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Sustainability Index and Status of Private Forest Management: A Study of Ecology, Economics and Technical Aspects of Forestry, in Toraja Regencies, Indonesia

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Abstract

Private forest in Toraja cannot be separated from tradition and local culture. Products from private forest are used for traditional ceremonies, raw materials of traditional house “tongkonan”, and souvenirs for tourists. The potency of private forest has decreased, concequence to the supply-demand imbalance of raw material fulfillment. This research aims to: (1) analyze the sustainability index and status of private forest management based on aspect of ecology, economics and technical forestry; (2) analyze sensitivity indicator of ecology, economics, and forestry technicality in the private forest management. The research was conducted in Toraja area (Tana Toraja and North Toraja regency) on three locations of private forests (Tampo, Padangiring, and Sangkaropi). The research was conducted from October 2014 to June 2015. The research approach using multidimensional scaling (MDS) analysis, which is modified from Rapfish (Rapid Appraisal for Fisheries). The results shown that the ecology aspect index values between 54.14% - 63.00% (quite-sustain status), economic aspects index values between 22.08% - 44.12% (unsustainable and less-sustainandquite-sustain status) , and the technical aspects of forestry index values between 41.92% - 53.02% (less-sustainandquite-sustain status).

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Out of the 25 indicators that were analyzed, 6 indicators as influential sensitive lever factor and need to be intervened towards the increasing of sustainability status of ecology, economics and forestry technicality in the private forest management.

Keywords: sustainability index and status; private forest management; multidimensional scaling.

1. Introduction

Management of natural resources has to continually maintain the natural environment quality (sustainable). Definition of sustainable development which stated by the United Nations Commission on Environment and Development (known as the Brundtland Commission) in 1987 is "development that meets the present needs without compromising the ability of future generations to meet their own needs". The main concept is social, economic and environmental/ecology objective should be mutually supporting each other and involved in .development process. If not, there will be "trade off" of inter-objectives [1].

Forest management is the application of business methods and technical of forestry principles in managing forests. The purpose of forest management is to achieve the multiple use, such as producing wood, settling the water system, wildlife habitat, livestock and human food sources, and recreation areas. Based on those definition, private forest must have forest management activities that include: preparation of management plans, forest use, forest protection and nature conservation which at the implementation gives priority to the forest sustainability. This means that discussing forest management can not be separated from sustainability aspect [2].

In various studies of institutional and policy of forest resources management, it is often mentioned that in order to achieve sustainable natural resource management required good relation among the functions of economics, ecology, and social [3,4,5]. It could be correlated with the concept of sustainability, which contemplated by the International Tropical Timber Organization (ITTO 1998), as a process of managing forests to achieve one or more management objectives in producing forest goods and services, which is continually required without any reduction of forest value and productivity in the future, and without undesirable impact on physical and social environment.

This case is also found in Toraja (Tana Toraja and North Toraja) where private forest management is closely related to the tradition and culture of Torajanese. Utilization of private forests are used for traditional ceremonies, raw materials of traditional house “tongkonan”, and souvenirs for tourists. In line with that, the development progress of private forest (kombong) has been degraded, consequence to thesupply-demand imbalance of raw material fulfillment. Besides, the presence of Toraja Region as protected forest area which located in the plateau area with altitude of 600-1500 m above sea level and is dominated by heavy topography which vulnerable to erosion and landslides, and has a role as catchment area and upstream of several major rivers (DAS Saddang). Environment management practices in this area will significantly affect the continuity of water supply of both quantity and quality in downstream areas [6].

Based on those problems, this study was conducted to: (1) analyze the index and sustainability status of private forest management based on aspect of ecology, economics and technical of forestry; (2) analyze sensitivity

indicator of ecology, economics and technical of forestry in private forest management.

