversing the argument, we have proven why Semendonese (D_2_SMD) is the most productive ethnic group in the study area, shown by their INCM.

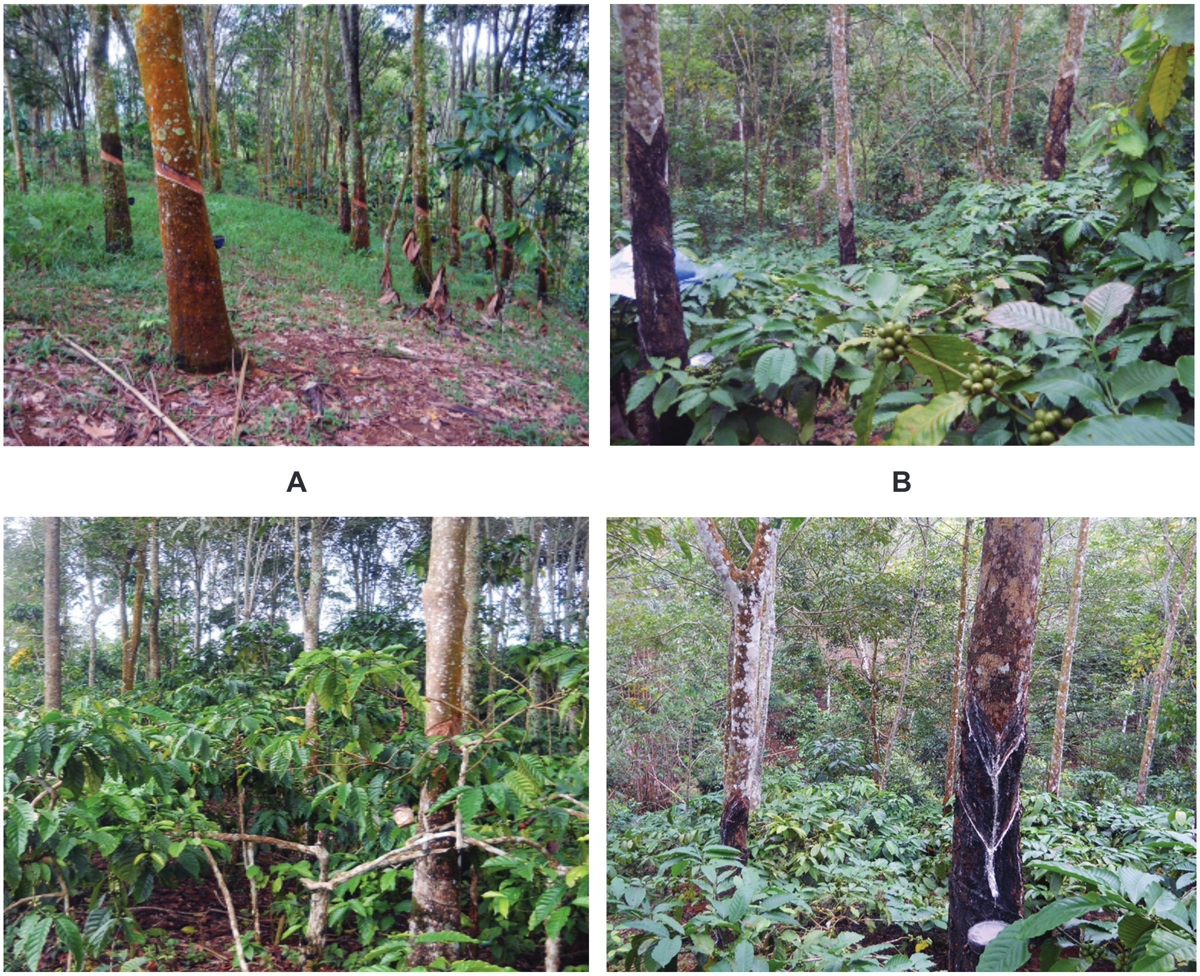
We would be trapped in a wrong argument if we insist on using the origin of people to explain Sundanese or Lampungese productivities. Although Sundanese are the newcomers, they commonly live side by side with Semendonese. Like them, the ancestors of Sundanese in West Java commonly lived in the upper area of a landscape, cultivated rice on terraced land combined with fish ponds and wood plants in their backyard. The agrocomplex system pattern in Sundanese community was found during the field research. Except for cultivating rice and managing fish ponds, both Sundanese and Semendonese prefer to live in an area biophysically very similar so they commonly live side by side. Sundanese, however, are more intensive in adopting skills for the cultural technique of rubber agroforestry in daily work. This background can serve as an appropriate explanation why Sundanese are more productive than Javanese. A reverse argument perhaps could explain better why the productivity of Lampungese is not different from Javanese as expressed by their average INCM. The implication in developmental economic planning in relation to the four ethnic groups planners should take into consideration whenever they convey the technical assistant in extension activities.

