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Sustainability Status Assessment (SAA) in the integrated farming system of dairy-cattle and horticultural-crops in Indonesia

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Abstract : Integrated farming system of crops-livestock (IFS-CL) –crops including horticulture plant, and livestock including dairy cattle– provides provides several advantages both environmental and economic. The study aims to assess the status of sustainability in integrated farming system of dairy cattle and horticultural crops in Indonesia. The research has been conducted in Nongkojajar, Pasuruan Regency, Province of East Java, Indonesia. Sustainability Status Assessment (SAA) methods that has been used this study is Rapid Appraisal for Crops-Livestock$_{(dairy)}$ System (RapCLS) base on economic, ecological, technical, institutional and social (EETIS) dimensions. The sustainability status of the integrated farming system of crops-livestock (IFS-CL) model in Nongkojajar, Pasuruan Regency be in a position quite or fairly sustainable (67,79). Therefore, to improve the sustainability status should be efforts to improve and to increase the value of the attributes of each dimension of continuity, particularly in order to guarantee the sustainability of the two main dimensions, economic and environmental dimensions. EETIS dimensions of sustainability in value up to the category of sustainable status, are the sustainability of ecological dimension (73.88) and the social dimension (71.18), which means socio-ecologically more sustainable, rather than economically (67.98), technology (56.74) and institutional (69.15) which need to be given attention mainly on the attributes of each dimension that is less sustainable.
Key words: sustainability status assessment (SSA); economic, ecological, technical, institutional and social (EETIS) dimensions; integrated farming system of crops-livestock (IFS-CL).

Introduction

Sustainable development indicators attempt to measure sustainable development in its entirety, taking into account the multi-dimensional and integrated nature of sustainable development[1].Concept of sustainable development aims to maintain economic advancement and progress while protecting the long-term value of the environmentally, it provides a framework for the integration of environment policies and development strategies.

Recently, there is an urgent need to adopt more sustainable agricultural systems, and logic evaluation process is needed to determine alternative management strategies for success[3]. The functionality of systems in a geographic domain and use this definition to formulate a new quantitative indicator of sustainability, the index of sustainable functionality[4].Sustainability assessment is strategic, sustainability-oriented, constructive and potentially transformative. Its key role is to explore the opportunity-creation and problem-solving potential of

framing contexts other than those in place, such as alternative institutions, technologies, spatial and temporal arrangements, price relations and associated policy regimes[5].

Implementation of environmentally based farming system is highly dependent on the perception of agriculture practitioners (citizen) and policy makers (government). The citizen's perception about his/her role in protecting the environment represents a personal aspect, since an individual could be more or less involved in protecting the environment regardless of his/her concern about the situation[6]. In Indonesia, the crop livestock integration system has become one of the government programs in environmentally sound livestock development program. Recently the system integration of cattle-plant has become a national priority to create an environment friendly agriculture.

In recent, one model of environmentally sustainable farming isintegrated farming system of crops-livestock (IFS-CL). The importance of the role of integrated crop-livestock systems for sustainable development, and that integrated crop-livestock systems, implying a diverse range of integrated ecological, biophysical, socio economic conditions, have been a foundation of agriculture for hundreds of years[7]. Technologies and management schemes that can enhance productivity need to be developed, at the same time, ways need to be found to preserve the natural resource base. Within this framework, an integrated crop-livestock farming system represents a key solution for enhancing livestock production and safeguarding the environment through prudent and efficient resource use[8].

One of the efforts that need to be developed in the cattle livestock farming that is environmentally sound dairy cattle farming. Dairy cattle farming should be developed byan integrated farming system of crops-livestock (IFS-CL)−crops including horticulture plant, and livestock including dairy cattle−because a lot of the obvious benefits of crop livestock integration system.

East Java province as an area which has the most dairy farmers in Indonesia, producing about 800 tons of milk per day, and one of the main production areas in the province that isNongkojajarsub district. Current dairy farming in Nongkojajar is not only to produce fresh milk as primary product, but also able to produce by-products such as organic fertilizer (bioslurry) and alternative energy (biogas). It seems that the current dairy farming in that site is currently being integrated with horticultural crops in the integrated farming system pattern, so the cycle of dairy cattle farming activities in addition to increasing household income also preserve a sustainable environment[9].

Materials and Methods

The research was conducted using a survey, where the method of sampling was purposive sampling. The area survey is Pasuruan Regency, Province of East Java, Indonesia. In this regency has an sub regency region that had the largest population of dairy cattle is Sub Regency of Tutur Nongkojajar.The purposive sampling is selecting the sample, depending on research purpose[10]. Main criteria of sample respondents, according to the research purpose are farmers who practiced the integrated farming system of crops-livestock (IFS-CL), farmers have dairy cow, horticultural crops, forage plants, and has a biogas reactor installation. Number samples are amounted to 10% of the 1,220 farmers who meet the criteria, so that the number samples are 122 IFS-CLfarmers.

