

Ecological sustainability of smallholder dairy farm with Leisa pattern

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Received March 10, 2018; Accepted September 10, 2018

ABSTRAK

Penelitian ini bertujuan untuk mengetahui status keberlanjutan usaha peternakan sapi perah rakyat yang menerapkan pola *Low Exeternal Input Sustainable Agriculture* (LEISA) dan merumuskan model yang berkelanjutan. Penelitian dilakukan pada 8 peternakan sapi perah rakyat di Kawasan Usaha Peternakan (KUNAK) Kabupaten Bogor dengan kriteria: rataan kepemilikan ternak 11 ekor, menanam rumput gajah di sekitar kandang, mengalirkan kotoran ternak pada lahan kebun rumput, tidak menggunakan pupuk kimia, luas lahan 4250 m². Analisis data dilakukan dengan cara: 1) penentuan atribut, 2) penentuan skala ordinal berdasarkan kriteria keberlanjutan, 3) analisis data (*software Rap Dairy*), 4) mengkaji nilai indeks dan status keberlanjutan, 5) mengkaji atribut sensitif (analisis *Leverage*) dan 6) validasi model (analisis *Monte Carlo* dan *Square Correlation* (SQR)). Atribut dan skala ordinal pada keberlanjutan ekologi adalah kepadatan ternak, kapasitas tampung, kondisi air, drainase kandang, kesuburan tanah, topografi, curah hujan, kelembaban, suhu dan ketinggian tempat. Analisis *Rap Dairy* menunjukkan bahwa usaha peternakan sapi perah rakyat pola LEISA secara ekologis cukup berkelanjutan dengan indeks 57.95. Indeks dapat ditingkatkan menjadi 88.39 (berkelanjutan) melalui simulasi model dengan memperhatikan atribut sensitif. Analisis *Leverage* menunjukkan bahwa topografi, kepadatan ternak, kapasitas tampung, ketersediaan air merupakan atribut sensitif. Analisis *Monte Carlo* dan SQR menunjukkan bahwa model dapat menjelaskan data dengan baik.

Kata kunci: leisa, berkelanjutan, sapi perah, rapdairy, ekologi

ABSTRACT

This study was conducted to determine the sustainability status of smallholder dairy farms applying Low External Input Sustainable Agriculture (LEISA) pattern, and to formulate sustainable model. Eight smallholder dairy farms located in livestock business area (KUNAK) were purposive selected with criteria was they had 11 heads dairy cows, planted an elephant grass, dispose the manure to grassland, did not use chemicals fertilizer, 4250 m² land area of dairy farming. Data were analyzed by: 1) attribute determination, 2) ordinal scale determination based on sustainability criteria; 3) data analysis (Rap Dairy software); 4) assessment of index and sustainability status; 5) review sensitive attributes (leverage)

analysis) and 6) validation model (Monte Carlo and Square Correlation (SQR) analysis). Attributes and ordinal scale on ecological sustainability were density of dairy cow, carrying capacity, supply water, drainage cages, soil fertility, topography, rainfall, humidity, temperature and altitude. Results of Rap Dairy analysis showed that smallholder dairy farms who apply LEISA pattern ecologically was quite sustainable with index of 57.95. The index could be increased to 88.39 (sustainable) through model simulation with respect to sensitive attributes. The results of Leverage analysis showed that topography, density of dairy cow, carrying capacity, supply water availability were sensitive attributes. Analysis Monte Carlo and SQR showed that model could explain data well.

