Multidimensional scaling approach to evaluate the level of community forestry sustainability in Babak Watershed, Lombok Island, West Nusa Tenggara

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Abstract. Community forestry in Babak watershed is one of the efforts to reduce critical land area. The aim of this research was to evaluate the level of community forestry sustainability in both of community forest (HKm) and private forest in Babak watershed. Multidimensional scaling (MDS) was used to analyse the level of community forest sustainability based on the five dimensions of ecology, economy, social, institutional, and technology as well as 29 attributes. Leverage analysis was used to know the sensitive attributes of sustainability, while Monte Carlo analysis and goodness of fit was used to find the accuracy of MDS analysis. The result shows that HKm was in moderate sustainability level (sustainability index 54.08%) and private forest was in less sustainability level (sustainability index 48.53%). Furthermore, the ecology and technology in HKm were classified as less sustainable, while the institution and technology in private forest were considered less sustainable. There were 11 sensitive attributes of HKm and 19 sensitive attributes of private forest. The priorities of attribute improvement in HKm include land recovering (the dimension of ecology) and cooperative development (the dimension of technology). In private forest, the priorities of attribute improvement include leadership capacity building (the institutional dimension) and also the use of silviculture intensive and soil conservation (the dimension of technology).

Keywords: Babak watershed, leverage analysis, Monte Carlo analysis, multidimensional scaling, sustainability index.

Abstrak. Kegiatan kehutanan masyarakat di DAS Babak merupakan salah satu upaya untuk mengurangi lahan kritis. Tujuan penelitian ini adalah mengetahui tingkat keberlanjutan kehutanan masyarakat baik HKm maupun hutan rakyat di DAS Babak. Metode yang digunakan pada penelitian ini adalah multidimensional scaling (MDS) yang terdiri dari lima dimensi (ekologi, ekonomi, sosial, kelembagaan dan teknologi) dan 29 atribut sebagai dasar penilaian indeks keberlanjutan. Analisis leverage digunakan untuk menentukan atribut yang sensitif terhadap indeks keberlanjutan, sedangkan analisis Monte Carlo dan analisis ketepatan digunakan untuk mengetahui keakuratan analisis MDS. Hasil analisis diketahui bahwa HKm berada pada tingkat cukup berkelanjutan (nilai indeks 54,08%) dan hutan rakyat pada tingkat kurang berkelanjutan (nilai indeks 48,53%). Dimensi ekologi dan teknologi merupakan dimensi kurang berkelanjutan pada HKm, sedangkan dimensi kelembagaan dan teknologi merupakan dimensi yang kurang berkelanjutan pada hutan rakyat. Pada HKm terdapat 11 atribut sensitif sedangkan pada hutan rakyat terdapat 19 atribut sensitif terhadap tingkat keberlanjutan. Perbaikan atribut pada HKm dapat dilakukan dengan perbaikan penutupan lahan (dimensi ekologi) serta pembentukan koperasi (dimensi teknologi). Perbaikan atribut pada hutan rakyat dapat dilakukan dengan peningkatan kepemimpinan (dimensi kelembagaan) serta penggunaan silvikultur intensif dan konservasi tanah dan air (dimensi teknologi).

Kata Kunci: *analisis leverage, analisis Monte Carlo, DAS Babak, indeks keberlanjutan, MDS.*

1. Introduction

Marginal land is one of complicated environmental issues that has not been overcome yet. According to Kementerian Kehutanan (2014), deforestation rates in 2011-2012 reached 613,480.7 hectares, whereas the productive land and forest rehabilitation was only 15,000 hectares per year. Babak watershed is a restored watershed (Murtilaksono, 2014). Based on BP DAS Dodokan Moyo Sari (2008), the increase of critical land in period 2008-2014 was very high, which was almost 42.27%. The critical land has caused the environment degradation, thus, the priority to overcome this issue is required. There are some impacts of critical land to the environmental quality, such as the economic value and water quality (Fiquepron *et al.*, 2013), discharge and sedimentation (Yan *et al.*, 2013), erosion, biodiversity and air quality (Li *et al.*, 2013), and also physicochemical and soil biology (Hazarika *et al.*, 2014).

The critical land is strongly associated with the land utilisation. The land utilisation requires an accurate regulation (Nunes *et al.*, 2011; Li *et al.*, 2013) to prevent and rehabilitate the critical land. Forest is considered as the solution to overcome the prevalence of critical land. As the forest functioning, forest and vegetation have an important role in response to flooding and drought, precipitation, and in some cases can improve the discharge (Asdak, 2010). Forest also has a major role in climate change adaptation, mitigation activity including carbon sink, as well as the environment goods and service provider, biodiversity, recharge area, and food reserves providers to face the drought period which is susceptible to climate change (Nkem, 2006).