This argument is in line with the findings of Nurhaida et al (2007) who proved the local language usage in extension activities was very effective in enhancing farmers' knowledge about the role agroforestry on soil and water conservation control. Nurhaida et al. (2011) also conducted a research at buffer zone of Way Kambas National Park-Lampung Province and reported the use of three tribal languages (Javanese, Sundanese, Balinese) in cartoon media of fable. They were much more effective in conveying messages of wildlife conservation than in Indonesian. Beside the language, the local knowledge about the matter (that had been inventoried before) also to was utilized in the extension media designed by Nurhaida et al. (2007, 2011). In Figure 2 is described that agroforestry pattern demonstrated by Semendonese or Sundanese should be introduced to Javanese or Lampungese by a subtle extension methods in order to be accepted without any cross culture barrier.

Additionally, the relevant custom including norm, habit, satire, allusion, folklore and other cultural acceptability or heritage from their ancestor were used exhaustively in Nurhaida et al. (2007, 2011). Because the participation in extension (EXT) is positively significant in enhancing INCM (Table 5), it is a rational way in using up the strategic program in order to become the strategy for fostering HKm's SUST through improving BIODV. All of the culture heritage of every tribe such as hospitality, local norm, habit, local wisdom, should be taken as consideration in developing extension programs.

Effect of productive asset

Among the 8 variables of productive assets (Table 3) only landholdings under HKm scheme acreage have a significant effect on INCM. This claim is connoted by *P*-value of 0.000 which means this variable significantly influences the income because it has an error below 5 %. Its coefficient is 278.203 which means that the family income will increase by USD 278.203 per ha per year on landholding plots under HKm scheme. This implies that in the study area a landholding is still limited to achieve the community's welfare such as in Tanggamus Regency of Lampung Province (Ruchyansyah et al. 2018). This constraint can naturally encourage further encroachment if the authority cannot make an incentive policy to slow this tendency down. Thus, the challenge for forestry planners is to look for another productive asset that is possible to leverage INCM without presupposing any need to increase land allocation. In relation to this challenge, fish pond management, goat and poultry development are prospectively economic activities that are possible to improve the economic performance due to their better economic gains.



A B C D

Fig. 2. Croping pattern in rubber silviculture: (A) Javanese, monoculture, seems deligent to clean weed as their ancessor who custome with annual crops in Java Island; (B) Semendonese almost an ideal agroforestry pattern; (C) Sundanese seems make adaptation to Semendonese; (D) Lampungese seems too litle cultivation.

The effect of information and physical accessibility

Among the 4 variables, only the land elevation gives a significant effect on INCM. Farmers whose land elevation lies above 100 m a.s.l. will reduce their income by USD 0.503 per year. Perhaps the farmers must spend more effort or a bigger budget to cultivate rubber on land with higher elevation such as found by Zhafira et al. (2019). The rubber sap productivity will also decrease significantly if cultivated on higher elevation due to the temperature suitability for rubber crop growth (Andrian et al. 2014).

As for both TVOW and HPOW variables, they do not significantly affect INCM. Farmer participation in extension programs, on the contrary, plays a significant role in the enhancement of INCM. This kind of condition is based on the results of Idayanti et al. (2019) and Supriadi et al. (2018). Both research results have also proven that HPOW and TVOW have no effect on the income.

It is only the variable of farmer's participation in EXTN among the 6 ones of the information and physical accessibility having a positively significant effect on INCM. Farmers who are more active in EXTN can get an income of USD 166.790 per year, or more than those who are not. This proves that the extension program is an important source of information for the villagers such as found by Wulandari and Inoue (2018) in West Lampung. The knowledge contained in the extension can be very valuable in rubber cultivation activities. It is also possible that the social atmospheric interaction among the villagers has been improved by the extension activities so that the social capital can be developed as well.