Keywords: leisa, sustainability, dairy, rap dairy, ecology

INTRODUCTION

Sustainable agriculture is a farming system which developed ecologically harmless, economically profitable, socially in accordance with the local culture with a holistic approach (Horrihan *et al.*, 2002). Sustainable agriculture system in general sense is ecologically oriented, while in specific sense is optimizing local agricultural resources without using of external inputs. There were several terms used in sustainable agriculture system: Low External Input Agriculture (LEIA) (Jager *et al.*, 2001); Low External Input Sustainable Agriculture (LEISA) (Diwyanto *et al.*, 2001; Ibeawuchi *et al.*, 2015); Low External Input Strategies (Yengoh and Svensson, 2008); Sustainable Agriculture (Kassie and Zikhali, 2009); Low External Input Technology Agriculture (LEITA) and High External Input Technology Agriculture (HEITA) (Anyanwu, 2011); Ecofarming (Salendu and Elly, 2011); Low Input Sustainable Agriculture (LISA), (Najafabadi *et al.*, 2012); or Organic Agriculture (Augustine *et al.*, 2013).

Mustikarini *et al.* (2010) stated that LEISA is an agro ecosystem designed to maximize the recycling process, minimize the use of external inputs, and provide income periodically so that farmers can meet the needs of life continuously. External inputs were only used to supplement less elements in the ecosystem and exploit the use of genetic resources complementary and synergistic thereby minimizing environmental damage. LEISA is a concept of combining agriculture, livestock and fisheries sustainable that suppress the use of external inputs to obtain an efficient, eco-friendly, crisis-resistant and competitive farming system. Ibeawuchi *et al.* (2015) stated that LEISA generally applied by small-scale farmers with the use of technology, labor, capital and low production materials.

Agriculture as a production systems were

produce pollution, causes of land and environmental degradation, marginal land expansion and maritime outflow (downstream) (Salendu and Elly, 2011). Thus, if farming system and livestock did not processed in a sustainable way, it will lead to degradation of natural resources and the environment.

In Indonesia, smallholder dairy farms were traditionally managed and tend to apply the LEISA pattern to reduce the use of production costs. Similarly in Bogor's Livestock Business Area (*Kawasan Usaha Peternakan, KUNAK*), the application of LEISA pattern was done by rearing the cows integrated with elephant grass in order to reduce cost of feed purchasing. In the rainy season the use of feed in the form of agricultural waste (rice straw) as additional feed is quite low (Asminaya *et al.*, 2017). The disposal of dairy cow manure and wastewater disposal were flown to the grasslands to support the availability of soil nutrients for elephant grass growth and reduce the use of chemical fertilizers.

The traditional management applied in *KUNAK* in line with zero waste principle. Zero waste was an integration technology to gain a double advantage: 1) increase productivity, 2) overcoming environmental pollution, 3) cheap, increase fertility and sustainability of the land, and 4) increase farm income and efficiency (Galib, 2008). Zero waste agricultural technology can be developed with the support of human resources at the productive age and the level of education (Sunanto and Nasrullah, 2012). This pattern was done to reduce the use of high production cost so that the maintenance system is still far from the standard of Good Farm Practice (GFP). Most dairy farms did not pay attention to general maintenance management, ignoring animal health control, veterinary and animal conditions, feeding and drinking water, the environment and infrastructure and also handling of products. Then will be implication to the low

dairy cow productivity.

In this regards, it is necessary to assess the most sensitive attributes, statuses and index ecological sustainability of dairy farms in the rainy season. The results of this study can be used as a foundation in the development policy of dairy farm ecologically to increase dairy cow productivity.

MATERIALS AND METHODS

Time and Place

This research was conducted during rainy season (January-March 2015 and November-December 2015). The data were collected from dairy cattle farms those applied LEISA pattern with land ownership of 4250 m² in *KUNAK*, Cibungbulang, Bogor.

Collecting Data

Data were collected by observations and interviews with dairy farmers, government official and academic/expert. The collected data were density of dairy cow, carrying capacity, supply water, drainage cage, soil fertility, topography, rainfall, humidity, temperature and altitude.