The efforts of critical land recovery should involve the community participation, including by promoting community forestry both within and outside of the forest area based on the scheme of land and forest rehabilitation. The activity of community forestry within the forest area is known as community forest (HKm), while those outside the forest area is known as a private forest. The policies in pertaining with community forestry have two important roles,

namely to increase the economic aspect (Khanal 2011; Irawanti *et al.*, 2012; Aji *et al.*, 2015) and to restore the environment quality (Rahayu *et al.*, 2010; Irawan, 2011; Ritonga & Rochana, 2013; Nurwanti, 2014). Therefore, the performance of community forestry to address the critical land problem can be assessed from the models of community forestry, which determine the sustainability benefit for the ecology and social economy of the community. The sustainable community forestry should be formulated based on the criteria and indicators that can determine the goal of community forestry.

Pokharel *et al.* (2015) stated that the sustainability can be evaluated based on four criteria of forest resources, social economic benefit, forest management practices, and institutional and governance framework, which are specified into 26 indicators. Awang *et al.* (2008) suggested that some criteria that can be used to evaluate the sustainability are ecology, institution of forest management, community income, and also social condition. Meanwhile, Pikun (1998) formulated the sustainability of community forestry or social forestry can be identified from the factors of ecology, social (regarding community participation), management (in terms of land management and farmer group organisation), and also economy (productivity and product marketing). From those formulations, the ecology, economy, social, institution and land management are used as the basic of community forest evaluation as included in BP DAS Dodokan Moyo Sari (2008) and Nandini (2013).

The identification of the sustainability level of community forestry is required to arrange the improvement in order to attain the goals. Furthermore, the sustainability evaluation can be done either by using manual scoring or software based on multidimensional scaling (MDS). Nandini (2013) examined the community forest in HKm Darussadiqien located in the upstream of Babak watershed by using manual scoring, while Sukwika *et al.* (2016) examined the sustainability of private forest in Bogor by using MDS. MDS was employed by Pitcher and Preikshot (2001) as the tool to

evaluate the sustainability of fisheries, which is known as *Rapfish* and further developed for various fields such as *RapPforest* (Sukwika *et al.*, 2016), *RapLandUse* (Widiatmaka *et al.*, 2015), RALED (Budiharsono, 2014), *RapSisprodi* (Nazam *et al.*, 2011), and also *RapDAS* (Suwarno *et al.*, 2011). In this regard, the aim of this research was to evaluate the sustainability level of community forestry both of community forest (HKm) and private forest in Babak watershed by using *RapCF,* which was developed from MDS.
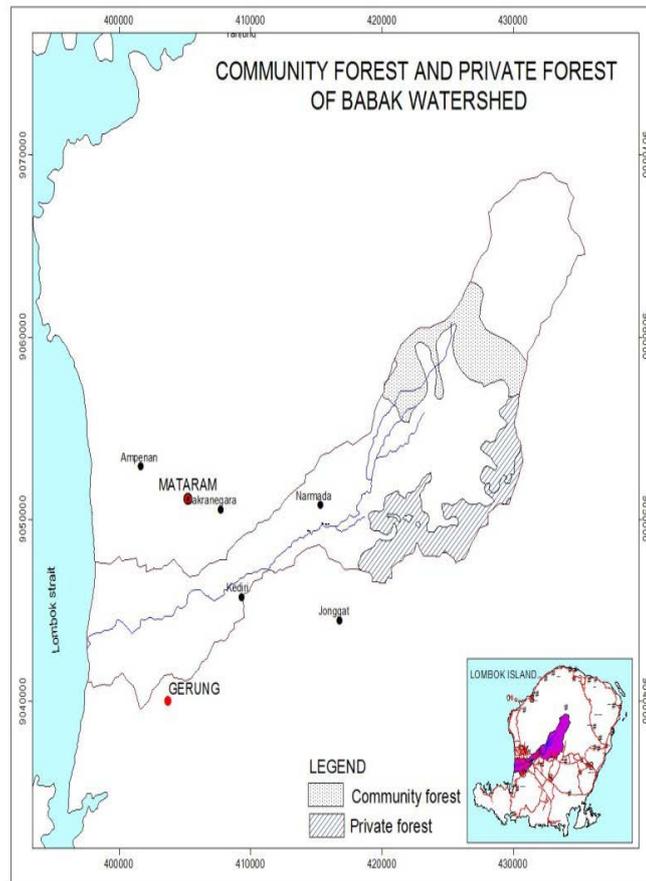

