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# Sustainability of Traditional Crop – Livestock Integration System of Local Rural Community in Tanah Datar, West Sumatra.

**Rifli Rindes M[1]*, Asdi Agustar[2], Suardi MS[3], and Novirman Jamarun[3].**

[1] Departemen Agriculture Pascasarjana Andalas University, and Departement Animal Production Jambi University, Indonesia.
[2]Departmen Sosial Ekonomic Animal Husbandry Andalas Universitas, Indonesia.
[3]Department Animal Reproduktion Andalas University, Indonesia.
[4]Department Animal Nutrient Andalas University, Indonesia.

**ABSTRACT**

Integrated Crop Livestock System is widely believe as one of the solution for future challenge of agriculture system to provide food security of increasing human population while in the same time to maintain the health of environment. Local Indonesia farmers already developed this system which is applied for generations. Although studies already showed the benefit of this system, sustainability of classical Indonesia system was hardly analyzed. In this study, sustainability of classic crop-livestock integration system (CLIS) was conducted on system which applied in Tanah Datar, West Sumatra. Research was conducted by survey method and sampling area was determined by purposive sampling method. Data was analyzed by *Multidimensional Scaling* with Rapfish software. Error level of this study was determined by Monte Carlo analysis, Stress level, and $R^2$. The result indicated that CLIS was quite sustain with sustainability index of 53.03 with high confidence level (Monte Carlo <1, Stress level >0.25, and $R^2$ = 0.95). This study also showed 3 key factors to improve sustainability which were (1) application of pesticide during farming practices, (2) application of herbicide during land clearing, and (3) reluctancy of farmers to apply cow's dung produce by their livestock as fertilizer for crops.
**Keywords:** crops, integrated farming, livestock, sustainability.

***Corresponding author***

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## INTRODUCTION

Increasing population in many regions of the world created a scenario of complete food insecurity in the future. This condition lead to intensifying crop and livestock production. However, this practices produced new challenges circumventing the problems arising from application of farming practices with high environmental impact, such as mitigating emissions of greenhouse gases, reducing the erosion and loss of soil fertility, reducing the silting of watercourses and preventing pollution of soil and water (Moraes et al. 2014).

In order to answer the challenges, modern farming practices started to reduce the input to farming system and develop much integrated food production system combining crop and livestock, known as integrated crop-livestock system (ICLS) (Moraes et al. 2014). This system provides several benefits include: 1) improvement of production system which creates improvement in the workforce, increasing economic factoers while in the same time reduce the risk, 2) increasing chances of producers to reach their socio-cultural aspirations in a equitable way, and 3)improve food security to meet consumer's demand regarding the qualty of the products and production processes (FAO, 2010). As for environment, this system could maintain high level of biodiversity, which is essential to support the intensive agricultural system while reducing environmental degradation and adapting agriculture to climate change ( Preston, 2000; Putra and Nakamura, 2009; Munandar et al. 2015).

Integrated crop-livestock systems are as system designed to exploit synergisms and emergent products as result of interaction in soil-plants-animals-atmosphere compartements that integrate crops and livestocks production activities on different spatial-temporal scales, covering the exploitation of crops and animal production in the same area concurrently or sequentially in rotation or succession (Moraes et al. 2013). Most human society with history of agriculture had developed this system prior to green evolution era in Indonesia (Soedjana, 2004; Haryanto, 2009), Africa (Lal, 2001; Franke et al. 2008; Ugwumba, 2010; Ezeaku et al. 2015Asia (Takeuchi et al. 2003; Gill et al., 2009 . Kumar et al., 2012; Murthy et al., 2013; Dash et al., 2015), and South America (Calvanho and Moraes, 2011; Moraes et al., 2013).

Indonesia as a country which consists of islands separated by seas has limitation on the amount of land mass that could be use as agriculture area. Therefore, many regions in Indonesia developed unique agricultural system based on local culture and wisdoms also based on efficiency to increase productivity of limited farming area, Furthermore, this system mainly focused on conservation of natural resources of agriculture such as soil fertility, water availability, and healthy ecosystem services. One of the area where classical system of agricultural still in use is Tanah Datar located in West Sumatra Province, Indonesia.