Sustainability Dairy Farm Analysis

Analysis of sustainable dairy farm was carried out by multidimensional scaling approach (MDS) (Yusuf *et al.*, 2016) with Rap Dairy (Rapid Appraisal of Dairy) software. Rap Dairy were modification from Rapfish (Rapid Appraisal of Fisheries) to determine status and index sustainability of the smallholder dairy farms. (Pitcher and Preikshot, 2001). The stages of Rap Dairy analysis include:

1. Determination of ecological dimension attributes on smallholder dairy farms which apply LEISA pattern in *KUNAK*. Attributes include factors that affect sustainability of smallholder dairy farms.
2. Each attributes of ecological dimension were given an ordinal score from 0 (zero) to 9 (nine) which represents the lowest to highest stratum of assessment. Zero score was bad and nine score was good. The higher score will give the higher contribution to the sustainability of the smallholder dairy farm.
3. Analysis of attributes scores using Rap Dairy software
4. Assess the status and index sustainability of smallholder dairy farm which apply

LEISA pattern in *KUNAK* according to Kavanagh and Pitcher (2004): Index score 0.00-24.99 (bad, unsustainable); 25.00-49.00 (less sustainable); 50.00-74.99 (enough, quite sustainable); 75.00-100.00 (good, sustainable).

5. Sensitive attributes were assessed using Leverage analysis (Mulyana *et al.*, 2011). Sensitivity analysis was performed to see attributes that play a strong role in determine sustainability. Sensitivity analysis was done by look at the effect of *Root Mean Square* (RMS). The greater value of RMS changes due to the loss of an attributes, the greater role of attributes as a determinant of sustainability on smallholder dairy farm in *KUNAK*.
6. Evaluate the error rate score, score variation, data input error/missing data and high stress value were analyzed using Monte Carlo (Frimawaty *et al.*, 2013).

Validation Model

Validation of the model was done by look at stress value, Square Correlation (SQR) and differences between Monte Carlo value and rap analysis. The value of stress or a lack of fit measurement was less than 25% or $S \leq 0.25$ (Ratnaningtyas *et al.*, 2016). The value of SQR or the result of goodness of fit approaches 100, indicate that the model can explain the data and each of attribute is sufficiently accurate and reliable (Cahya, 2016). Goodness of fit in MDS was intended to see the distance of estimated point and original point and to see how well the measurement was (Baroleh *et al.*, 2016). Difference between Monte Carlo value and rap analysis are <5% (Kavaragh and Pitcher, 2004).

RESULTS AND DISCUSSIONS

Sustainability Status

Rap Dairy analysis of ecological dimension on smallholder dairy farm during rainy season in *KUNAK* was at position of 57.95 from index of 0-100 or in middle category (Figure 1). These sustainability index was lower than Erif Farm (76.21) and Cifa Farm in Cisarua (76.92) (Jaenudin *et al.*, 2017). The result of leverage analysis showed that attribute ≥ 4 was manure flow to the grassland, topography and rainfall (Figure 2). These attributes were an attribute that must be minimized in order to keep sustainability of ecological dimension on the operation of