2. Research Methods

2.1. Time and Studies Site

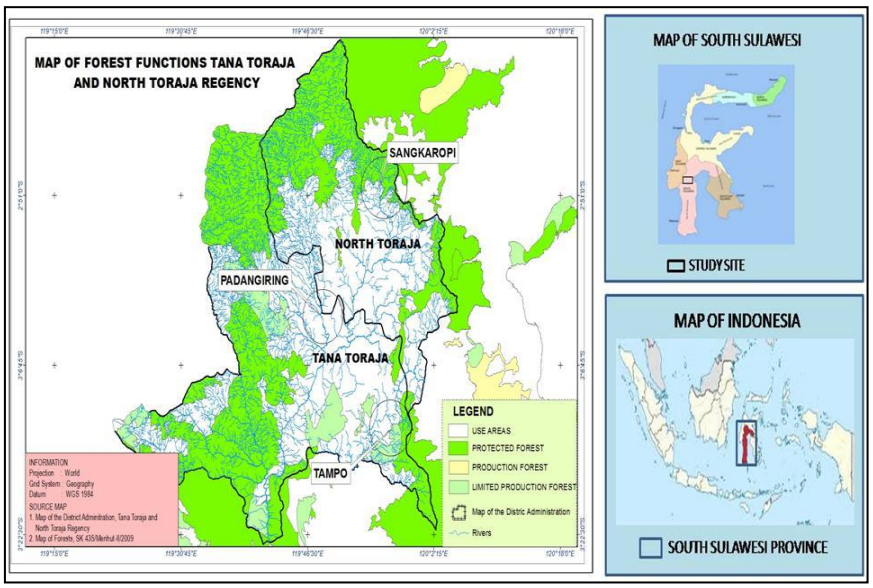

Figure 1: Study Site

The study was conducted in Toraja region, those are : TanaToraja (Tampo, Padangiring) and North Toraja Regency (Sangkaropi), South Sulawesi Province, as shown in Figure 1. The research started from October 2014 until June 2015.

2.2. Categories and Data Sources

Data used in this study are primary and secondary data. The primary data obtained through field surveys, in-depth interviews, and questionnaire. They were given to community and stakeholders who involved in the private forest management. Secondary data obtained through literature, reports and documents from various agencies related to this research topic.

2.3. Methods and Data Analysis

Sustainability status of private forest management in terms of ecology, economics and technical of forestry are determined by the Multidimensional Scaling (MDS) approach through Rapfish (Rapid Appraisal for Fisheries) application, which developed by Fisheries Center, University of British Columbia [7,8,9]. Due to its implementation, Rapfish used a technique called multidimensional scaling (MDS). The object or observed point is mapped into two or three dimensional space, so that the object or point is placed as close as possible to its source point. In other words, the two points or the same object is mapped into a point that is adjacent to each other. Instead objects or points are not the same are depicted with far-flung points [10]. Ordination technique

(spacing) in MDS is based on Euclidean Distance in the n-dimensional space that can be written as follows:

$$d(x,y) = \sqrt{(x1-y1)^2 + (x2-y2)^2 + \ldots\ldots + (xp-yp)^2} \qquad (1)$$

Caption : x1 = First object on observation i

y2 = Second object on observation i

p = Number of observation

Configuration or ordination from an object or a point at MDS is approximated by Euclidian regression distance (d_{ij}) from i point to j point with origin point (δij) as similar formula as following:

$$d_{ij} = \alpha + \beta\delta ij + \varepsilon \qquad (2)$$

The technique used for regressing above equation isalternately least squared method based on the roots of Euclidean distance (squared distance) or called as ALSCAL method. This is based on Maximum Likelihood. From the three methods, ALSCAL algorithm is the most suitable for Rapfish and it is simply available in most statistical software (e.g. SPSS and SAS) [11].