On average, size of farming area owned by farmers in this region between 0.3 to 0.4 ha with more 81% farmers owned less 0.75 ha (BPS, 2014) which is less than minimum economical farming size, around 0.78 ha per head of family, in Indonesia (Nazam et al. 2011). In order to improve the livehood of these groups of farmer it is necessary to develop farming system with high productivity and efficiency, such as low external input agriculture (LEIA) (FAO, 2001; Marimin, 2004; Supangkat 2009). Furthermore, change in demography, rate of income, availability of soil organic matter, land ownership created more pressure to sustainability of this system which (Reijntjes, 1999; Arifin 2001;Augusto et al., 2002; Zhang et al. 2012).

Studies on these farming systems have been widely reported, particular those that address economic, techical, and ecological aspects. However, the study that examine the sustainability of traditional crop-livestock integration system is still not widely reported.This paper reports the study results of the sustainability of traditional crop-livestock integration system in Tanah Datar, West Sumatra based on ecology, economic, and socio-cultural aspects.

## METHODS

Study was conducted in Kabupaten Tanah Datar, West Sumatra, Indonesia (Fig. 1) by survey method. This region located 200 to 1000 m above sea level with average precipitation 147 mm per month and amount of rain days about 12 days per month. This area also surrounded by Mount Merapi, Mount Singgalang, and Mount Sago which provided good climate condition for agriculture.

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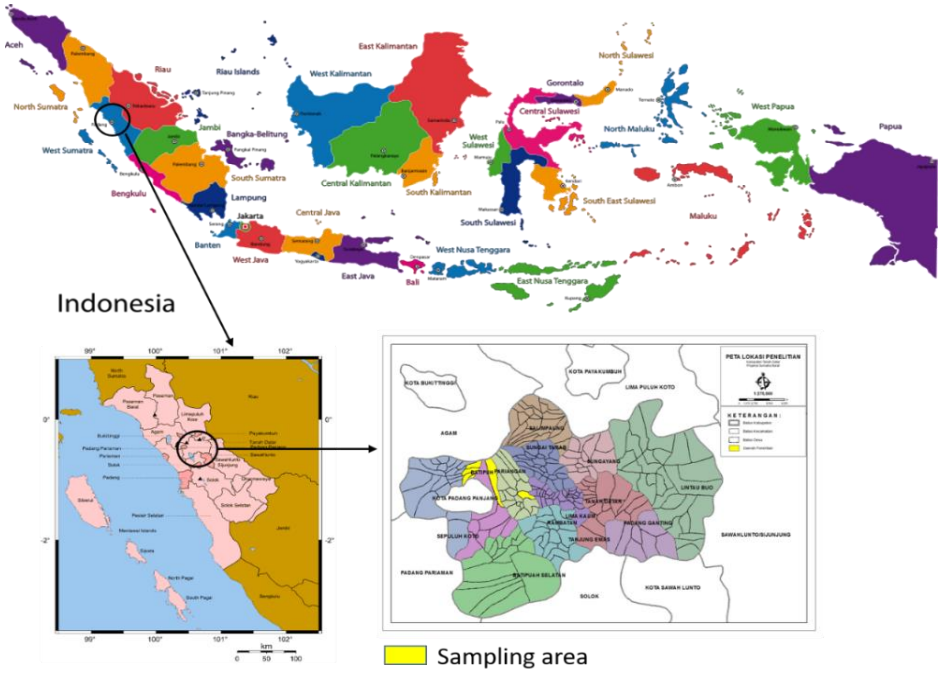


**Fig 1. Sampling location**

Sampling areas were chosed by Multi Stage Sampling method. Respondents were farmers, chose by purposive sampling, who has both crop plantation and livestoct farm while purposive sampling used to chose respondents.