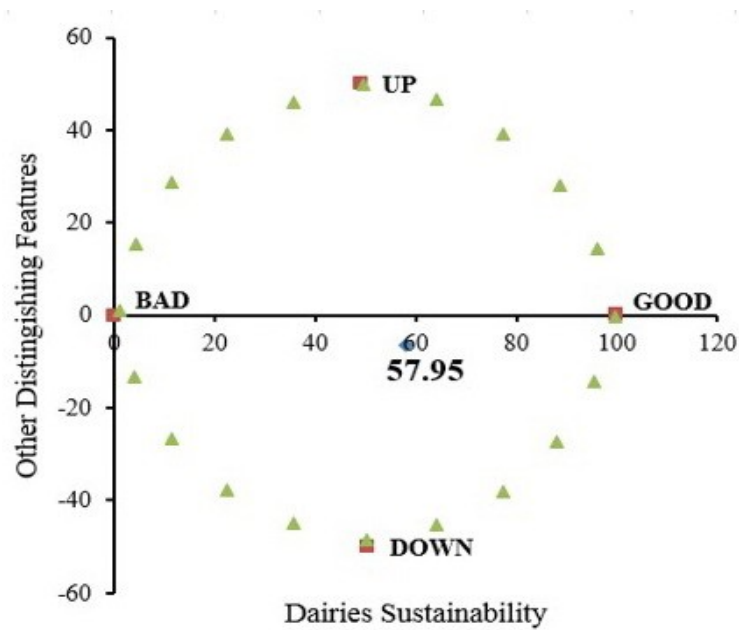


Figure 1. Rapdairy Ordination of Sustainability Ecology on Smallholder Dairy Farm which Apply LEISA Pattern in *KUNAK* during Rainy Season.

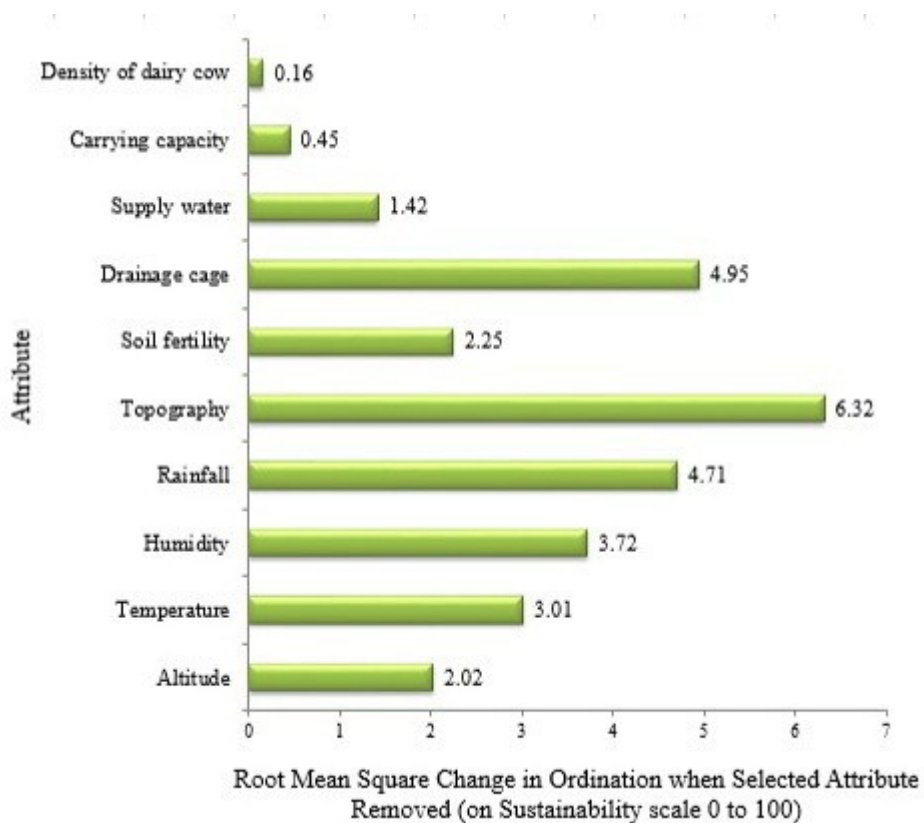


Figure 2. Leverage Analysis of Ecological Sustainability Smallholder Dairy Farm which Apply LEISA Pattern at *KUNAK* during Rainy Season.

smallholder dairy farms which apply LEISA pattern at *KUNAK*.

Manure flow to the grassland was closely related to the cleanliness of the animal housing, waste management and forage growth. The cleanliness of the animal housing closely related to dairy cow's health. The cleanliness of the animal housing will provide a comfort condition and healthy atmosphere for the cows to support optimal growth and productivity. Everitt *et al.* (2002) stated that housing hygiene, lactating cow conditions, equipments, dairyman greatly influenced the quality of produced milk and the number of milk bacteria. Kusnadi and Juarini (2007) stated that the number of milk bacteria (the total plate counts), milk fat and total solid were determinants of milk price in Indonesia.