ALSCAL method optimizes square distance (d_{ij}) over quadratic data (origin point = d'_{ij}) at two dimensions *(i,j)* which is noticed in the formula named S-Stress [12] at the following:

$$S = \sqrt{\frac{\sum_{i<j}^{n} (dij - d'ij)^2 \; a}{\sum_{i<j}^{n} d^2 ij}} \qquad (3)$$

Square distance is Euclidian distance which is weighted or written :

$$d^2 = \sum_{\alpha=i}^{r} Wka(Xia - Xja)^2 \qquad (4)$$

MDS method conducted through several stages, those are: (1) the phase of determining indicators of sustainable management of private forest for each aspect (ecology, economics, and technical forestry), (2) the phase of assessing each indicator in ordinal scale based on sustainability criteria for each factor and ordination analysis based on "multidimensional scaling" method, and (3) the phase of arranging the sustainability index and status of private forest management (ecology, economics, and technical aspects of forestry) in Toraja region based on basic scale (0-100). (4) analysis of sensitivity was performed to identify a sensitive indicator that contributing to the sustainability index, and (5) Monte Carlo analysis to evaluate the random errors effects in the process of estimating ordination value of private forest management.

The research is structured into four status of sustainability categories in basic scale (0-100) which is adaptive from stability criteria and sustainable management of Agro-ecosystem [13] and sustainable analysis from various previous research as shown in Table 1.

Table 1: Index values and sustainable status of private forest management

Value index	Sustainability status
0.00 - 25.00	Worse (unsustainable)
25.01 - 50.00	Less (less sustainable)
50.01 - 75.00	Sufficient (quite sustainable)
75.01 - 100.00	Good (very sustainable)

Source: developed by Marten, 1998

3. Results and Discussion

3.1. Sustainable Status of Ecology Aspect

Ecology aspect has ten indicators for sustainability analysis. Those indicators are considered to affect sustainability rate of ecology aspect, namely: (1) understanding of sustainability, (2) efforts to conserve, (3) understand the certainty of private forest boundary, (4) conversion attempt for private forest, (5) private forest protection, (6) plan and animals diversity rate, (7) forest products management, (8) understanding of increment, (9) basic increment for determining felling, and (10) planting and maintenance efforts. Based on MDS analysis, index value of ecology aspect of each unit as shown in Figure 2 (a) are obtained that Tampo Village at 63.00%, Padangiring Village at 54.99% and Sangkaropi Village at 54.14%. These values are at interval 50.01-75.00 with status of quite sustainable. Leverage analysis is conducted to identify sensitive indicators that could influence the sustainability index value ecology aspect. Based on the leverage analysis in three sites, we gained two sensitive indicators, namely: (1) private forest protection, and (2) plan and animals diversity rate. In the future, by intervening the two indicators, it expected that the sustainability status of ecology aspect could be improved. Sustainability index and leverage analysis results are shown in Figure 2.