A large number of definitions of sustainable development have emerged so far, and varies the measurement method of agricultural sustainability. Sustainability Status Assessment (SAA) methods that has been used this study is Rapid Appraisal for Crops-Livestock$_{(dairy)}$ System (RapCLS) base on economic, ecological, technical, institutional and social (EETIS) dimensions.Rapid Appraisal for Crops-Livestock$_{(dairy)}$ System(RapCLS) analysisis modified from RAPFish method by Pitcher and Preikshot model. Measurement of sustainability by 3-5 dimensions or aspects of sustainable metrics[11,12]. In this study are economic, ecological, technical, institutional and social(EETIS)dimensions.

Each dimension is determined attributes, the number of attributes of each dimension depends on the object of study of sustainability in the research area.Selected attribute reflects the level of sustainability in every dimension, and adjusted to the availability of information that can be obtained from the character of the resources that were examined in the study area. Then each attribute given ordinal scale of 0 to 5, where a scale of 0 means bad (poor) and 5 means excellent scale (high). Research has been using 16 attributes of economic dimension, 17 attributes of ecological dimension, 18 attributes of technological dimension, 15 attributes of

institutional dimension, and9 attributesof social dimension, the total attributes are 75 attributes as expressed in Table 1.

Table 1. Attributesnumber each sustainability dimension

EETIS Dimensions	Attributes Number
Economic	16
Ecological	17
Technological	18
Institutional	15
Social	9
Attributes Total	**75**

The more the number of attributes, the better and the precise of sustainability status obtained. The attributes of each dimension in this study, are :

1) **Attributes of the economic dimension, are:** (1) The level of family income; (2) the proportion of IFS-CLrevenues tofamily expenditures; (3) IFS-CL contribution to the family income; (4) IFS-CL revenue-cost ratio; (5) the ownership scale of dairy cattle; (6) ownership scale of horticultural crops land; (7) the availability of feed concentrates; (8) the allocation of farmers working time; (9) savings as capital reserves; (10) the availability of credit; (11) the amount of direct subsidies for farmers from third parties; (12) the availability of milk market net; (13) the availability of crops market net; (14) the availability of compost market net; (15) the level of the cost of substitution of chemical fertilizer to organic fertilizer; and (16) the level of substitution of fuel subsidy to biogas incentive.
2) **Attributes of the ecological dimension**, are: (1) height of the land; (2) temperature; (3) relative humidity; (4) the level of rainfall; (5) the availability of clean water sources; (6) the slope of the land; (7) the level of afforestation /reforestation; (8) the level of utilization of forage crops on erosion-prone land; (9) potential biochemical / chemical oxygen demand (BOD / COD) in the river; (10) potential reduction in GHG emissions (methane, CO2) through biogas; (11) the use of dairy cow manure to biogas; (12) the use of dairy cow manure waste to compost; (13) the use of crop waste for livestock feed; (14) the potential for substitution of chemical fertilizer with organic fertilizer; (15) the potential for fuel substitution by biogas; (16) the availability of electricity and energy; and (17) the availability of cage drainage.
3) **Attributes of the technological dimension**, are: (1) the construction of cage; (2) air circulation and ventilation; (3) the application of artificial insemination; (4) prevention and treatment of diseases; (5) cow bathing and cage washing equipment; (6) the milking equipment; (7) hygiene and sanitation of milk collection tools; (8) the availability of forage varieties; (9) the provision of quality concentrate feed; (10) technology applications for forage preservation (hay); (11) the application of ammoniation technology of forage and cropstraw waste; (12) the use of probiotics for the manufacture of feed; (13) storage of livestock manure; (14) the arrangement of biogas reactor; (15) the use of biogas; (16) the manufacture of organic fertilizer; (17) the use of organic fertilizers on crops and forages; and (18) the application of three strata (horticultural plants - shrubs forage - tree forage).
4) **Attributes of the social dimension**, are: (1) the perception of farmers on organic farming; (2) the perception of farmers on crop-livestock integration system; (3) the perception of farmers on biogas; (4) the perception of farmers on organic fertilizers; (5) the perception of farmers on soil and water conservation; (6) the proportion of gender in livestock-crop systems integration; (7) participation of farmers on environmental extension and training; (8) the ability of farmers to school their children; and (9) the public response to the application of IFS-CL.
5) **Attributes of the institutional dimension**, are: (1) implementation of the Law on Environment; (2) socialization of the Law on Environment; (3) the implementation of legislation on the environment; (4) dissemination of environmental laws and regulations; (5) the existence of sanctions against violations of environmental laws and regulations; (6) implementation of the general plan of the regional spatial; (7) implementation of zoning on dairy development and horticultural crops; (8) the presence of village officials who had attended the environment extension and training; (9) the training and mentoring of government agencies, NGOs, private farm businessman; (10) the role of cooperatives in the purchase and distribution of milk from farmers; (11) the marketing chain of compost; (12) the institution of credit providers; (13) the organization / group / cooperative of farmers; (14) the organizational dynamics (group / farmer

