Agroforestry Sustainability Status to Support Food Resilience

(Study in Cisokan Sub Watershed, West Java Province, Indonesia)

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ABSTRACT- ***At present, Cisokan sub watershed in West Java Province, is not good enough to support good quality of life and many people living in the area are suffering from food deficiency. In many parts of the sub watershed, the land use/ land cover is consist of critical land, crop plantation in the hills without terraces and encroached forestland.To overcome this, certain type of land use should be implemented. In this case, agroforestry can play important role, not only for food but for ecosystem protection as well. The success of agroforestry system development in Cisokan subwatershed can only be met if supported by complete and up to date data on social, economy and ecology or environment of the area. Based on that data, the sustainability of agroforestry practices can be assessed. Agroforestry sustainability status from social dimension is 43.22 (less sustainable), economic dimension 49.81 (less sustainable), environment dimension is 52.93 (sufficiently sustainable) and multidimensional value is 48.65 (less sustainable). Some attributes that significantly contribute to agroforestry sustainability are willingness to change main food, farmer households expenditure for food nutrients as well as plant pests and diseases control. In order to improve the sustainability level of agroforestry practices, more attention should be paid to social and economics dimensions with comprehensive approaches to all attributes.***

Keywords---- agroforestry, sustainability. sub-watershed, multidimension

1. INTRODUCTION

Cisokan sub watershed covering an area of 118,939.90 hectares is one of the sub-watersheds of the Citarum watershed and situated in four districts, namely Bandung, Cianjur, West Bandung and Sukabumi. Cianjur and West Bandung are the two districts with the number of households of the population classified as not hold food reached an average of 78.82 % [2].

On the other hand, in these two districts, there is a critical land caused by the misuse of agricultural land, which include planting on the slopes of the mountain / hill without terracing and forest encroachment without any attempt for rehabilitation. Therefore it is very necessary to develop agricultural activities that does not require a lot of water but it can improve the quality of the environment, and to support the achievement of food resilience.

An alternative effort to improve food resilience is agroforestry development [9 and 5]. Through the development of agroforestry, support for the achievement of food resilience and ecosystem sustainability will be achieved. The purpose of this study are to determine the practice and the sustainability status of agroforestry systems to support food resilience. Agroforestry sustainability status from social dimension is 43.22 (less sustainable), economic dimension 49.81 (less sustainable), environment dimension is 52.93 (sufficiently sustainable) and multidimensional value is 48.65 (less sustainable).

2. METHODOLOGY

2.1.Location and Time

Research was conducted in Cisokan sub-watershed covering four districts, namely Cianjur (92,226.98 ha), Bandung Barat (26,018.29 ha), Bandung (168.64 ha) and Sukabumi (526.07 ha). Geographically, Cisokan sub-watershed is situated in the central part of the Citarum watershed. Geographical position is at coordinates 6° 39' 34" - 7° 7' 18" South Latitude and 106° 57' 50" - 107° 34' 56" Longitude. The study was conducted in May to September 2014. Research location can be seen on Figure 1.

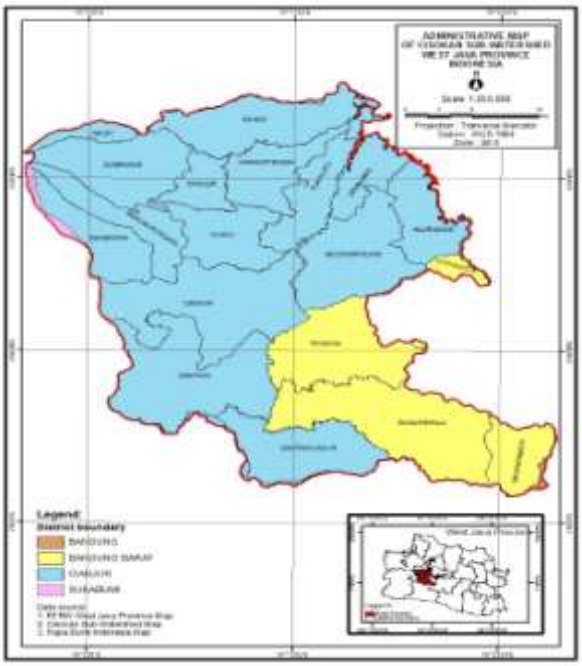

Figure 1: Research location

2.1. Sources and Data Types

The data source came from government institutions, experts, farmers and literatures. The data used are primary and secondary data, both numerical and spatial.