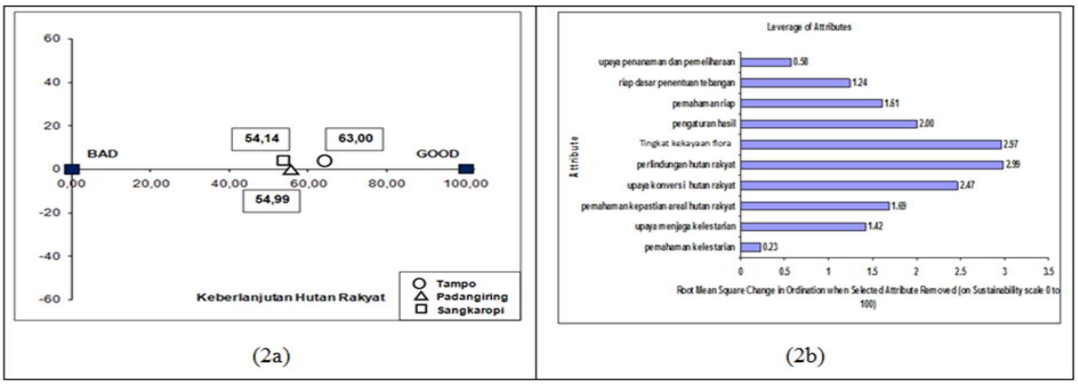

Figure 2: Sustainability index and leverage analysis of Ecology Aspect

Figure 2(b) the results of leverage analysis show private forest protection is the most sensitive indicator. These indicators include forest fire control, pest and disease protection, and illegal grazing. Based on the interview, fires in dry season is very difficult to anticipate because of lack of public awareness and limited infrastructure. Therefore, in order to improve the sustainability status on this indicator, it takes prevention through socialisation, installation of warning boards/signs, and build forest fire monitoring post. Fire control and prevention can be done by local communities, namely: (a) creating a map of vulnerable areatotheforest fires, (b) monitoring the weather, fuel accumulation and symptoms prone to fire, (c) preparing fire brigade, (d) build watchtowers, (e) preparing fire-fighting equipment, and (f) create firebreaks [14]. In terms of pests and diseases, protection in private foresthas not been optimal because of lack of information and knowledge. To anticipate it, counseling and training are necessary in order to improve the knowledge and skills [15,16]. Likewise, wild grazing that interferes the growth of forest stands, that could kill the trees before harvest time. To improve the condition, livestock owners need to create an integrated shed as part of wild grazing control [17,18,19]. The second sensitive indicator, diversity rate of flora and fauna that is obtained based on the results of field surveys and interviews show private forest owners only plant certain tree species related to customan draw materials requirement for *tongkonan* house. Tree species include: *Casuarina junghuniana* Miq, *Ermerillia ovalis* , *Paraserianthes sp*, *Paraserianthes falcataria* , *Pinus merkusii*, *Pterocarpus indicus*, *Pigafetta filaris*, *Toona sureni* and *Bambusa sp*. A kind of effort that could improve the biodiversity (plan and animals) is implementing a pattern of layered plantings (multilayer) with multispecies [20,21].

3.2. Sustainable Status of Economic Aspect

Indicators that are considered give effect to the sustainability rate for economic aspect that consists of five indicators, namely: (1) extent of private forest land, (2) type of cultivated rees, (3) income level, (4) forest products marketing, and (5) stumpage value.

The results of MDS analysis show that index value of economic aspect of each unit as shown in Figure 3 (a) are obtained at Tampo Village 44.12% with status of quite sustainable, while at Sangkaropi Village 22.08% and at Padangiring Village 24.07% are in the interval from 0.00 to 25.00 with a status of worse (unsustainable) and 25.01 to 50.00 with a status of Less (less sustainable). Based on leverage analysis, it gained two indicators that are sensitive to sustainability index of economic aspect, namely: (1) income level, and (2) the type of cultivated trees. Sustainability index and leverage analysis results are shown in Figure 3.

Income level is the most sensitive indicator (Figure 3 (b)). Results from field survey showed the income of private forest owners, especially in the Padangiring and Sangkaropi Village are included in low category. The average income of owners in private forests are around of Rp. 1.200.000,00- Rp. 2.550.750,00 per year or has a contribution rate about 6.78% - 8.50% of total income. At this rate, their income is not able to improve the welfare of private forest owners [22]. Exploitation of private forest is still a kind of a sideline business under taken by small farmer families subsistencely. Income from private forest is still positioned as a side income and incidental with no more than 10% of total income. However, the economic benefits of forest can be felt by people directly and indirectly give effect on economics of the village [23]. In order to make private forest management be moresustainable in economic side, income from private forests must not depend on timber

products, but has to be directed to the product of private forest activities such as non timber products (fruit, honey, rattan, sugar palm) and handicrafts products from bamboos [20]. Related to types of cultivatedtrees as sensitive indicators, interviews and field survey results showed that the farmers have a habit to manage private forest by planting certain species only (*Ermerillia ovalis* , *Casuarina junghuniana* Miq, *Palaquium Xanthochymum*, *Pigafetta filaris)* with a long enough harvest period. Kind of efforts to realize the sustainablility in economic are through agroforestry system and planting fast growing species such as *Gmelina arborea*, *Paraserianthes sp* and *Anthocephalus cadamba* Miq [17,24].