cooperatives); (15) the role of the organization's members in determining the organization's policies; (16) the role of rural public figure (key person) in determining the policy of the organization; (17) the role of government officials in determining the policy of the organization; (18) the role of government institutions (livestock calving/breeding institution, agricultural extension agencies); and (19) community service ofuniversity for livestock farmers.

The value of each attribute of each dimension of economic, ecological, technological, social and institutional, based on data obtained through interviews and field observations (primary data) and through the study of literature (secondary data), analyzed the level of sustainability with multi dimentional scaling (MDS). Overall value of each dimension attribute is entered in the Microsoft Excel application program, then analyzed using Rapid Appraisal for Crops-Livestock$_{(dairy)}$System (RapCLS) that modified from the Rapfish application software.

Table 2. Status assessment category of sustainability

Index Value of Dimensions	Category	Sustainability Status
00,00–24,99	Poor	unsustainable
25,00–49,99	Less	less sustainable
50,00–74,99	Quite	fairly sustainable
75,00–100,00	Good	sustainable

Results of assessment of performance attributes of each dimension are mapped into two reference points which is a bad point and good point, and the level of performance is divided into four (4) categories of the assessment of attributes[11,13]. Assuming that the performance lies between 0 to 100% or bad to good to all, with four levels of sustainability status, which is bad, less, well being and with intervals of 0.25%, 50%, 75% and 100% as expressed in Table 2.the calculation manner of each dimension index[14] is as follow:

Dimension index : $$D_i = \frac{Xij - Xij(\min)}{Xij(\max) - Xij(\min)} x100$$

Multidimensionindex : $$MD = \frac{\sum_{i=1}^{n} \sum Yi}{n}$$

where :
- D_i = Sustainability index of dimension ith
- X_{ij} = Median score of attribute jth on dimension ith
- $X_{ij(\max)}$ = Maximum median score on dimension ith
- $X_{ij(\min)}$ = Minimum median score on dimension ith
- MD = Sustainability index of multidimension (overall dimension)
- n = Sum of dimensions

3 Results and Discussion

Analysis of sustainable dairy cattle and horticultural crops farming integration systems in the area of research is done to determine the level of sustainability status, and determine the attributes of each dimension of sustainability needs to be leveraged to improve and enhance the future sustainability status. Results of the analysis of the sustainability status of each dimension can be seen in Table 3.

Table 3. Status of sustainability each dimension

EETIS Dimensions	Index Value of Dimensions	Category	Sustainability Status
Economic	67,98	Quite	fairly sustainable
Ecological	73,88	Quite	fairly sustainable
Technological	56,74	Quite	fairly sustainable
Institutional	69,15	Quite	fairly sustainable
Social	71,18	Quite	fairly sustainable
Overall dimensions	**67,79**	**Quite**	**fairly sustainable**

Results of the analysis are shown in Table 3 shows the overall sustainability dimensions on integrated farming system model ofdairy-horticultural crops in the district of PasuruanTutur be in a position fairly sustainable with each dimension index is between 50.00 to 74.99, which means not yet in sustainability status peak with an index more than 75.00 to 100.00. Results of the analysis of the overall sustainability of each dimension can also be seen on the kite diagram shown in Figure 1.

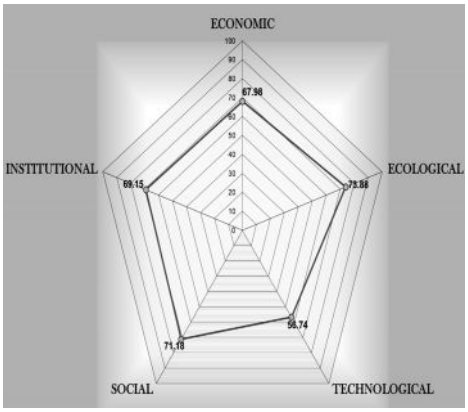

Figure 1. Sustainability Status Position of Each Dimension

Results of the analysis shows that the sustainability status of each dimension of sustainability status closest to the sustainability of the good status (sustainable)are the ecological dimension (73.88) and the social dimension (71.18) which means socially and ecologically more sustainable, compared with an economic dimension (67.98), technology (56.74) and institutional (69.15) which need to be given attention mainly on the attributes of each dimension that is less sustainable.