All scores were recorded in ordinal scale based on sustainable characters. Scores based on the sustainability of each observed character, ranged from bad (score = 0) to good (score = 100). Furtherly, all data analyzed by ordination using Multidimensional Scaling (MDS) method. All ordination process was conducted by Rapfish(Pitcher, 1999;Kavanagh,2001). Final result of MDS was visualization of sustainability of proposed system at horizontal dan vertical axis. This system considered as sustain when the index score more than 50%.

## RESULT AND DISCUSSION

Sustainability score of crop-livestock integration system of Tanah Datar (CLIS), based on score of 26 elements showed score 53.03 of 100 (Fig. 2). The result indicated that the system was quite sustain.

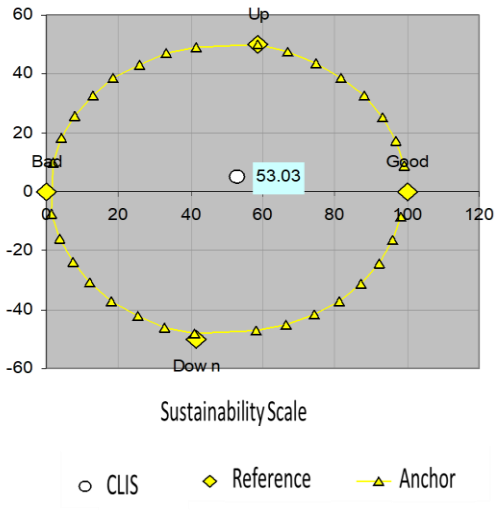


**Figure 2. MDS Analysis of all dimension of Crop-Livestock Integration System (CLIS) of Tanah Datar**

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In order to find the sensitive and dominant factors that influenced sustainability of the system, levarage analysis was conducted for all atribut of system. The result indicated that among 18 atributs scored, score for application of pesticide and herbicide during cultivation was the highest (Fig. 3). Based on the result of leverage analysis, both factors could negatively effects the sustainability of the system through their negative effect on agroecosystem and farmer health.