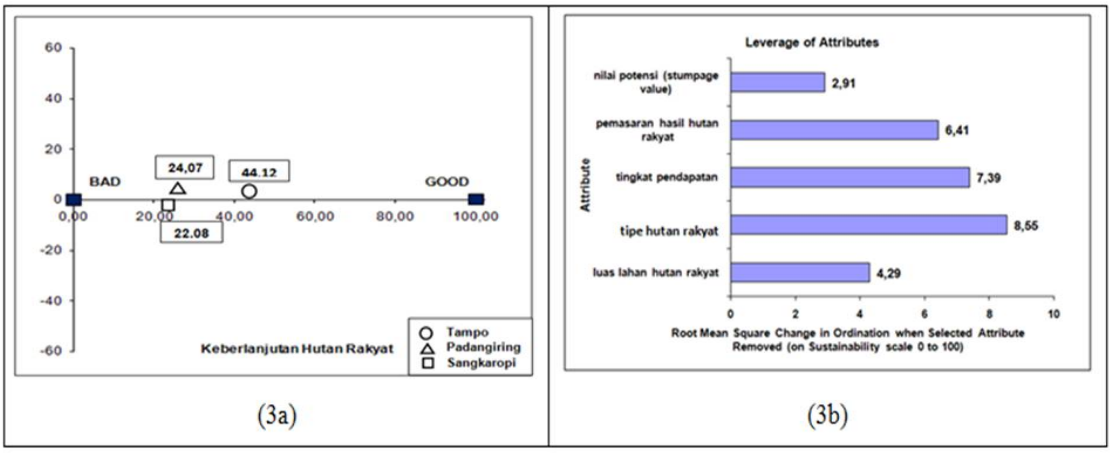

Figure 3: Sustainability index and leverage analysis of Economics Aspect

3.3. Sustainable Status of Technical Forestry Aspect

Indicators that are considered could affect to sustainability rate technical aspect of forestry, consists of ten indicators, namely: (1) land preparation, (2) seedling resources use, (3) seedling selection, (4) determination of stand density, (5) plant stratification, (6) fertilization, (7) exemption from pests, (8) pruning, (9) thinning, and (10) harvesting. The results of MDS analysis about index value of technical aspect of forestry from each unit as shown in Figure 4 (a) obtained at Tampo Village is 47.37% with a status less (less sustainable), at Padangiring Village is 41.97% and at Sangkaropi Village is 44.29% with status less sustainable. Leverage analysis of technical aspect of forestry obtained two sensitive indicators, namely: (1) fertilization, and (2) plant stratification. Sustainability index and leverage analysis results are shown in Figure 4.

Figure 4 (b) shows fertilization as a sensitive indicator or could affect the sustainability of private forest management. Based on the interview result, there was information that the owner of private forest has done fertilization in plants, but not continuously. Fertilization is conducted only at the beginning of planting stage by using manure made from animals feces (buffalo, pigs). Even some owners of private forest do not fertilizing at all because of have not enough time. In order to support the sustainability of technical aspect of forestry, fertilization must be carried out and be done continuously. This is in line with the purpose of fertilization, that is to improve soil fertility so that plants get enough nutrition to improve the quality and quantity of plant growth. Provision of fertilizer by using the organic form like compost or manure for cultivation need about 2 to 5 kg per plant, but it depends on the soil fertility [25].