Therefore, sanitation and control on feeding, equipments and milking process should be received special attention. Before milking process started, the cows should be cleaned at around their stomach and udder using warm water. Similarly, the housing and equipments also must be cleaned before milking. The cleanliness of housing will be in clean condition if the housing drainage is well managed, so that the waste management becomes more manageable. Minister of Agriculture regulation No. 100/Permentan/OT.140/7/2014 concerning Good Farming Guidance for Dairy Cow Breeding mentioned that every dairy cow farm must have a good drainage and sewerage, with floor's slope of 2-5 degrees, not slippery, not rough, easy to dry and resistant stamping and also use mat (carpet/mat) to keep the animal house clean and not inundated with water. Good management of animal house's drainage will also facilitate easy waste management (fesses/urine) for organic fertilizer or biogas.

Topography attributes also required attention since it greatly affects the position of the animal housing, the comfort of the cows, and the worker's activities for forages supply. Land with flat topography will make the cows farmers more comfort and more easily to run farm's activities such as feeding, milking and feed and milk transportations. Suratman and Busyra (2006) showed that the best topography slopes for dairy farm was less than 15%, if the slope more than 30% needed intensive land conservation. The growth of some forages species will be vulnerable under conditions of highlands more than 1200 m above sea level. Yani and Purwanto (2006) stated that the best topography for dairy farm was more than 800 m above the sea level.

Rainfall is attributes that have been fixed and cannot be modified by management activity. So, if we want to develop smallholder dairy farm which apply of LEISA pattern must pay consider to rainfall conditions since rainfall is microclimate which indirectly influence the productivity of dairy cows (Yani and Purwanto, 2006). According to Suratman and Busyra (2006), the suitable temperatures and humidity for optimum growth of forage and dairy cow production were 18-35°C and 60-90%, respectively. The excessively dry rainfall (less than 400 mm/year) and drought conditions more than 8 months/years will slow up the growth of forages. The suitable temperatures and humidity for dairy cow production were 18.3°C and 55%, respectively (Yani and Purwanto, 2006).

Leverage analysis were attributes those did not sensitive but influenced the sustainability of smallholder dairy farm. The attributes were the density of dairy cow, carrying capacity of land and supply of water. All of the attributes score must be increased so that the farmers could keep their dairy farm sustained. The attributes of dairy cow density will affect the availability of forage (Ajayi *et al.*, 2005) and the feed fulfillment (Despal *et al.*, 2011). The results showed that there has been over capacity of dairy cow at the smallholder dairy farm which apply LEISA pattern in *KUNAK*. This condition was caused by the wish of farmers to increase their income without taking account the availability of the forage. All respondent of this study kept the dairy cow almost twice than that of the number of dairy cows those should be retained. Based on the existing land conditions and the availability of forage, the density of dairy cow should be less than 7 animal units (AU); however they kept up to 11 AU. Thus, the availability of existing feeds did not able to meet dairy cow's need and the addition of external feeds (concentrate and forage) in limited quantities did not offer a good impact on the cow's productivity.

Ecologically Sustainable Model of Smallholder Dairy Farm

The analysis result of ecological dimension on the model showed that the smallholder dairy farm's sustainability which apply LEISA pattern could be sustain and had a 88.39 from index category 0-100 (Figure 3). The value was obtained by an improvement of ecological dimension. The result of leverage attribute