The position of the sustainability status of each dimension is based on a kite diagram above, are described as follows:

1) **Economic dimension.**The economic dimension is the main and most important dimension in defining the status of the sustainability of a farming system. Results of the analysis showed that the measurement of the economic dimension of the economic dimension has a value of 67.98 or in sufficiently or fairly sustainable status. Results indicated that the model of the integrated farming system of crops-livestock (IFS-CL) in TuturNongkojajar, Pasuruan Regencyis still needs to be accelerated and improved economically, because of economic factors, especially the increase in income of livestock farmers are the main factors of a system of farming to survive and sustainable.
   To encourage the index number to a higher level, especially on the attributes that determine and still low contribution to economic sustainability, which is an attribute of capital savings, credit availability, and the availability of concentrate feed, which is followed by a third-party attribute the availability of subsidies.Other attributes even lower contribution, but need to be given attention to further improving the economic sustainability of integrated dairy-horticultural crops farming system in the study area.
2) **Ecological dimension.** The measurement results show that the ecological dimensions of the ecological dimension has a value of 73.88 or in sufficiently or fairly sustainable status. Attributes that contribute to environmental sustainability is reduction in greenhouse gas emissions (GHG), shows that biogas production component though not maximum utilized by dairy farmers households, but has contributed to high environmental sustainability status. Attribute slope contributes both to ecological sustainability, due to the implementation of government and community programs for afforestation and cultivation of forage fodder in sloping lands as mitigation of erosion and landslides.Additionally attributes rainfall, humidity and air temperature sufficiently contribute to environmental sustainability in dairy-horticultural crops farming integration system with in the study area.
   Other attributes are still low contribution, so it needs to be addressed to further improve the ecological sustainability is mainly attribute waste handling of dairy cattle. This is due to the utilization of biogas and bioslurry which is still less than optimal, so that they contribute relatively low in the integrated farming

system of crops-livestock (IFS-CL)sustainability. Other attributes despite not being the main attributes and dominant, but still need to be given attention by the farmer and decision maker.

3) **Technological dimension.** Results of the analysis of the sustainability status position for the dimension of sustainable technologies in quite category (56.74), attributes of dairy cattle farming has not strengthen the integrated farming system of crops-livestock (IFS-CL). This is caused by the techniques and equipment used as commonly in developing countries are still a simple technology or traditional technology, in which the characteristics of such technology is used because of limited capital to finance intermediate technology or advanced technology as in common in developed countries.
   Viewed from the technological aspect, the attribute with the highest scale application attributes preserving forage, ammoniation sewage plants and feed probiotics, but it is still very rarely applied by livestock farmers. This result means that, attributes that have been applied to other technologies such as the use of milking equipment, cages and other construction, but are still classified as a low-tech (low technology) so that the results of the analysis still shows a low contribution to the sustainability dimension of technology.
4) **Institutional dimension.** Results of the analysis showed that the institutional dimension measurement of the institutional dimension has an index value of 69.15 or in sufficiently or fairly sustainable status. Institutional dimensional position measurement results that show the status of the ongoing enough, shows that institutional factors in Tutur Nongkojajarstill need to be improved to better status, because the institutional factor is a factor supporting the development of a farming system in developing countries.
   Attributes the highest role institutions in encouraging the implementation of the system of sustainable farming in the area of research, with which the implementation of the general plan of the regional spatial (RUTR/RDTRD) that sets the region TuturNongkojajar as a center for the production of dairy cattle[15], so that there should be no beef cattle to prevent competition in land use forages and forage food livestock between the two types of these cattle farmers. Other attributes enough to contribute, but there is also a low contribution, but all attributes basically need to be addressed and can be leveraged to improve the status of institutional continuity in implementing environmentally friendly and sustainable farming systems.
5) **Social dimension.** Results of the analysis of the position of the social dimension of sustainability status reached an index of 71.18, or in the category of fairly sustainable. If seen from the achievement of the social dimension of the index value compared with the other dimensions, the dimensions of sustainability is the second highest among the five dimensions measured in contributing to social sustainability. Attributes the highest role in encouraging the implementation system of sustainable farming in the study area, seen from the aspect of technology with the scale above is the perception of farmers on soil and water conservation, perception of organic fertilizer, and gender proportion in the system integration of dairy cattle and horticultural crops.