2.2. Respondents Determination

Respondents were selected purposively, i.e. eight informants/experts that includes government officials, academia, agricultural/forestry extension workers and head of farmer groups. Structured interviews were conducted to determine the status of the sustainability of agroforestry in Cisokan sub-watershed. Table 1 shows a list of informant/expert respondents.

Table 1: Agroforestry sustainability respondents

Respondent No	Profession
1	Planning Agency officer
2	Forestry Agency officer
3	Food Resilience Agency officer
4	Academicia
5	Academicia
6	Forestry extension worker
7	Agricultural extension worker
8	Head of farmer group

2.3. Data Analysis

Data analysis of agroforestry practices was performed by means of descriptive statistics, while RAPFISH modified software has been used to analyze the status of agroforestry sustainability. Modifications were done to change the attributes of each dimension used in accordance with the criteria required for the assessment of the agroforestry sustainability. Dimension and attributes used in the research can be seen on Table 2.

Table 2: Dimension and attributes used to assess agroforestry sustainability

No	Dimension	Attributes
1	Social	1. Life expectancy
		2. Farmer formal education level
		3. Agricultural land status
		4. Area of land for agroforestry activities
		5. Utilization of agroforestry products as a source of food.
		6. Willingness to change the basic food
		7. Membership in farmer's groups
		8. Extension
		9. Training
		10. Institutional support
		11. Local wisdom related to environmental conservation
		12. Famers' knowledge about the environment
2	Economy	1. Means of livelihood
		2. Agroforestry production to fulfill food
		3. Farmer household income
		4. Farmer household spending
		5. Farmer household spending for nutrition food fulfillment.
		6. Source of foodstuffs
		7. Distance between the farmhouse and food market
		8. Distance between the farmhouse and agricultural products inputs market/shop
		9. Agricultural products inputs availability
		10. Affordability of agricultural products inputs
		11. Economic prospect of the development of agroforestry
3	Environment	1. Agricultural land location
		2. Watershed hydrology
		3. Land and climate suitability for agroforestry
		4. Soil and water conservation technology
		5. Agroforestry practice composition
		6. Planting crop as soil fertilizer
		7. Fertilizing crops
		8. Plant pest and disease control
		9. Planting trees in agroforestry practices
		10. Benefit of tree crops and livestock
		11. Cattle raising

Agroforestry sustainability data processing is as follows :

1. Perform descriptive statistical data analysis of farmer household respondent.
2. Determine the attributes that will be used to assess the sustainability of agroforestry covering the social, economic and environment.
3. Assess each attribute in every dimension of sustainability to give figures on the range of bad-good value by using an ordinal scale. The number value indicates the leverage of each attribute (attribute leverage), the magnitude of the effect that the criteria for each dimension.
4. Perform Multi-Dimensional Scaling (MDS) ordinance.
5. Monte Carlo analysis at the 95% confidence level to minimize errors that occur in the process of sustainability analysis.
6. Analyze the leverage to know sensitive attributes that need to be considered to improve the sustainability status of each dimension . The higher the value of the attributes of a dimension in the analysis of leverage , the attribute increasingly affecting the sustainability of these dimensions.

7. Determine the status of sustainability for each dimension in multi-dimensional scaling.
   Indices and category used to analyse the agroforestry sustainability status can be seen on Table 3.