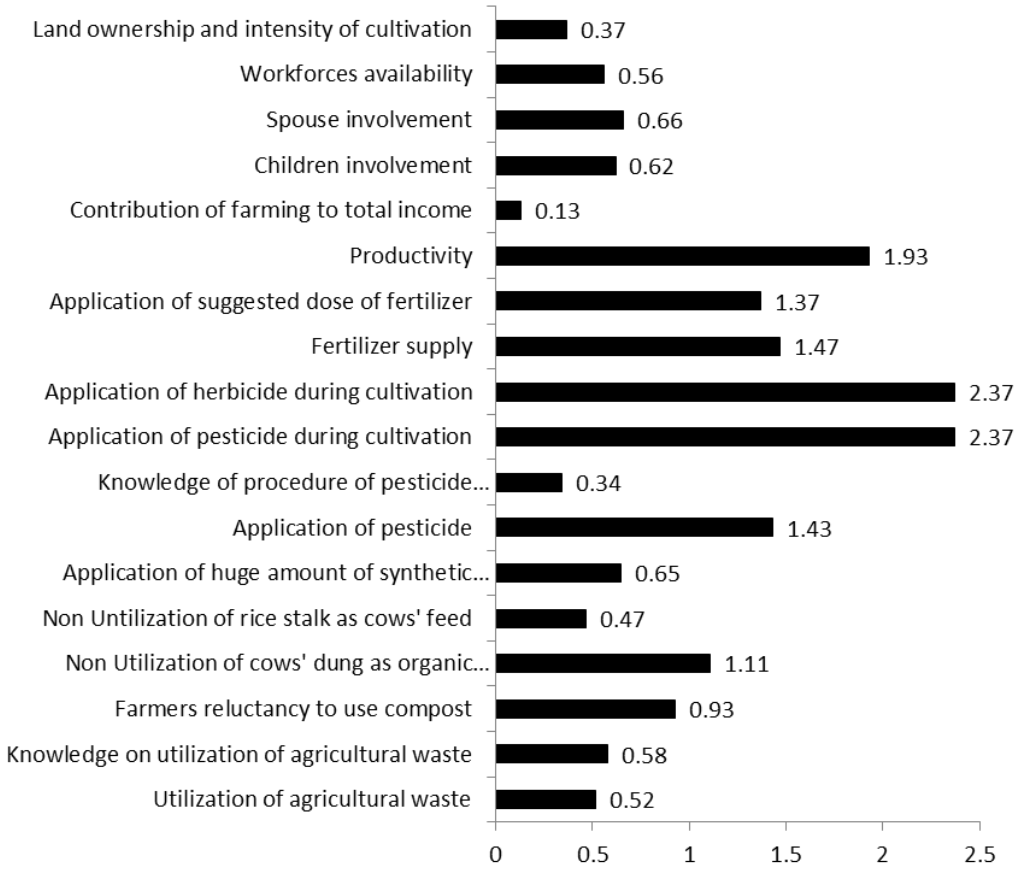


**Figure 3. Leverage analysis of factors that shape crop-livestock integration system of Tanah Datar.**

In the term of economic, MDS score was 54.26 which indicated that the system economically sustain. The value much higher than whole system which indicated higher benefit of the system to economic of farmers (Fig. 4).


**Figure 4. MDS Analysis of Economic of Crop-Livestock Integration System (CLIS) of Tanah Datar**

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Leverage analysis on the economic dimension of the system showed the importance of children and spouse involvement on the system (Fig. 5). The involvement of family members for integration system is crucial since the system requires significantly larger numbers of worker compare with conventional farming system while in the same time reduce the cost of labor. However, in the reality involvement of children was considered low as most farmers highly encourage their children to pursue higher education in order to obtain job outside agriculture.

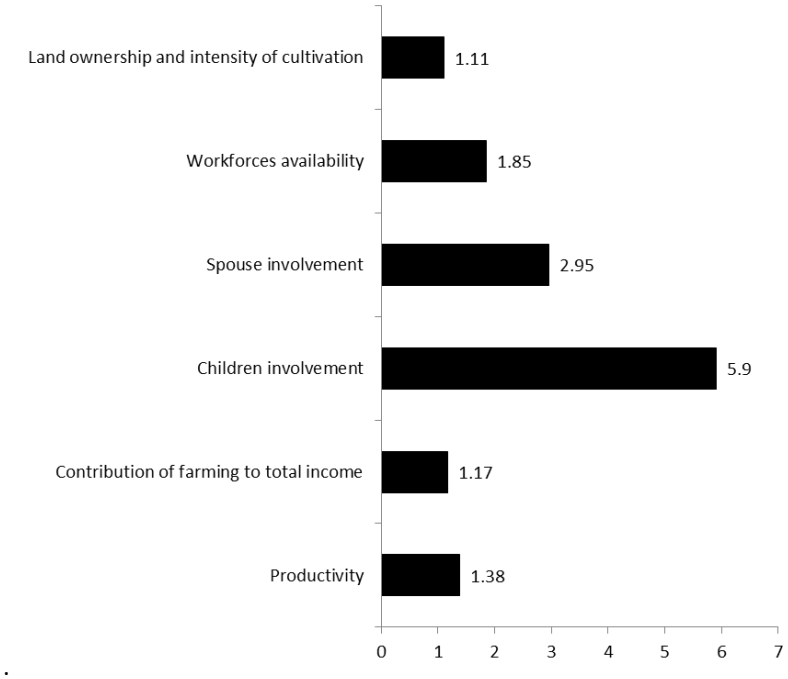


**Figure 5. Leverage analysis of economic factors that shape crop-livestock integration system of Tanah Datar.**

In the term of environment, MDS score was 55.82 which indicated that the system environmentally sustain. The value much higher than whole system which indicated higher benefit of the system to environmental aspect of agricultural system (Fig. 6).