Other results showed low contribution of some social attributes, such as community response to system integration and perceptions of farmers towards organic farming, though special dairy farmers have introduced a system of integration and utilizing organic fertilizers for horticultural crops. Other attributes even lower contribution, but need to be given attention. The social dimension relates to the attitudes, responses and perceptions that need to be improved through extension, training and demonstration plots to further enhance the social sustainability of the integrated dairy cattle-horticultural crops farming system existing in the study area.

General discussion on the above results as follows: Results of the analysis of the integrated farming system of crops-livestock (IFS-CL) sustainability in Tutur Nongkojajar obtained the highest scale are ecological dimensions and social dimension, which means socio-ecologically more sustainable than the economic dimension, institutional and technology. These results differ from the results that beef cattle fattening sustainability in Ciamis Regency, West Java Province, Indonesia is simultaneously less sustainable[16] andagribusiness sustainability of dairy cattle in the district Cisarua and Megamendung have the technological dimensions as the highest scale (sustainable status), while the social dimension in the category of less sustainable[17]. A researchreported that the agropolitan based sustainability status in Situbondo showed the highest scale but only makes fairly sustainable categories, arethe economic dimension and the social dimension, while other dimensions are less sustainable in the category are the institutional dimension, the ecology dimension, and technological dimension[18].

The economic dimension is the dimension that greatly contribute to the sustainability of agriculture, whether monocultures, mix, and integrated farming. Attributes on the economic dimension of dairy-horticultural crops integration system sustainability, especially determining the income of farmers, which are an attribute of capital savings, credit availability, and the availability of concentrate feed, which are followed by a

third-party attribute the availability of subsidies.These three attributes a very important role because of the facilities received by farmers as members of cooperatives, especially the subsidy provided by the government and NGOs to farmers through cooperatives KPSP Setia Kawan Nongkojajar. Moreover, the sustainability of this economy will be higher, if given the intensive subsidy or compensation by the government for the use of biogas and organic fertilizer. Other economic dimension attributes are also still need to be given attention to further improving the economic sustainability of the integration farming system in the study area.

Attributes technological dimension in technical dairy cattle farming has not strengthen the sustainability of the dairy-crop integration system, as most technology and equipment used by farmers in this area is still a simple technology or traditional technologies than in developed countries that already using advanced technologies (high technology).

Traditional technologies are still used by farmers, due to lack of capital to finance the procurement of intermediate technology or advanced technology mainly equipment and supplies such as milking supplies and equipment, feeders and watering equipment, barn and parlor supplies, animal care supplies, veterinary supplies, animal control, outerwear,etc. The technology that has been used in study area are the utilization of the milking equipment, cages and other construction, but are still classified as a low-tech, so that the results of the analysis still shows a low contribution to the sustainability dimension of technology.

Contributions to the social dimension of sustainability was still low by some social attributes, such as community response to integration system and perceptions of farmers towards organic farming, though dairy farmers have introduced a system of integration and utilizing organic fertilizers for horticultural crops. The social dimension relates to the attitudes, responses and perceptions that need to be improved through extension, training and demonstration plots to further enhance the social sustainability of the dairy-horticultural crops farming integration system in the study area.

Institutional dimension is an important dimension in the sustainability of farming, particularly in developing countries. Attributes the highest role in the institutional dimension in driving the implementation of sustainable farming systems which the implementation of the general plan of the regional spatial in the study area. Attributes facilities and assistance from the government, relevant agencies, Non Governmental Organizations (NGOs), private institutions and Milk Processing Industry (MPI) enough to contribute to the institutional dimension status, while other attributes enough to contribute, but there is also a low contribution. All attributes of institutional basically need to be addressed and can be leveraged to improve the status of institutional continuity in implementing sustainable farming systems and environmentally friendly.

Conclusion

The sustainability status of the integrated farming system of crops-livestock (IFS-CL)model in Nongkojajar, Pasuruan Regency be in a quite or fairly sustainable position (MD=67,79). Therefore, to improve the sustainability status should be efforts to improve and to increase the value of the attributes of each dimension of continuity, particularly in order to guarantee the sustainability of the two main dimensions, economic and environmental dimensions.

Dimensions of sustainability in value up to the category of sustainable status, are the sustainability of ecological dimension (D_i=73.88) and the social dimension (D_i=71.18), which means socio-ecologically more sustainable, rather than economically (D_i=67.98), technology (D_i=56.74) and institutional (D_i=69.15) which need to be given attention mainly on the attributes of each dimension that is less sustainable.

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