Table 3: Indices and Sustainability Category

No	Indices	Category
1	0.00 – 24.99	Bad (Not sustainable)
2	25.00 – 49.99	Less (Less sustainable)
3	50.00 – 74.99	Sufficient (Sufficiently sustainable)
4	75.00– 100.00	Good (Very sustainable)

(Data Source: Kavanagh and Pitcher, 2004. Modified)

3. RESULT AND DISCUSSION

Agroforestry sustainability analysis conducted by analyzing social, economic and environment dimensions as follows :

3.1. Social Dimension

Analysis of the social dimension of sustainable agroforestry uses twelve attributes indicate that the index value of 43.22 on a scale of 0-100 sustainability, so included into the category of less sustainable because it has a value that goes on range from 25.00 to 49.99. When compared with the value of other dimensions, the social dimension of the index value is the least sustainable . This is in line with the results of other research who found one of the problems encountered in the development of agroforestry to support food resilience is the weak tenure and social settings [5] .

Low levels of the social dimension of sustainability is more influenced by the willingness to change the attributes of staple food menu has a leverage value by 3.46 . This condition is in accordance with the results of the questionnaires, which is only 14.74 % of the farmers who are willing to change the menu staple food of rice into the food that comes from trees, including breadfruit and jackfruit. The reluctance of farmers to change menu staple food in general, is because it was accustomed to consume rice. Average rice consumption of West Java Province residents in 2011 and 2012 were 107.93 kg/capita/year and 99.46 kg/capita/year respectively [2].

Attributes as other levers are agro-forest land area of 3.07. Leverage of land area is characterized by a relatively small area of agroforestry areas cultivated by farmers in Cisokan sub-watershed, i.e. on average only 0.16 hectares. The detailed analysis of the factors on the social dimensions, namely social dimension sustainability and social dimension attribute values can be seen on Figure 2 dan 3 respectively.