Effect of rural facility investment activities

These exogenous variables include FIVST, NURSY, and SCNET. The presence of FIVST has decreased INCM, farmers joining the temporary work have an average income of USD 171.85 less than those who do not. Perhaps the farmers spend too much time in the non farm work so they sacrificed the opportunity to work in the fields, including plant care, tapping sap, processing latex, etc. A similar situation also occurs in NURSY. These jobs are more attractive because the villagers can take cash than take money from selling rubber latex, coffee bean, cocoa and other agroforestry yields which the prices always decrease in the harvest season. This condition is also proven by Idayanti et al. (2019) that the improvement of project facilities has a negative influence on the INCM.

As for SCNET program it has no significant effect on INCM. It seems that the money allocation in cash has reduced the work spirit of the farmers. But based on his research among pine (*Pinus merkusii* Jungh. & de Vriese) sap tappers community at forest plantation in Central Java-Indonesia, Cahyono (2010) reported that SCNET in cash assistance had been lessen the farmers' morale on working, reduced their productivity and increased consumption spending. On the contrary was the research conducted in the community of sap damar (*Shorea javanica* Koord. & Valeton) farmers at West Lampung Regency reported by Setiawan et al. (2014). SCNET in cash had stimulated their spirit in working and had induced their INCM enhancement. Both Cahyono (2010) and Setiawan et al. (2014) recommend that enhance extension program in order to foster the farmer's spirit to be able to empower themselves gradually escaping from poverty trap.

The role of income on tree biodiversity performance

As seen in Table 7, G statistic is big enough (G = 15.685) with P-value = 0.000. This can be equated with P-value = 0.0004 because the rounding of 3 digits will be the same as P-value = 0.000. So the meaning of P-value = 0.0004 (or P-value = 0.04 %) is that 99.06 % (100 % subtracted by 0.04 %) of BIODV variations among the 230 respondents' land parcels can be explained by the sole INCM variable, whereas the remaining 0.004 % can not, but should be explained by other variables that were not applied in this model. In brief, the precision of this model is very high because the confident level is more than 99.04 %.

As for how much INCM variable can multiply BIODV, we need to refer to Odd Ratio obtained, namely 1.13 with *P* = 0.000 that can also be equated to *P* = 0.0004 (Table 7). It connotes that every farmer's income increases by an average of USD per year, accompanied by increasing of BIODV by 1.13 times. The increase is around 95 % CI (namely in between 1.01 and 1.26) with the missing probability being only around 0.06 %. This very small probability tells us that the model built is strong. This fact also justifies that the improvement of BIODV through farmers' income improvement in this research area is in line with the mission of HKm Scheme. In other words, HKm Authority has conducted an amendment program for rehabilitating the degradation of protected forests through farmers' income increasement effort. It indicate that the reforestation program under HKm scheme has been effective as proved by the responsiveness HKm members to the program of planting some annual and cash crops under rubber trees stumpage. It is logical that farmers depend on forest's biodiversity for their daily needs so they will manage their forest neatly and conserve the biodiversity (Wulandari et al. 2018).

The role of tree biodiversity performance on HKm's program sustainability

The BIODV effect is strong enough to be the predictor variable of HKm Program sustainability. As seen in Table 8, this claim is proven by Gald statistic results at 5.801 with *P*-value = 0.016. It means that the sole predictor variable of BIODV is reliable as the indicator of sustainability of HKm due to its small missing probability of only 0.016 (=1.6 % or less than 5 %). This number tells us that there will be 16 units missing if we use BIODV variable to predict 1,000 sustainability of HKm Program. Therefore we can rely on this model to predict the sustainability of HKm.

We, furthermore, are interested in knowing how big the change of sustainability of HKm is in case BIODV rises from low to medium or high. Unfortunately, the sustainability of HKm will drop to only 0.52 as BIODV rises from low to medium or high. This clue is indicated by Odd Ratio described in Table 5, namely 0.52 (CI = 0.30 to 0.89) with *P* = 0.017, indicating the model is strong enough.