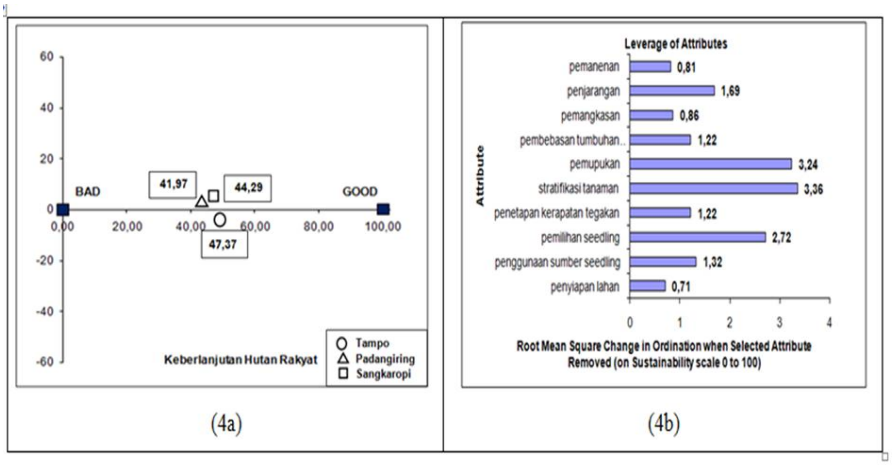

Figure 4: Sustainability index and leverage analysis of technical forestry Aspect

Plant stratification is the second sensitive indicator that need to be intervened. This indicator is caused by planting pattern that conducted by the owners of private forest are lack in variety and are only dominated by certain types (*Ermerillia ovalis* , *Casuarina junghuniana* Miq). This condition occurs dominantly in Sangkaropi and Padangiring Villages, while in Tampo Village has implemented a mixed pattern. To improve the circum stance, agroforestry implementation that combines farming, plantation, livestock and forestry is necessary in the future. This pattern will give a few stratification, starting from the top layer dominated by tree species (*Ermerillia ovalis* , *Casuarina junghuniana* Miq, *swietenia mahagoni, Paraserianthes sp, Pinus mercusii, Palaquium Xanthochymum* , *Gmelina arborea, Toona sureni*), second layer by agricultural crops *(coffee, cocoa, avocado , banana, olive, coconut, citrus, nut)* and the bottom layer is dominated by food sources *(cassava, yams and grass for buffalo).* The sustainability index value of ecology, economics, and technical aspect of forestry are shown in Kite Diagram in Figure 5.

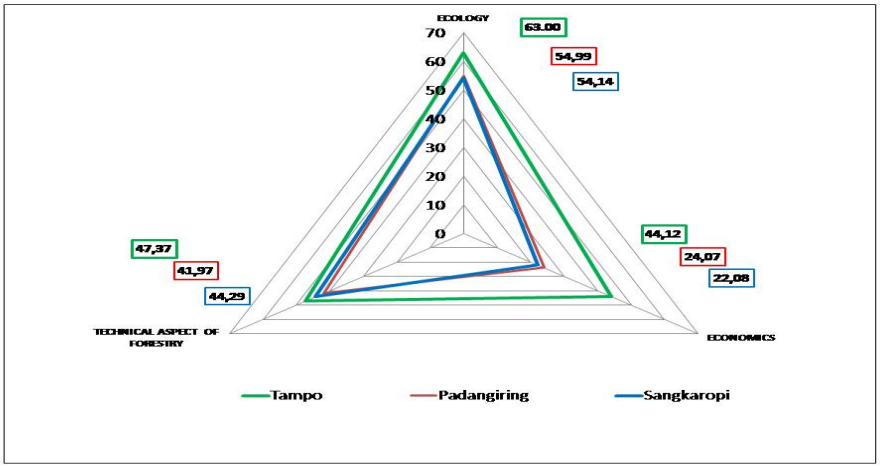

Figure 5: Kite Diagram of sustainability index value of ecology, economics, and technical aspect of forestry

Figure 5 shows the ecology sustainability in Tampo Village has the highest index value of 63.00%, where as the

lowest index value by 22.08% on economics sustainability is in the Sangkaropi Village.