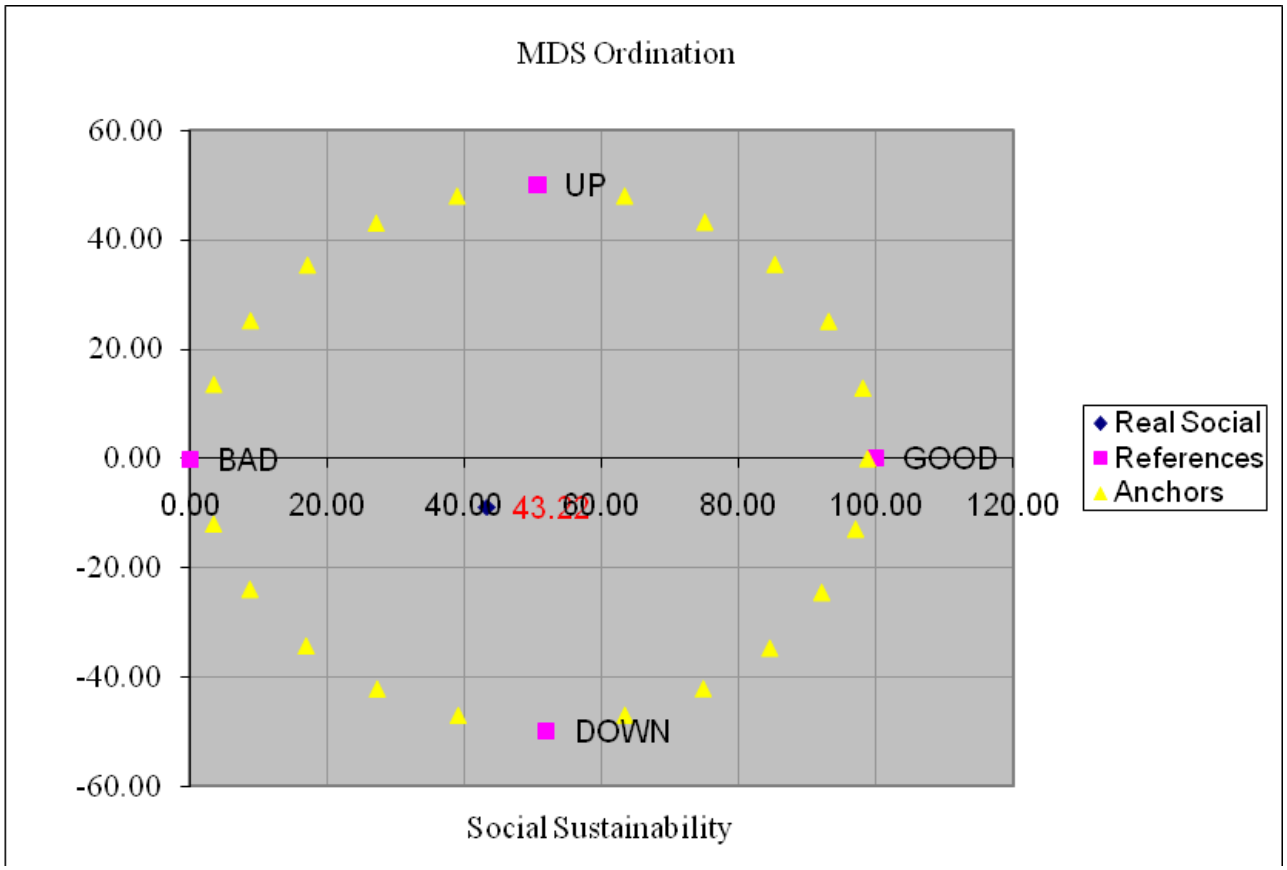

Figure 2: Social dimension sustainability

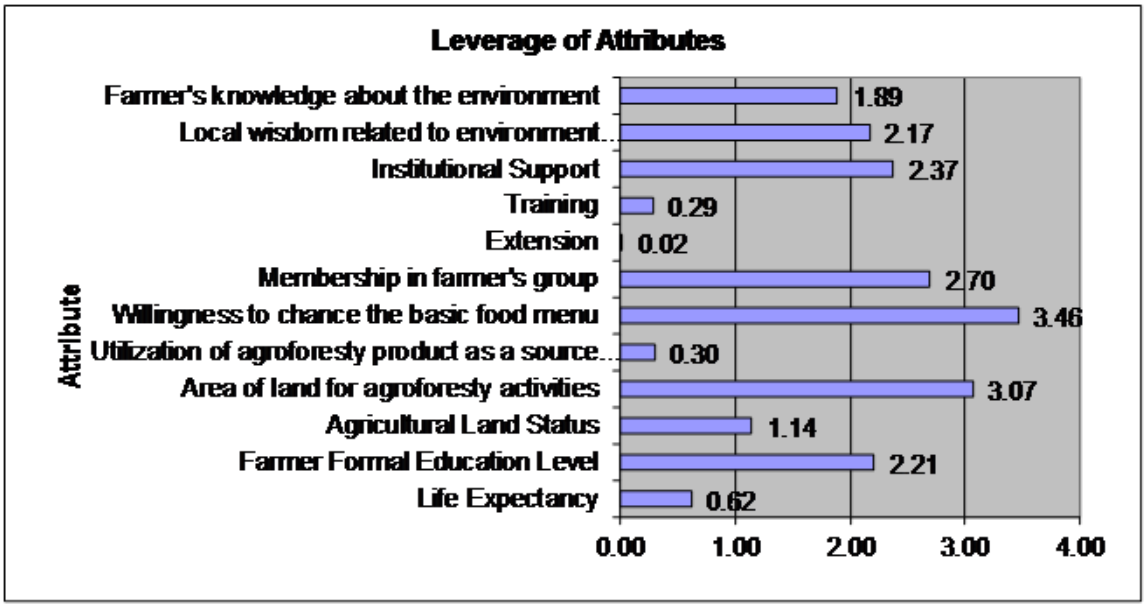

Figure 3: Social dimension attribute values

MDS value of the social dimension is 43.22 %, while the Monte Carlo analysis of the social dimension is 43.39 %. Thus, the validation value for MDS analysis is 0.17 %. This indicates that the value of MDS of the social dimension is valid (< 5 %).