Figure 1. Community forest and private forest in Babak watershed

2. Research Method
a. Study Area

This research was conducted in the community forest and private forest in Babak watershed, Lombok Island, West Nusa Tenggara. It was conducted from April to July 2015. Babak watershed is located on 8°42'-8°67' in the South and 116°07'-116°39' in the East with a total area of 29,948.39 hectares. Babak watershed is situated in the centre of Lombok Island with the area coverage of the North and Middle Lombok districts in the upstream and midstream and also Mataram municipally and West Lombok district in the downstream. Most of Babak watershed is the part of Rinjani Mount. The dominated geology is andesite in the upstream, basaltic in the midstream, and alluvium in the downstream of Babak watershed. It is also dominated by the slope of 0-8% (34.53%), the soil type of Brown Regosols and Lithosols (27.55%), and the land use of shrub (25.06%). The average annual rainfall is 1854.4 mm with four dry months and seven wet months in a year and classified as "B" type of climate (almost wet).

Babak watershed is one of the critical watersheds in Lombok Island, which is listed as the national strategic of watershed (the Presidential Decree No. 12 of 2012). Some potential features of Babak watershed include the natural tourism, water resources, and community forestry in which the last feature

became a pilot project in Lombok Island. In 2008-2014, the critical land in Babak watershed increased significantly. In 2014, Murtilaksono reported that Babak watershed was one of restored watershed that must be revitalised immediately. The community forestry is one of the rehabilitation efforts initiated by the government to solve the critical land issue by involving the community participation. The HKm is located in the upstream of Babak watershed with a total area of 1,809.5 hectares, while the private forest is located in the midstream of Babak watershed with a total area of 1,702.2 hectares (Figure 1). Since HKm is located in the forest area, the local communities who manage the forest must have the license of community forest management (*IUPHKm*) issued by the government. Meanwhile, the private forest is located in the private/individual land. Hence they are free to manage their lands.

b. Data Collection

The data was collected through interviews with the farmers in the community forest and private forest as the respondents. The parameters included the aspects of demography (age and gender), ecology (land productivity, soil conservation, land cover, vegetation density, and land cultivation area), economy (community forestry products, product market, contribution of forestry community income, contribution of non-forestry community income, poverty level, family member of dependants, adaptation on agricultural commodities demand), social (education level, perception on soil conservation, perception on community forestry activity, participation in community forestry), institution(farmers groups activity, farmers accompaniment, knowledge of institutional rules, decision-making process, and leadership), and also the use of technology (land preparation, planting, plant maintenance, harvesting, post-harvest processing, and soil conservation). The respondents of each group of community forestry were determined randomly based on the Slovin's formula (Sevillla *et al.*, 2007) with

a significance level of 10%. The total numbers of respondents were 147 farmers. Respondents from HKm were the members of four farmer groups in Setiling, Aik Berik, Karang Sidemen and Lantan. Furthermore, the respondents of private forest were the members of three farmer groups in Pemepek, Setiling, and Sepakek. In HKm, the respondents aged 24 to 75 years old, the dominant education was elementary school, the average number of dependants was 3 (three) people, and the average cultivated land was 0.64 ha/farmer. Meanwhile in private forest, it was dominated by the respondents aged 27 to 70 years old, education background was senior secondary school, the average number of dependants was 4 (four) people, and the average cultivated land was 0.59 ha/farmer.

The data was analysed by using MDS method. The MDS analysis was performed by using *Rapid appraisal for community forestry (RapCF)* which was developed from *Rapfish* (Pitcher & Preikshot, 2001). There were five dimensions (ecology, economic, social, institutional, technology dimension) and 29 attributes used in this research. The attribute valuation was in ordinal scale based on the sustainability criteria of each dimension (Supplement 1). The criteria were ranked from 0 (the lowest) to 3 (the highest). The assessment of sustainability index was categorised into four groups (Kavanagh & Pitcher, 2004), namely: not sustainable (0-25%), less sustainable (>25-50%), moderate sustainable (>50-75%) and good sustainable (>75-100%). The level of sustainability dimensions was displayed simultaneously by using kite diagrams.

c. Analysis

The evaluation of sustainability index was followed up by the determination of the leverage factors and Monte Carlo analysis. The leverage analysis was used to find the sensitive sustainability attributes based on RMS value (Kavanagh & Pitcher, 2004). The higher the RMS value, the greater the attribute effect on the level of sustainability. The RMS value was obtained through the equation as follows:

$$RMS = \sqrt{\sum_{i=1}^{n} a_i^2}$$ ....(2)

a= standard error,

Monte Carlo analysis was used to determine the random error of all dimensions. The results of Monte Carlo analysis was compared to those of MDS analysis, as a result is 95% degree of confidence, hence it could be determined that the difference value between the results was approximately 5%. Furthermore, if the difference was <5%, the MDS result was sufficient to predict the sustainability of community forestry.