The reduction in HKm program sustainability as a result of the increase in BIODV gives a signal of a critical phase. It implies that farmers, whose BIODV has been rising up, need more nurturing from HKm authority to support a critical breakthrough of a biodiversity development phase especially for newly wooden planted crops other than rubber. During that phase the farmers must pay much more attention in order to promote the growth of the newly planted wooden tree other than rubber. Those plants must survive from weed disruption, pests and borne diseases, poor soil fertility, and even from rubber plant shading. The farmers need to allocate their resources more than when planting rubber in a monocultural way, such as controlling weeds and pests, applying soil fertilizer, pruning rubber canopies and using them for green manure. This certainly will reduce the farmers' opportunity to earn income from the rubber sap production. This claim is also in line with FMLSZ roles to INCM as expressed in Table 6. HKm authority, therefore, strongly recommended to conduct activities, including technical assistance through intensifying extension activities beside financial aids in the form of chemical material and cropping facilities for farmers whose BIODV has been rising up; otherwise, BIODV will possibly decrease.

For the sake of pursuing SUST, it recommends to continue fostering HKm members by managing the endogenous variables in order to rise up INCM, and then multiply BIODV as well as to broaden HKm members' awareness on voluntary planting some wooden trees that have been adaptive or endemic at local ecoregion such as *Fagraea fragrans* Roxb (Bramasto and Sudrajat 2018), *Cinnamomum* sp. (Menggala et al. 2019), and *Shorea javanica* (Wakhidah et al. 2020).

Conclusion

The hypotheses have to be accepted at confident level more than 95% namely: (i) the endogenous variables with positive effect on the income from agroforestry yield (INCM) were the family number size, participation in extension activities, land holding acreage, tribes Sundanese and Semendonese higher than Javanese, and with negative effect was the land elevation; whereas the exogenous variable affected negatively the rural facility construction and nursery demonstration plot activities; (ii) the INCM effect on tree biodiversity (BIODV) enhancement namely BIODV performance will rise up by 1.13 if ENCM rises up by USD one per year; and (iii) the BIODV on HKm's program sustainability (SUST) will reduce by 0.53. It is clue that the nurturing phase on HKm member at critical stage. It recommends that continue fostering HKm members by managing the endogenous variables in order to rise up INCM, and then multiply BIODV as well as to broaden HKm members' awareness on voluntary planting some wooden trees is the prerequisite of pursuing SUST.

Recommendations

Three consecutive models have been achieved by this research and are certainly very meaningful tool for developing next programs, particularly the strategies in fostering every HKm member in order to be able to contribute in pursuing HKm's program sustainability (SUST). Model III is the final point and flash back to use Model II and Model I. At the ultimate objective that the enhancement of tree biodiversity performance (BIODV) has to be able to stimulate the awareness of HKm's member to add wood tree at every vacant space of their lands. The extension activities, including silviculture techniques, are certainly a strategic way to broaden their knowledge if planting some wooden tree species will get some benefits of improvement in: shading coffee or cocoa crops, litter basalt and mulch of organic matter, soil fertility, and the opportunity to make earning from miscellaneous vegetable yields. Planting timber tree crops, therefore, can generate these economic incentive for the farmers. On the other side, planting many species of timber tree crops for HKm authority is the main indicator of succeeding duties in forest recovery program from the encroachment phenomenon.

As proved by Model II, this scenario in fostering SUST through corner stones of improving tree biodiversity (BIODV) will be possible as the prerequisite if and only if the farmer's income (INCM) can be risen up. The flash back, therefore, we have to exploit the Model I as the basis for enhancing INCM strategy. It is clear that we have to use the endogenous variables which have characteristic of enabling to and being possible to induce INCM. From the six of endogenous variables (Table 4), only does the extension variable (EXTN) that meets the two characteristics, whereas the three variables remain do not, namely the family number size, land holding acreage, and land elevation.

Family size number is the endogenous variable that does not have meaning for fostering SUST. This variable is not possible to be added or reduced for the sake of enhancing INCM. And so does the elevation of land parcel position, there is no real act that can be conducted on changing the land elevation position across the landscape in whole HKm location. Additionally, although the land holding variable is possible to be expanded in order to enhance INCM, but adding the allocation of land tenure to HKm members is contrary to the main mission of the HKm Authority namely to free the protected forest from the occupation problem. So that the only strategic way in fostering SUST through INCM enhancement (that later on inducing BIODV) is the promoting extension.

In order to achieve SUST, therefore, the extension promotion is a very important strategy in fostering of every HKm member. Therefore, even though the extension materials are focused on silviculture techniques, as exemplified by Nurhaida et al. (2007, 2011), the implementation of the activities of each extension program must also consider the ethnicity variables, which in this HKm Sundanese and Semendonese need to be distinguished from Javanese or Lampungese.

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