3.2 Economic dimension

The index value of sustainability for the economic dimensions that uses eleven attributes amounted to 49.81 on a scale of 0-100 sustainability, in the category of less sustainable, since it has a range of values that go on range from 25.00 to 49.99. Low levels of sustainability of economic dimension is more influenced by the willingness of farmers to household expenditures for food nutrition with a value of 4.05. This condition is in line with data in Cianjur and Bandung Barat Districts. During the period of 2007-2013 the proportion of expenditure for food in Cianjur District population continues to decline [4]. Similarly, there was a decline in the proportion of food expenditure resident of West Bandung District during the period of 2011-2014 [3]. This value compared to the other dimension values, the value of the index of economic dimension is at a low value and less sustainable. The detailed analysis of the factors on the economics dimensions, namely economics dimension sustainability and economics dimension attribute velues can be seen on Figure 4 dan 5 respectively.

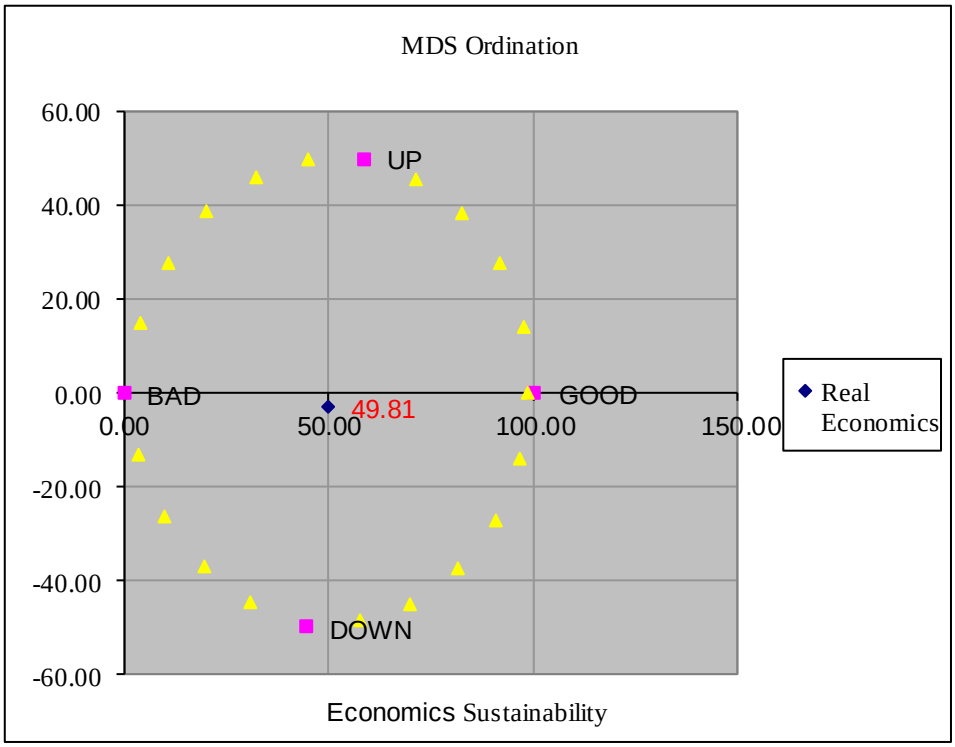

Figure 4: Economic dimension sustainability