The final stage was the goodness of fit using S-stress value by calculating the values of S and R^2. The lower the S, the higher the goodness of fit. The S value was set based on Kavanagh & Pitcher (2004), namely S<0.25.

3. Results and Discussion

a. The level sustainability of HKm in Babak watershed

The result showed that the sustainability of HKm in Babak watershed was in moderate sustainability with the average sustainability index of dimensions of 54.08%. It means that in general, the performance of HKm in Babak watershed was fairly good, hence the goals of community forestry can be achieved despite of its sub-optimally yield. Among all dimensions, the ecology and technology were classified in the level of less sustainable. Based on the results, the ecology and technology should become the priorities for further improvement to enhance the level of HKm sustainability. Subsequently, the institutional dimension obtained the highest sustainability index, while the ecology had the lowest sustainability index (Figure 2).

The leverage analysis on HKm indicated only 11 out of 29 attributes were categorised as sensitive attributes, specifically 3 (three) attributes of ecological, 4 (four) attributes of economic, 2 (two) attributes of social, and also one attribute for each of institutional and technology dimension. Those attributes can be prioritised to augment the sustainability level of HKm in Babak watershed. The higher the RMS value means the greater the attribute role in sustainability level (Kavanagh & Pitcher, 2004). The result showed that the highest RMS value was gained by the farmer groups join activity (RMS 13.95), while the lowest was the participation in community forestry (RMS 0.15), which were included in the institutional and social dimension, respectively (Table 1). It means that the farmer groups' activity contributed highly on the sustainability index compared to the participation in community forestry.
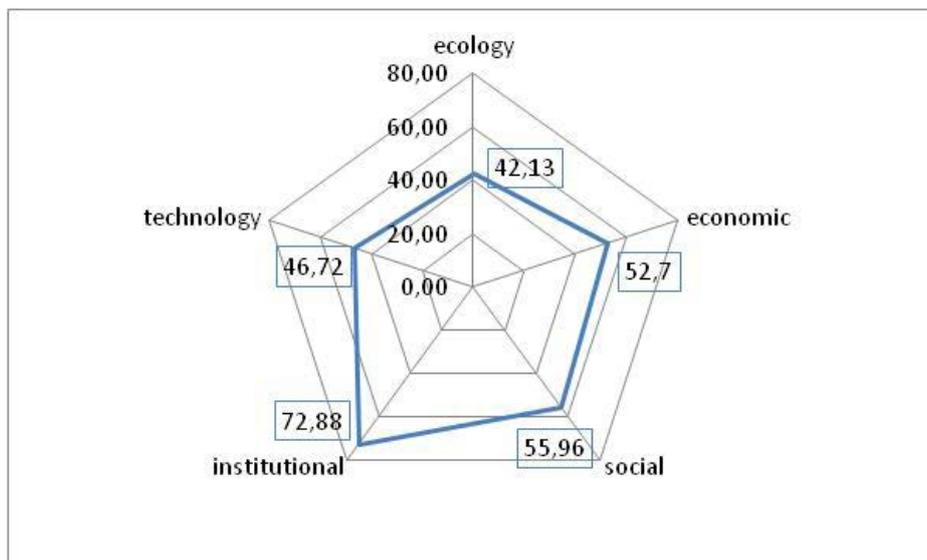

Figure 2. *Sustainability level of HKm in Babak watershed*

Table 1. The RMS value of attributes and dimensions based on leverage analysis of HKm in Babak watershed.