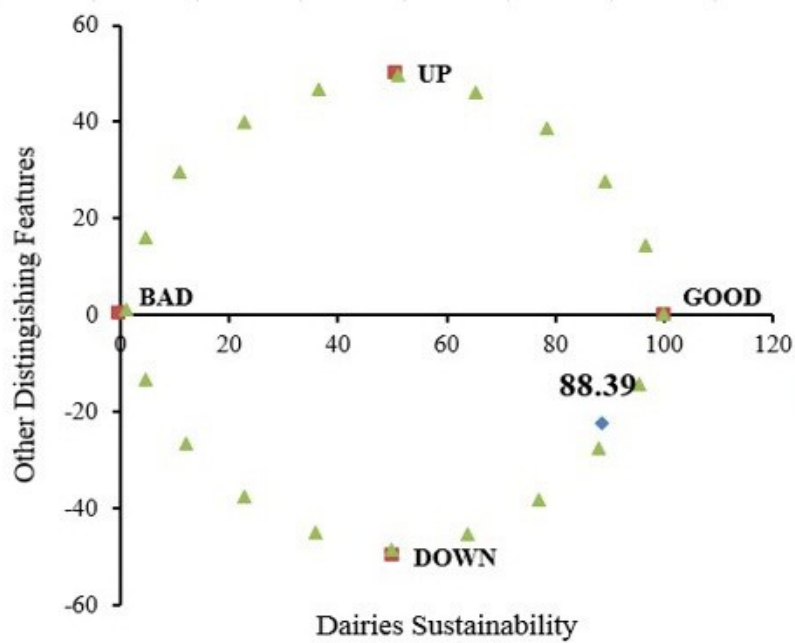


Figure 3. Rapdairy Ordination of Ecologically Sustainable Model of Smallholder Dairy Farm which Apply LEISA Pattern in *KUNAK* during Rainy Season.

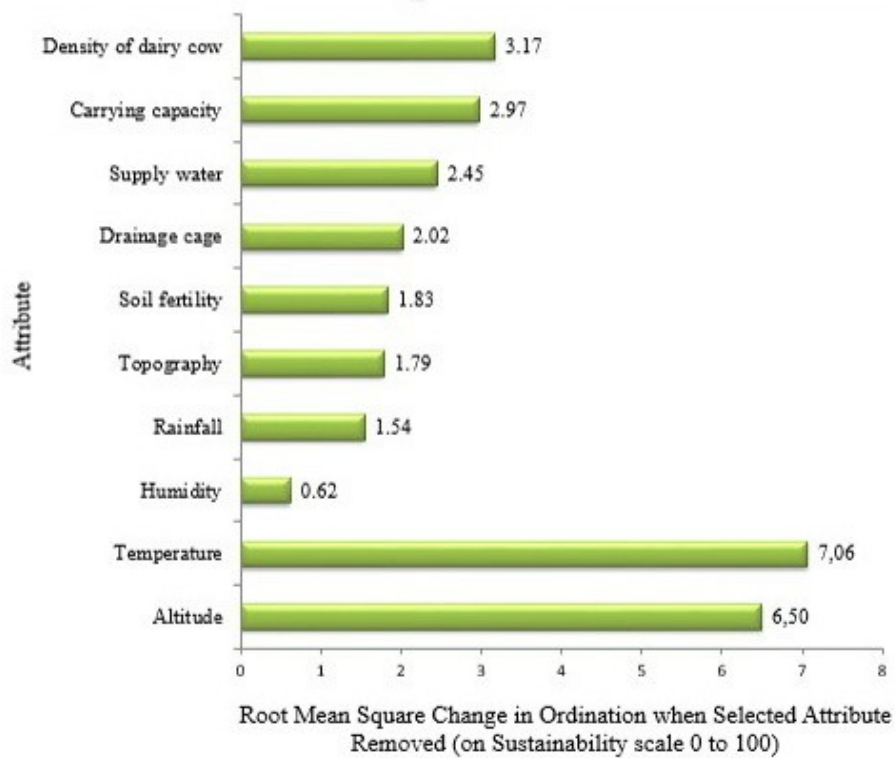


Figure 4. Leverage Analysis Model of Ecological Sustainability Smallholder Dairy Farm which Apply LEISA Pattern at *KUNAK* during Rainy Season

analysis was shown in Figure 4.