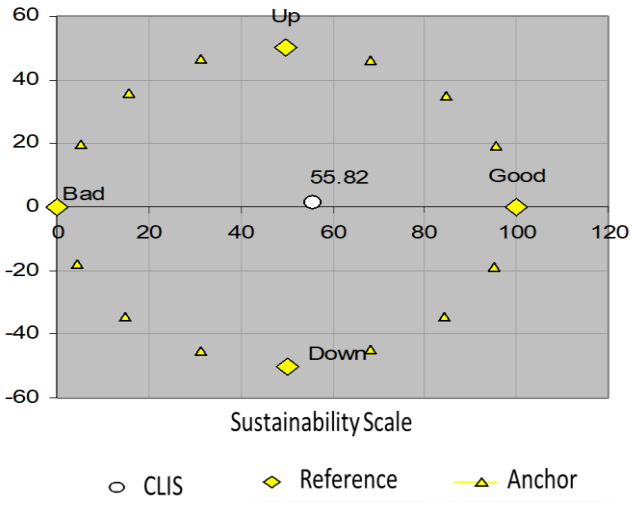


**Figure 6. MDS Analysis of Environment of Crop-Husbandry Integration System of Tanah Datar**

Leverage analysis on the environmental dimension of the system showed the importance of application of both pesticide and herbicide during cultivation for the sustainability of the system also timing of synthetic fertilizer application (Fig. 7). All of these factors could directly change to environmental health of agriculture

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system through deposition of chemical inside soil and water system. In the reality, most farmers using scheduled application of pesticide and herbicide with high focus on maintaining good crop condition and low consideration of the impact on the environment which could hamper the land productivity in the future.

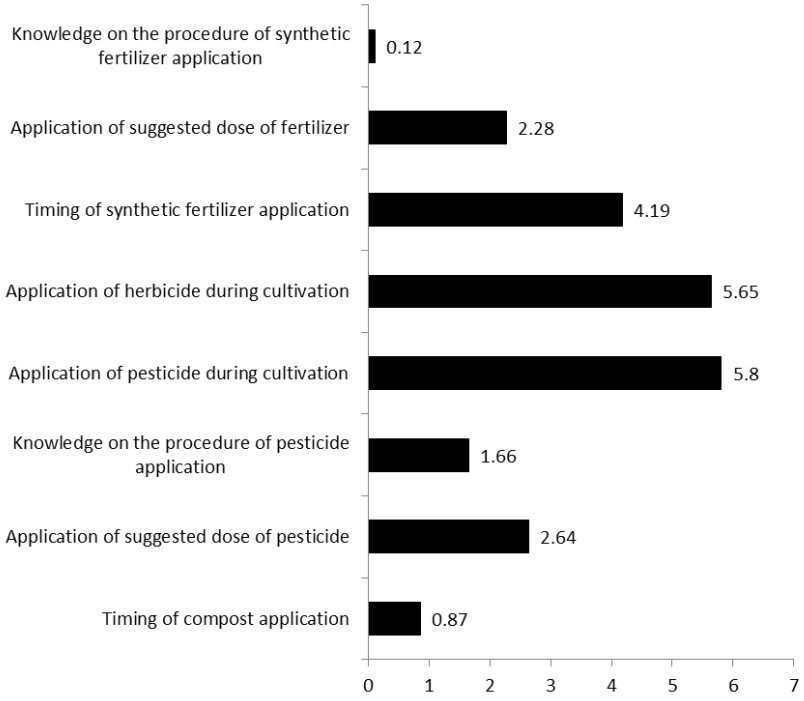


**Figure 7. Leverage analysis of environmental factors that shape crop-livestock integration system of Tanah Datar.**

In the term of social and culture aspect, MDS score was 46.81 which indicated that the social and culture part of the system was not sustain. (Fig. 8). This result indicated the importance of improvement of social and cultural aspect of crop-husbandry system in Tanah Datar to significantly improve its sustainability.