Dimension	Attribute	RMS
Ecology	Runoff	3.89*
	Soil erosion	6.06*
	Land productivity	1.02
	The use of soil conservation	1.58
	Land cover	6.13*
	Vegetation diversity	1.79
	Land cultivation area	3.36
Economic	Sum of product	2.12
	Product market	4.03*
	Contribution of community forestry farming income	4.15*
	Contribution of non-community forestry farming income	4.27*
	Poverty level	5.50*
	Family member dependants	0.80
	Adaptation of agricultural commodities demand	1.58
Social	Education level	9.99*
	Perception of soil conservation activity	1.33
	Perception of community forestry activity	9.51*
	Participation in community forestry	0.15
Institutional	Farmer groups activity	13.95*
	Farmer accompaniment	6.61
	Knowledge of institutional rules/*awig-awig*	6.60
	Decision-making process on farmer groups	6.61
	Leadership on farmer groups	6.71
Technology	Land preparation	1.86
	Planting	2.43
	Plant maintenance	2.47
	Harvesting	6.85*
	Post-harvesting processing	2.75
	Type of soil conservation	2.60

Description: * is sensitive attribute.

The soil erosion, runoff, and land cover as the ecology attributes and the harvesting included as the technology attribute were considered sensitive to the sustainability level. The soil erosion, runoff, and land cover are three attributes that are highly inter-correlated (Cadaret *et al.*, 2016; Zokaib & Naser, 2012; Ochoa *et al.*, 2016).The improvement of land management can be implemented to reduce the runoff and soil erosion, such as land restoration and also soil and water conservation application (Miardini & Susanti 2016).The land restoration can be done by intensification and diversification of the land use. This matter is also a part of the improvement of an economic attribute related to the farmer incomes as suggested by Winata *et al.* (2015), although the sustainability of economic dimension was in moderate level. However, in HKm, the intensification could not be done easily due to the prevailing regulation of forest utilisation as stated in the Government Regulation No. 6/2007, even it is possible for the diversification of land use. In addition to land restoration, the law enforcement of composition in forest area, which is 70% of timber and 30% of Multipurpose trees species (MPTS) should be maintained.

The income of farmers is one attribute of economic dimension which is sensitive to sustainability level of HKm in Babak watershed

in pertaining to the land area (Winata *et al.*, 2015). The income of farmers determines the poverty level (*Badan Pusat Statistik Provinsi NTB,* 2014), thus that the enhancement of this attribute can support other dimensions. The determination of land area for HKm should be focused on the minimum area to prop up proper life. The average minimum area for proper life in HKmof Babak watershed is 1.62 hectares. However, it is unattainable because of the forest management license issued by the government as HKm (*IUPHHKm*) is limited, while the farmer has active involvement in HKm. It can be addressed by changing the land management by increasing the productivity of the land (Febryano, 2008; Mu'min *et al.*, 2014), but still retaining the composition of 30% timber and 70% MPTS based on the rule of forest utilisation at the same time. The land management can be done through the land intensification and diversification (Wijayanti *et al.*, 2016) as an attempt to increase the farmer's income.

The harvesting technique is the sensitive attribute of technology dimension in HKm. Generally, the farmers rely on the wholesaler to harvest their products. Although it is disadvantageous for the farmers, the role of the wholesaler is crucial due to the difficulties in facilities provision and the lack of information of the markets network. Syahza (2003) asserted those difficulties as the common constraints that hinder the success of the agribusiness sector. In order to overcome this constraint, the establishment of a rural economic institution which among of the functions is to regulate the products marketing is required (Syahza, 2003). In HKm, the rural economic institution can be in the form of cooperative as a part of management unit in the farmers group. The establishment of cooperative under the farmers group requires assistance until the institution is stable and autonomous.

Based on the MDS analysis, the HKm of Babak watershed has a high validity and goodness of fit, hence it can be used as the basic evaluation of the sustainability of HKm in Babak watershed. It was indicated by Monte Carlo and goodness of fit analysis in which the difference between MDS result and Monte Carlo analysis of each dimension was very low (Table 2).

Table 2. The result of Monte Carlo analysis at 95% degree of confidence in HKm of Babak watershed.

Dimension	MDS	Monte Carlo	Difference (%)
Ecology	42.13	42.29	-0.19
Economic	52.7	52.08	0.59
Social	55.96	55.91	0.04
Institutional	72.88	72	0.61
Technology	46.72	46.64	0.1

Based on Kavanagh and Pitcher (2004), it explicated that the attributes scoring of each sustainability dimension was classified appropriate so that those attributes were reliable to evaluate the sustainability level of HKm in Babak watershed. The result of the goodness of fit analysis showed that R^2 had a very high value in all dimension, while S value had very low value (Table 3). Based on Kavanagh and Pitcher (2004), it means that the MDS analysis in HKm of Babak watershed is appropriate so that it was reliable to evaluate the sustainability level of HKm in Babak watershed.

Table 3. The results of the goodness of fit analysis of HKm in Babak watershed.