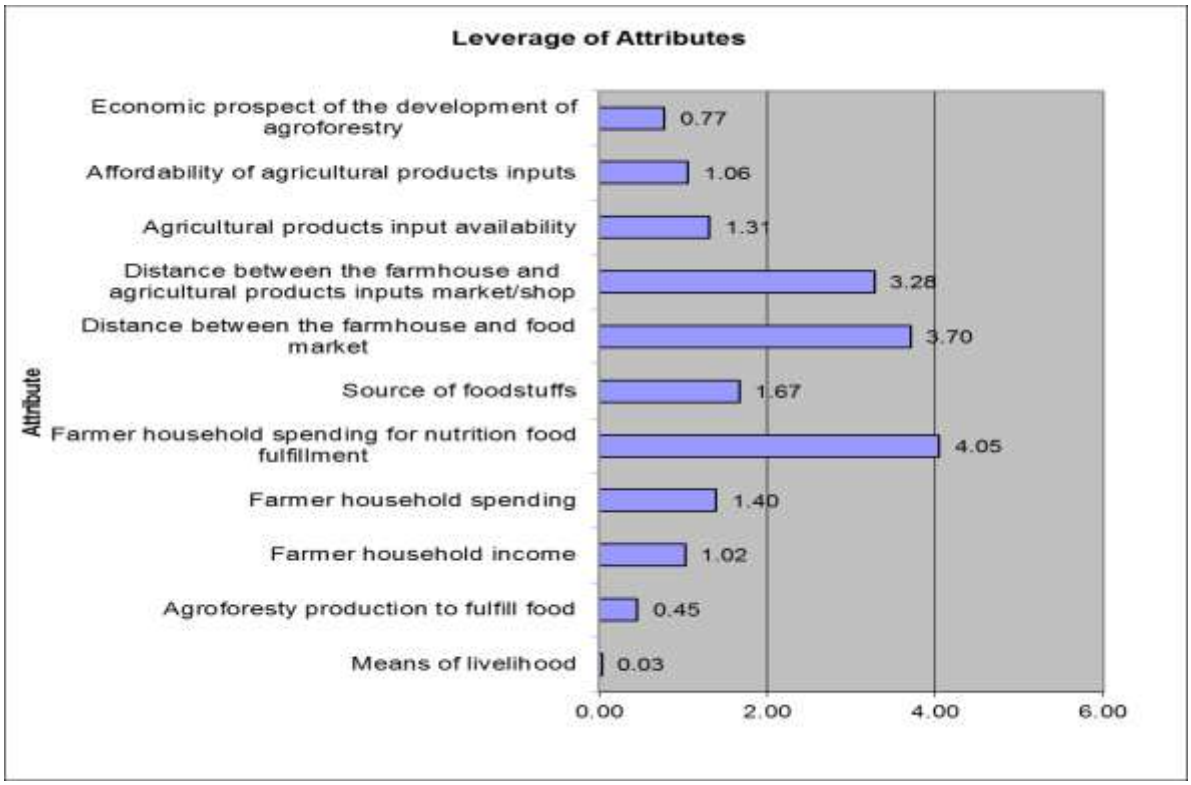

Figure 5: Economic dimension attribute values

The calculated values of Multidimensional Scaling (MDS) on the economic dimensions is of 49.81%, while the Monte Carlo analysis on the economic dimensions is of 49.73%. Thus, the validation value for MDS analysis is of 0.08 %. This indicates that the value of MDS to the economic dimension is valid (<5%).

3.3. Environmental Dimension

The index value for the environmental dimension of sustainability is of 52.93 on a scale of 0-100, in the category of sufficiently sustainable because it has a range of values that go on range from 50.00 to 74.99. The environmental dimension of sustainability level is more influenced by plant pests and diseases control with a value of 3.98. This is because in controlling the plant pests and diseases, 48.00% the number of farmers using chemicals, and as many as 19.00 % using biological stuffs. A total of 33.00% of farmers do not control plant pests and diseases. The detailed analysis of the factors on the environmental dimensions, namely environmental dimension sustainability and environmental dimension attribute velues can be seen on Figure 6 dan 7 respectively.