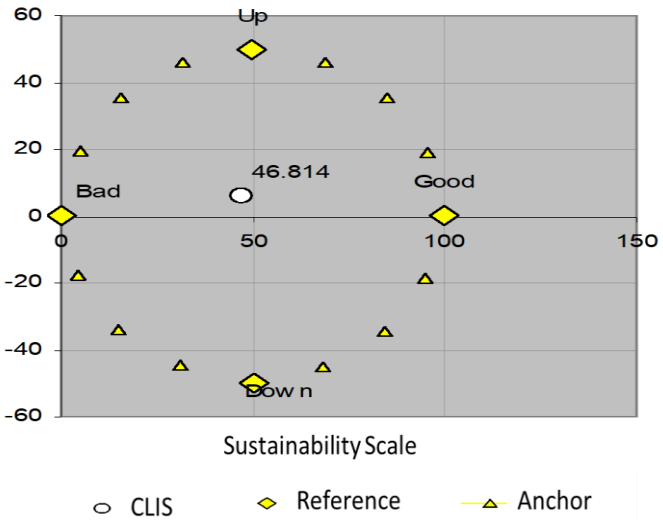


**Figure 8. MDS Analysis of Socio-Cultural of Crop-Livestock Integration System (CLIS) of Tanah Datar**

Leverage analysis on the socio-cultural dimension of the system showed the importance of knowledge on utilization of agricultural waste, non utilization of cows' dung as organic fertilizer and reluctancy of farmer to apply compost (Fig. 9). Similar result on the unsustainability of socio-cultural aspect also reported from different regions in Indonesia (Mersyah, 2005; Ritanumalina, 2008).

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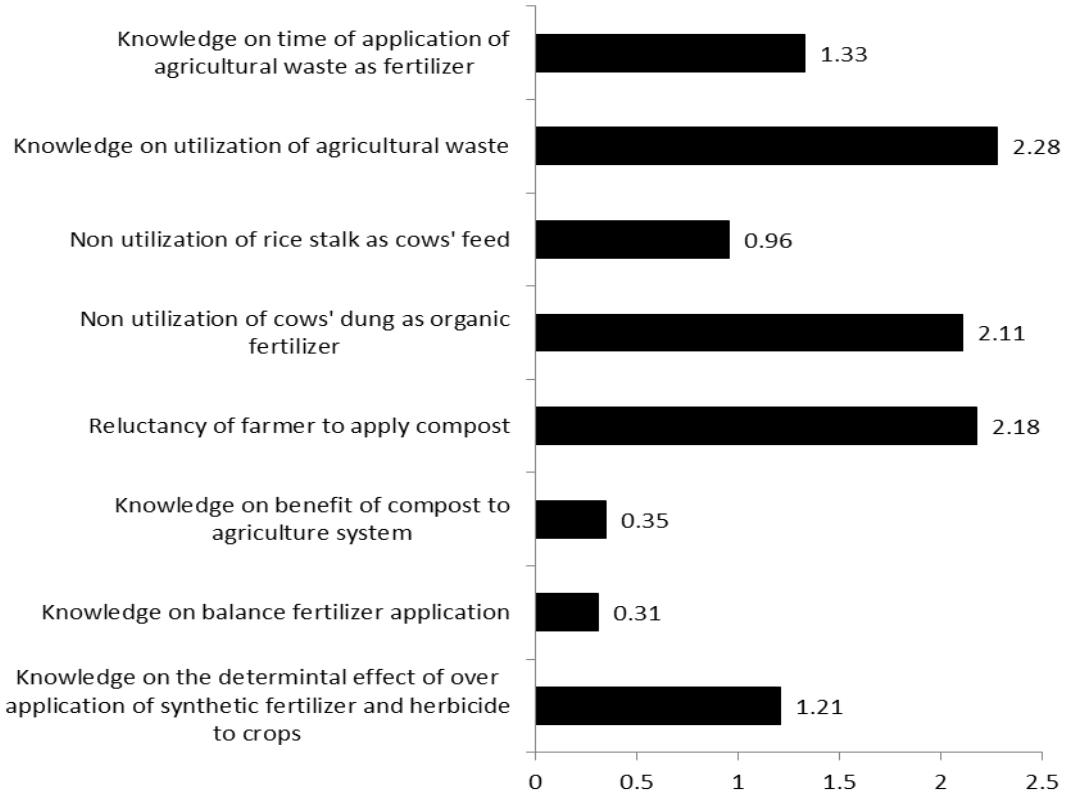