	Ecology	Economy	Social	Institution	Technology
S	0.14	0.14	0.15	0.14	0.15
R^2	0.94	0.94	0.95	0.95	0.94

b. The sustainability level of private forest in Babak watershed

The result demonstrated that the sustainability of private forest in Babak watershed was classified in less sustainable level with an average sustainability index of 48.53%. It means that in general, private forest in Babak watershed was less optimal; hence the improvement of several attributes was needed to achieve the goal of community forestry. Among the dimensions, the institution and technology were included in the less sustainable level. According to the results, the improvement of institutional dimension and technology should be the main concerns. Thus the sustainability level of private forest would be increased. The social aspect obtained the highest sustainability index, while the technological dimension had the lowest sustainability index (Figure 3).

The leverage analysis of private forest showed that only 19 from 29 attributes were categorized as sensitive attributes, particularly 5 (five) attributes of ecology, 5 (five) attributes of economy, 2 (two) attributes of social, and also 5 (five) attributes of institution, and also 2 (two) attributes of technology. Those attributes can be prioritised in order to increase the sustainability level of private forest in Babak watershed. The result indicated that

the highest value of RMS was the perception of soil conservation activity (RMS 10.95), while the lowest was the participation in community forestry (RMS 0.03), and both of them were attributes of social dimension (Table 4). It means that the perception of soil conservation activity highly contributed to the sustainability index by comparing with the leadership of farmer groups.

Furthermore, all attributes of institutional dimension were sensitive, while the plant maintenance and type of soil conservation as the attributes of technology were sensitive for the sustainability level of the private forest. The institution of the private forest was dormant due to several reasons including few activities of farmer groups, the absence of farmer assistance, ineffective rules of farmer groups, less involvement of the farmers in decision-making and less passage of the leadership in farmer groups. The development of private forest institution was initiated by the government through the forestry extension under the scheme of land rehabilitation. Forestry extension serves as the initiator that mentors, facilitates, and promotes the farmer groups of private forest as stated by Uphoff (1986). The initiator has power to influence the participation of the institution members (Pretty, 1995).
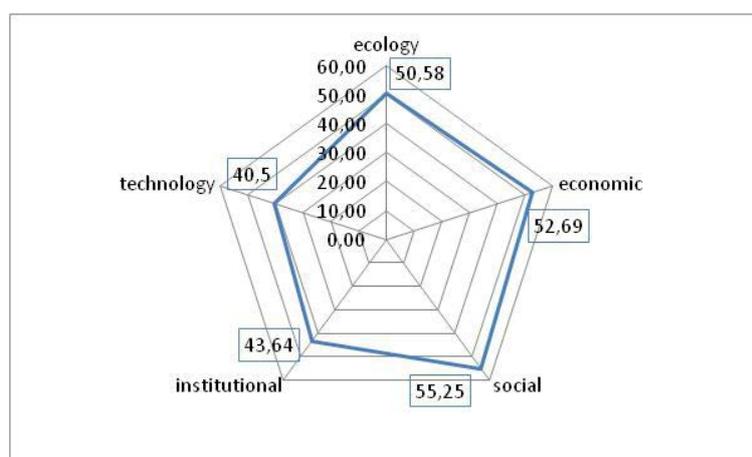

Figure 3. Sustainability level of private forest in Babak watershed

Based on the interviews, the institution was determined as inactive since the initiator did not provide mentoring, facility, and promotion for the farmer groups. It means that the initiator has

been successfully building the frame, structure and mechanism (rules) of the institution, yet failed to raise the autonomous of institution (Djogo *et al.*, 2003). The condition should be

overcome by participatory capacity building and community empowerment (Uphoff *et al.*, 2006; Awang *et al.*, 2008). The institution built based on the local participatory depends on the leadership (Sheelanere *et al.*, 2013), so that the leadership must be constructed suspiciously according to the mutual trust within the farmer group to motivate and support the institutional activity. If the leadership functions properly, the attributes of institutional dimension such as the activity of farmer groups, farmer accompaniment, the rules/*awig-awig* practices, and also decision-making would function properly.