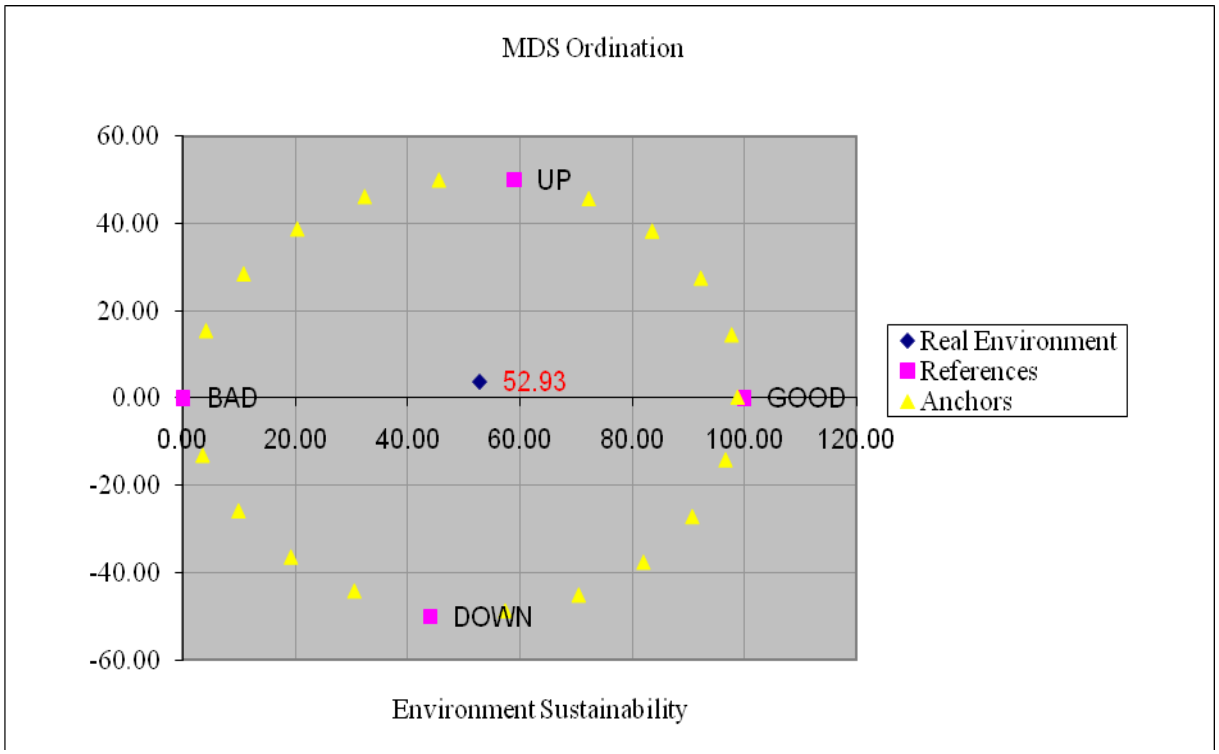

Figure 6: Environmental dimension sustainability

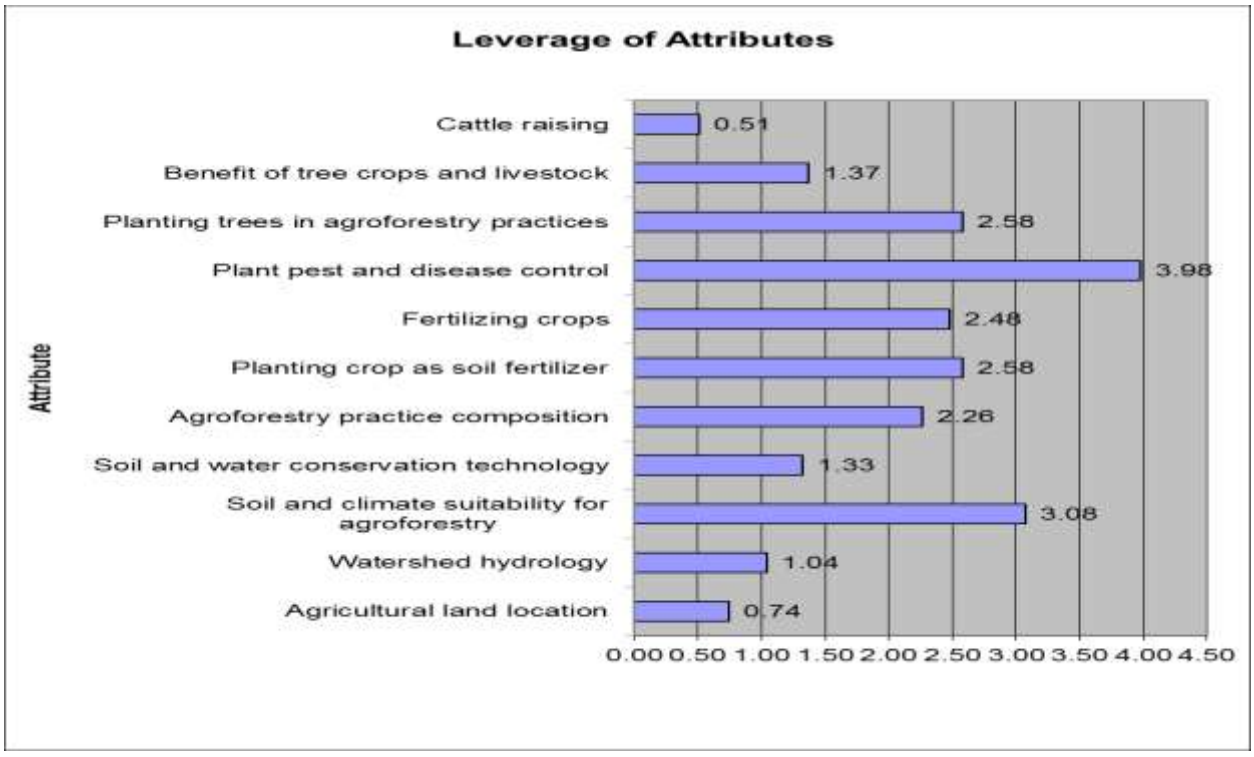

Figure 7: Environmental dimension attribute values

MDS value of the environmental dimension is of 52.93 %, while the Monte Carlo analysis for the environmental dimension is of 52.50. Thus, the validation value for MDS analysis is of 0.43 %. This indicates that the value of MDS for the environmental dimension is valid (<5 %).

3.4. Multidimensional Analysis

Multi-dimensional analysis of sustainability shows that the development of agroforestry is at a level of less sustainable as shown in Table 4.

Table 4: Multi-dimensional Matrix of Agroforestry Sustainability

Dimension	Sustainability index		Difference (%)	Category	Statistical value		Iteration
	MDS (%)	Monte Carlo (%)			Stress	R^2	
Social	43.22	43.39	0.17	Less sustainable	0.14	0.95	2
Economy	49.81	49.73	0.08	Less sustainable	0.14	0.95	2
Environment	52.93	52.50	0.43	Sufficiently sustainable	0.14	0.95	2
Multi-dimension	48.65	48.54	0.11	Less sustainable	-	-	-