**Figure 9. Leverage analysis of social and culture factors that shape crop-livestock integration system of Tanah Datar.**

This study showed 3 socio-cultural values that lower the sustainability of CLIS of Tanah Datar, (1) utilization of cow's dung as fertilizer, (2) farmer perception of application of compost, and (3) source of agriculture waste for livestock feed.

Reluctancy of farmer to apply cow's dung as fertilizer of their crops due to asumption that fertile soil will produce good crops which attract disease and pests. Based on this asumption they prefer to apply chicken manure from other region which provide enough nutrition to crops without any over growth which may attract disease and pests.

Lower sustainability of socio-cultural aspect in future will hinder the application of CLIS as all aspects observed in this study are interrelated. Education and disemination of simple technology that show the application of cow's dung as fertilizer which provide more benefit that disadvantage would be necessary in order to create more sustain system.

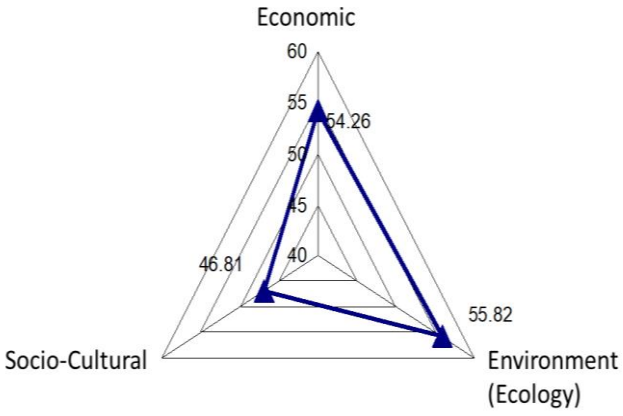


**Figure 10. Comparison of Economic, Environment, and Socio-Cultural of CLIS of Tanah Datar**

In general, it could be conculed that sustainability of CLIS of Tanah Datar was toward economic and ecology (Fig 10.). The result indicated the potency of application of this system in other region with low economic and environmental sustainability. Education and access to new knowledge might improve the socio-cultural sustainability although the impact on the economic and environment should be monitor and put in the great concern.

Table 1 showed stress value and $R^2$ value of all observed paramater. Lower stress limit of good value is 0.25 (Fisheries, 2004) while higher $R^2$ indicates accurate analysis. The result indicated all atributes used in this study able to explain result on economic, environment, and socio-cultural sustainability level..

**Table 1.Parameter statistic (*Goodnes of fit*) dari analisis keberlanjutan**

| Statistic Parameter | Multi Dimensional | Economic Dimension | Ecology Dimension | Socio-Cultural Dimension |
|---|---|---|---|---|
| Stress | 0.1265 | 0.15570 | 0.14326 | 0.15689 |
| $R^2$ | 0.95835 | 0.94248 | 0.94776 | 0.94365 |
| | | | | |
| MDS | 53.02 | 54.26 | 55.82 | 46.81 |
| Monte Carlo | 52.37 | 53.56 | 55.22 | 46.52 |
| Depriciation | 0.65 | 0.70 | 0.60 | 0.29 |

Furthermore, deprication between MDS and Monte Carlo analysis recorded in this study was lower than 1 which indicated high confidene level of the result (Mersyah, 2005).

Thus, it could be concluded that the result of this study could be use as foundation to design strategy for future crop-livestock integration system in Tanah Datar or other regions similar to Tanah Datar.

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