Table 4. The RMS value of each attribute and dimension based on leverage analysis of private forest in Babak watershed

Dimension	Attribute	RMS
Ecology	Runoff	5.40*
	Soil erosion	6.91*
	Land productivity	7.54*
	The use of soil conservation	9.12*
	Land cover	4.18
	Vegetation diversity	3.93
	Land cultivation area	5.11*
Economy	Sum of product	4.41*
	Product market	6.39*
	Contribution of community forestry farming income	5.52*
	Contribution of non-community forestry farming income	6.38*
	Poverty level	5.71*
	Family member dependants	1.77
	Adaptation of agricultural commodities demand	2.97
Social	Education level	2.00
	Perception of soil conservation activity	10.95*
	Perception of community forestry activity	9.55*
	Participation in community forestry	0.03
Institution	Farmer groups activity	2.34*
	Farmer accompaniment	1.82*
	Knowledge of institutional rules/*awig-awig*	1.62*
	Decision-making process on farmer groups	2.70*
	Leadership on farmer groups	1.76*
Technology	Land preparation	0.60
	Planting	0.28
	Plant maintenance	4.45*
	Harvesting	0.04
	Post-harvesting processing	0.50
	Type of soil conservation	3.48*

Description: * is sensitive attribute.

The plant maintenance and type of soil conservation were the sensitive attributes of technology dimension of private forest in Babak watershed. Based on the interview, private forest farmers did not applied the intensive silviculture such as prime seeds selection, fertilisation, pest control, and also crop thinning as the plant maintenance (Soekotjo, 2009). The plants grow naturally without any treatment; hence the growth was less optimal. The soil and water conservation was not applied in the private forest because

the majority was located in a flat area and safe from the erosion. Nevertheless, the soil conservation can be applied as mitigation in the form of the preference of specific type of vegetation that can improve land quality, e.g., a legume.

The MDS analysis of private forest in Babak watershed had a high validity and goodness of fit, so that it can be used as the basic evaluation for the sustainability of HKm in Babak watershed. The results generated from Monte Carlo and goodness of fit analysis, in which the difference of the results of MDS analysis and those of Monte Carlo analysis of each dimension was very low (Table 5).

Table 5. The result of Monte Carlo analysis in 95% of confidence of private forest in Babak watershed.

Dimension	MDS	Monte Carlo	Difference (%)
Ecology	50.58	50.08	0.50
Economy	52.69	52.08	0.61
Social	55.25	54.13	1.01
Institution	43.64	43.55	0.01
Technology	40.5	40.16	0.42

Based on Kavanagh and Pitcher (2004), the attributes scoring of each dimension of sustainability was classified appropriate, so that those attributes were accurate to evaluate the sustainability level of private forest in Babak watershed. The result of the goodness of fit analysis showed that R^2 had a very high value among all dimensions, while S value had very low value (Table 6). Based on Kavanagh and Pitcher (2004), it means that the MDS analysis of private forest in Babak watershed was appropriate, it was accurate to evaluate the sustainability level of private forest in Babak watershed.

Table 6. The result of the goodness of fit analysis of private forest in Babak watershed.

	Ecology	Economy	Social	Institution	Technology
S	0.14	0.14	0.15	0.16	0.16
R^2	0.94	0.94	0.95	0.94	0.94

4. Conclusions and Recommendations

The evaluation of the sustainability level of community forestry in Babak watershed carried out by using MDS indicated that the HKm in this area was classified in moderate sustainability level (sustainability index 54.08%) and the private forest was categorised in less sustainability level (sustainability index 48.53%). Moderate sustainability in HKm means that the HKm was fairly good, so that the goal of community forestry can be achieved even if it has not been optimal yet. Less sustainability in private forest means that the improvement of several attributes is required to achieve the goal of community forestry. In HKm, the ecological dimension and technological dimension were categorised in less sustainability level, the while institutional and technological dimension of private forest

were classified in less sustainability level. There were 11 sensitive attributes of HKm and 19 sensitive attributes of private forest; hence, improvement of the sensitive attributes was highly required in order to increase the sustainability level of community forestry in Babak watershed. The priority of attribute improvement in HKm includes land restoration (the ecological dimension) and also the cooperative establishment (the technological dimension). In private forest, the priority of attribute improvement includes the leadership capacity building (the institutional dimension) and also the use of intensive silviculture and soil conservation (the technological dimension).

The land restoration can be done by the diversification of the land use. The diversification both in HKm and private can be done by adding the different types of plant,

which has dense canopy and multiple benefits such as MPTS. However, the plant composition of HKm must follow the requirement of 70% timber and 30% as determined by the rule of forest utilisation in The Indonesian Governmental Decree (PPRI) No. 6/2007. The establishment of a cooperative under the farmer groups is required to regulate the marketing of the product. It is a solution to overcome the product marketing constraints, hence the farmers will not relied solely on the wholesaler. Leadership is a key for the autonomous institution, so the capacity building must be done to have a good leadership in a farmer groups of HKm and private forest. The intensive silviculture should be done as the plant maintenance to improve the quality of the community forestry products. It includes the prime seeds selection, fertilization, pest

control, and crop thinning. Although private forest is unsusceptible from the erosion, the soil and water technique of conservation is required as the prevention. It can be done by planting specific types of vegetation that can improve the land quality, e.g., legume.