The analysis showed that all attributes assessed against sustainability status of agroforestry system is accurate. It is seen from stress values under 0.25 (25%) and the coefficient of determination (R^2) of 0.95 which is close to 1. These results differ from the results of other research conducted [7] concluded that the business continuity of agroforestry in Cisokan sub-watershed be at a moderate level, i.e. with a value of 12.12 on the sustainability scale of 0-20. The difference in the level of sustainability is due to a decrease in the proportion of the population, including farmers expenditures for food, especially in Cianjur District in the period of 2007-2013, thus affecting the level of sustainability of the social dimension. In addition, there is a difference in time of the research, the number of dimensions used, as well as methods and a range of scales used. In the study conducted in 2007 to 2008 [7], used the cluster system with four dimensions of sustainability, i.e. the dimensions of agronomic, economic, social, cultural and ecological. Figure 8 shows the condition of multidimensional sustainability of agroforestry in Cisokan sub-watershed.

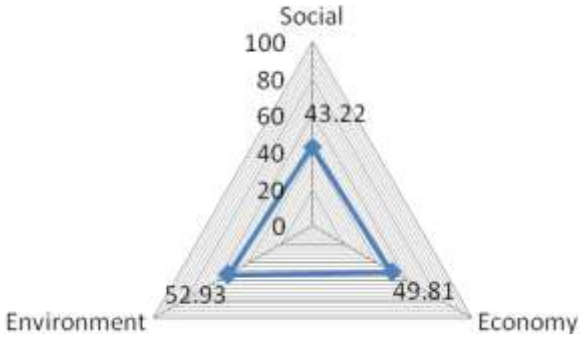

Figure 8: Multi-dimensional agroforestry sustainability

4. ACKNOWLEDGMENT

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