3.4. Validation Status of Sustainability from Ecology, Economics and Technical Aspect of Forestry in Private Forest Management

To determine the error rate in MDS analysis and Rapfish sensitivity, Monte Carlo analysis is done with confidence interval 95%. Based on Monte Carlo analysis, it shows the difference between sustainability index value of private forest management as shows in MDS results and the value of Monte Carlo test results as shown in Table 2.

Table 2: Differences of MDS values analysis and Monte Carlo analysis

Sustainability aspect	Tampo			Padangiring			Sangkaropi		
	MDS	Monte Carlo	Diffe-rent	MDS	Monte Carlo	Diffe-rent	MDS	Monte Carlo	Diffe-rent
Ecology	63.00	62.03	0.97	54.99	54.82	0.17	54.14	54.13	0.01
Economics	44.12	44.30	0.18	24.07	25.00	0.93	22.08	22.30	0.22
Technical of Forestry	47.37	47.70	0.33	41.97	42.40	0.43	44.29	44.18	0.11

Source : Data Analysis, 2015

Table 2 shows the difference between value of MDS and Monte Carlo analysis in each study site. The analysis showed that Tampo Village has a value about 0.18 up to 0.97, Padangiring Village 0.17 up to 0.93 and Sangkaropi Village 0.01 up to 0.22.

Differences in three study sites demonstrated very small average below 1 that is between 0.01 up to 0.97. This case indicates that the error in MDS and Rapfish analysis can be minimized. In other words, sustainability analysis of ecology, economics and technical aspect of forestry in private forest management can be stated as follows: (1) errors in scoring of each indicator is relatively small, (2) variations in scoring for opinions and assessments conducted by the researcher are relatively small, (3) data analysis process that is conducted repeatedly is relatively stable, and 4) data entry errors and data loss can be avoided [8].

Furthermore, to determine whether the indicators examined in MDS analysis is quite accurate and can be justified scientifically, can be seen from stress value and the coefficient of determination (R^2). These values are shown automatically in MDS analysis by using Software Rapfish.

The results of analysis are considered sufficiently accurate and reliable if it has a stress value less than 0.25 or 25% [26]. The smaller stress value obtained means that the better the quality of the analysis used. In contrast to coefficient of determination (R^2), the quality of the analysis results is better if the coefficient of determination

is greater (close to 1 or 100%) [7].

Table 3: Stress values and determinant co-efficient (R^2)

Sustainability aspect	Tampo		Padangiring		Sangkaropi	
	S-Stress	R^2	S-Stress	R^2	S-Stress	R^2
Ecology	0.137	0.948	0.151	0.942	0.151	0.942
Economics	0.154	0.938	0.148	0.942	0.141	0.939
Technical of Forestry	0.137	0.947	0.140	0.948	0.146	0.945

Source : Data Analysis, 2015

Table 3 shows the stress value and coefficient of determination (R^2) of MDS analysis in three study sites. Stress value ranged from 0.137 up to 0.154 is smaller 0.25 or 25% and the coefficient of determination (R^2) ranged from 0.938 up to 0.948 close to 1 or 100%. From both parameters (stress value and R^2) can be stated that all indicators that used in sustainability analysis of private forest management is relatively good and addition of indicatoris unnecessary to approximate the actual conditions.

4. Conclusion

The value of sustainability index and status of private forest management in Toraja regencies on ecology, economics and technical aspect of forestry are as follow: (a) the value of sustainability index of ecology aspect is between 54.14%- 63.00% with a status of aquite sustainable, (b) economics aspect is between 22.08-44.12% with a status of unsustainable and less sustainable, and (c) technical aspect of foretsry is betweeen 41.97% - 47.37% with a status of less sustainable. Sensitive indicators that take effect or necessarily intervened towards sustainability status increase of private forest management in the region of Toraja six out of twenty-five indicators, including: private forest protection, diversity rate of plant and animals (ecology aspect), income level, kinds of cultivated trees (economics aspect) and fertilizing, plant stratification (technical aspect of forestry).

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