Rap Dairy analysis results on the status of smallholder dairy farm sustainability which apply LEISA pattern at *KUNAK* indicated that there were some attributes that still need to be improved. The attributes need to be improved were density of dairy cow, the carrying capacity and supply of water so that status of smallholder dairy farm will be sustainable. The results showed that there has been excess capacity in the smallholder dairy farm which apply LEISA pattern in *KUNAK*. This can be seen from the number of dairy cows kept by the farmers (11 AU) more than the number should be maintained (7 AU). These conditions cause the availability of elephant grass is not sufficient for dairy cow needs and impact on the low productivity of dairy cow. Generally, the farmers keep the dairy cow to get big profit without considering the availability of feeding factor so that productivity becomes less optimal. In general, the production of elephant grass in the grassland is not able to meet the needs of the dairy cows. Elephant grass production at present is 194.95 ton/ha/season or equivalent to 2508.5 kg/m²/d. The production of elephant grass can accommodate dairy cow as much as 7.42 AU. The number of cattle kept by farmers are 11 AU, then the existing elephant grass production is not able to meet the needs of dairy cattle. In fact, to increase the productivity of dairy cattle required adequate amount of feed, available throughout the year and good quality.

Carrying capacity in dairy farm was closely related to animal feed (Ajayi *et al.*, 2005), nutrient needs (Despal *et al.*, 2011) and dairy cow density in the rainy season (Nugraha *et al.*, 2013). The results showed that the existing land did not able to meet the needs of dairy cattle feed because the number of dairy cows were maintain exceeds the capacity that should be.

Therefore, if farmers want to increase dairy cow productivity and sustainability status of smallholder dairy farm which apply LEISA pattern, hence breeders should keep dairy cow according to the amount of capacity they should be. Breeders at *KUNAK* should reduce the number of dairy cows their maintain to the number they should be breed according to carrying capacity. Reduce the number of dairy cow can be done based on selection of milk production. According to Karnaen and Arifin (2007), optimal milk production can be improved by improving the genetic quality by recording the cow identity, milk production, reproductive data, and animal health

so that the selection program becomes directed. A dairy cow has several times lactation during life so that more lactation records will be more precise and accurate production capability. Such records may be used to estimate heritability and breeding of dairy cattle. Dairy cattle that have high heritability and breeding values can be used as a mother on the next generation. In addition, the carrying capacity and supply of water must also be considered. Carrying capacity were related to stocking rate of forage production and milk yield (Macdonald *et al.*, 2008), enlarging of scale in dairy farming (Jaarsma *et al.*, 2013) and scenarios of diets (Peters *et al.*, 2016).

Validation of Sustainability

Validation of sustainability model of smallholder dairy farm which apply LEISA pattern at *KUNAK* was done by comparing the result of MDS calculation with Monte Carlo. The validation result on the model of sustainability of smallholder dairy farm which apply LEISA pattern in this research showed that the feasibility value of 0.128 MDS model was valid because the value is smaller than 0.25. The value of Squared Correlation (RSQ) in this study was 0.957. It means the sustainability of smallholder dairy farm which applies LEISA pattern in *KUNAK* at level 84.76 was in agreement with the actual conditions.

CONCLUSION

The ecological sustainability status of smallholder dairy farm which applies LEISA pattern can be increased from less sustainable (57.95) to sustainable (88.39) through structuring on attributes (animal density, carrying capacity and water and forage availabilities).

ACKNOWLEDGMENTS

Special thanks to Chairman of farmers in Cibungbulang Smallholder Dairy Farm for technical support throughout this study. This study was funded by Direktorat Jenderal Pendidikan Tinggi through Beasiswa Pendidikan Pascasarjana (BPPS) tahun Anggaran 2015, grant no: 2604/E4.4/2012 and Faculty of Animal Science Universitas Halu Oleo through "Hibah Doktor Fakultas Peternakan UHO tahun 2015"

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