5. Acknowledgements

6. References

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Supplement 1. The attribute and criteria appraisal of community forestry sustainability in Babak watershed.

Attribute	Description	Criteria
Ecology		
1. Runoff	Physical data	High (0), moderate (1), low (2), very low (3)
2. Erosion	Physical data	High (0), moderate (1), low (2), very low (3)
3. Land productivity (quintal/ha)	Land productivity appraisal by rice equivalence that occur in those area	none (0), less (1), equal (2), greater (3)
4. The use of soil conservation	Knowledge of soil conservation	Not know, not use (0), know, not use (1), not know, use (2), know, use (3)
5. Land cover (%)	Vegetation density in community forestry	<25% (0), >25-50% (1), >50-75% (2), >75-100% (3)
6. Vegetation diversity	Variety of vegetation	<3 (0), 3-6 (1), >6-10 (2), >10 (3)
7. Land cultivation area (hectare)	The area of land cultivation compare with the minimum area to proper life (MAPL)	No land (0), less from MAPL (1), equal to MAPL (2), greater than MAPL (3)
Economic:		
1. Sum of product	Sum of product from the land	<3 (0), 3-6 (1), >6-10 (2), >10 (3)
2. Product market	The pattern of product market	Not for sale (0), wholesaler (1), collectors (2), public market (3)
3. Contribution of community forestry farming income	Percentage of income from community forestry	<25% (0), >25-50% (1), >50-75% (2), >75-100% (3)
4. Contribution of non community forestry farming income	Percentage of income beside of community forestry	>75-100% (0), >50-75% (1), >25-50% (2) <25% (3),
5. Poverty level	Poverty rate (PR)	Under PR (1), equal to PR (2), above PR (3)
6. Family member dependants	The member of family	>7 (0), >5-7 (1), >3-5 (2), 1-3 (3)
7. Adaptation on agricultural commodities demands	The changing to fulfil the agricultural commodities demand	none (1) yes, no effort (2), yes, with effort (3),
Social:		
1. Education level	The level education of family member	none (0), primary school to junior high school (1), senior high school (2), college (3)
2. Perception on soil conservation activity	The perception on soil conservation benefit	No benefit (0) less benefit (1), moderate benefit (2), great benefit (3),
3. Perception on community forestry activity	The perception on community forestry activity	poor (1), moderate (2), good (3)
4. Participation in community forestry activity	The frequency of participation in community forestry activity	never (1), sometimes (2), always(3)
Institutional:		
1. Farmers groups activity	The farmers activity in groups a year	none (0), 1-2 activity (1), 3-4 activity (2), ≥5 activity
2. Farmers accompaniment	The frequency of farmers accompaniment a year	none 0), 1-2 x (1), 3-4 x (2), ≥5x (3)
3. Knowledge of institutional rules/ *awig-awig*	Knowledge of institutional rules/ *awig-awig*	Not know (0), none (1), yes, no sanctions (2) yes, with sanctions (3)
4. Decision-making process on farmers groups	The actors of decision making in farmers groups	Not know (0), government/ facilitator (1), caretaker (2), member (3)
5. Leadership on farmers groups	The appraisal of leadership on farmers groups	Not know (0), poor (1), moderate (2), good (3)

Attribute	Description	Criteria
Technology:		
1. Land preparation	Type of land preparation	burnt(0), clear cutting (1), fertilized (2), clear cutting and fertilized (3)
2. Planting	Planting implementation	Direct kernel planting (0), direct seed planting (1), planting with type arrangement (2), planting with distance arrangement (3)
3. Plant maintenance	Type of plant maintenance	None (0), 1 maintenance (1) 2-4 maintenance (2), ≥5 maintenance (3)
4. Harvesting	Type of harvesting	none (0), harvesting by wholesaler (1), self harvesting without arrangement (2) gradually arrangement (3)
5. Post-harvest processing	Type of post-harvest processing	None (0), raw product (1), processed in the same product (2), processes in other product (3)
6. Type of soil conservation	Type of soil conservation	none (0), vegetative conservation (1), civil technique conservation (2), vegetative and civil technique conservation (3)