Sustainability Indicators of Kalang Buffalo Production Systems in Swamp Ecosystems in South Kalimantan

Widya Nur Amalia[1], Tri Satya Mastuti Widi[2*], Panjono[2], Dyah Maharani[3], and Sigit Bintara[3]

[1]Postgraduate Student, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, 55281, Indonesia
[2]Department of Animal Products Technology, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, 55281, Indonesia
[3]Departement of Animal Breeding and Reproduction, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta 55281, Indonesia

ABSTRACT

This study aims to identify problems, identify and analyze stakeholders and determine indicators (qualitative and quantitative) for the sustainability of kalang buffalo production systems in swamp ecosystems in South Kalimantan. The kalang buffalo is a type of mud buffalo that is reared using the kalang system. In the local language, kalang is an enclosure built in the middle of swamp waters. This study is expected to be a source of information for academics, farmers, communities and policymakers in South Kalimantan Province regarding the strategic function of Kalang buffalo for the people of South Kalimantan. Data collection was done by describing the problem and determining relevant stakeholders. The literature study was conducted with expert discussion. FGDs were also conducted to explore important issues, followed by SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis and to determine relevant issues. Situation analysis and secondary data showed that the Kalang buffalo population is declining. Stakeholder identification identified the central and local governments as primary stakeholders; secondary stakeholders were scientists/academics, butchers, sellers, and consumers. The primary stakeholders selected were buffalo farmers, central and local governments, while secondary stakeholders consisted of scientists/academics, butchers, farmer sellers, and consumers. The selected indicators on the EES issue are economic indicators such as gross margin (GM), body weight, weaning weight, and reproduction (calf crop (%)); environmental indicators such as total grazing land use and waste disposal; and social indicators such total of buffalo, feeding procedures, mating system, cages, record keeping, time allocation for maintenance, social status and land use conflicts.

Keywords: Economic, Ecological, Kalang buffalo, Production system, Social

Introduction

Buffaloes traditionally live in nature, such as rivers, bushes, forest edges, or swamps. South Kalimantan Province is a province in Indonesia with germplasm farms, namely swamp buffalo (*Bubalus bubalis*), which have an important social and economic role for people living in swamps and ecologically for wetland ecosystems. The South Kalimantan buffalo has also been regulated as a special breed under Minister of Agriculture Decree No. 2844/KPTS/LB.430/8/2012 concerning South Kalimantan Buffalo Breeding. As many as 64% of the South Kalimantan swamp buffalo population in 2018 was kept under the Kalang system as a form of local wisdom for people living in swampland to utilize the swamp environment for their livelihoods (Sumantri *et al.*, 2021).

Swamp buffaloes in South Kalimantan are widely cultivated in the districts of Hulu Sungai Utara (HSU), Kotabaru, Tanah Laut, Banjar, Barito Kuala, Hulu Sungai Tengah (HST), and Hulu Sungai Selatan (HSS) (BPS South Kalimantan, 2018). The districts of Danau Panggang (HSU), Labuan Amas Utasa (HST), Daha Utara (HSS), Kuripan (Barito Kuala), and Bati-Bati (Tanah Laut) are potential areas for swamp buffalo development, as they have large swamp areas and natural feed sources. However, the swamp buffalo population has been difficult to increase. It has declined due to a lack of grazing land, limited feed, and a shift in the community's livelihood. Reduced grazing areas make it difficult to find grass that buffaloes prefer (Suryana, 2007). In addition, the increase in population and the shift in the use of livestock land for agricultural businesses have resulted in the availability of forage feed depending on the season (Alpianor *et al.*, 2017). Agusliani and Dharmaji (2017) explained that swamp forages favored by swamp buffaloes are kumpai minyak (*Hymenachne*

amplexicaulis), kumpai batu (*Paspalum sp*), Padi Hiyang (*Oryza sativa forma spontanea L.*), and Sempilang (*Cynodon dactylon L Pars*), these forages are not only tasty but also grow following the swamp water level. Water hyacinth (*Sichomis crassipes Solma*) growth causes siltation of waters, reduction of aquatic biota and reduction of fodder grasses, and ultimately reduced feed availability. Swamp buffaloes can live in relatively difficult areas with poor feeding conditions, although they can also breed in various agroecosystems ranging from wet to relatively dry areas (Suryana and Handiwirawan, 2009).

Kalang buffalo have an important role in society, such as saving money, producing meat, protecting the swamp ecosystem, and becoming a tourist attraction. Currently, the swamp buffalo is facing poor performance and a declining population (Sumantri *et al.,* 2022). It is feared that the good public preference for Indian buffalo meat (IBM) imported from India since 2016 will shift the role of buffalo as local meat producers and reduce the price of live buffalo, which in turn will reduce farmers' income and motivation (Sumantri and Chang, 2021). The reduced habitat of the Kalang buffalo in the swamp area is caused by swamp sedimentation and land conversion. The reduction of the Kalang buffalo in the swamp area is thought to have changed the swamp ecosystem resulting in land sedimentation. The complexity of the problems of the Kalang buffalo production system in the swamp ecosystem demands an integrated sustainability assessment approach that focuses on the level of sustainability indicators. A livestock production system is expected to be sustainable if it can reasonably produce itself until it changes when conditions demand long-term sustainable production (Atmoko *et al.,* 2023). Despite the important role of buffalo production as a provider of red meat, which provides economic benefits and social status for farmers in Daha Utara District, this sector still needs to be prioritized at the appropriate policy level. This can be seen from the lack of policy tools for decision-making and prioritization. This research aims to identify problems, analyze stakeholders, determine EES issues, identify and determine sustainability indicators of the buffalo production system in Daha Utara District. Analyzing strengths, weaknesses, opportunities, and threats was used to identify relevant EES issues of the Kalang buffalo production system. The results of the study will be used to recommend indicators of sustainability that should be selected in measuring the overall contribution to the sustainable development of buffalo production systems in the swamp ecosystem in Daha Utara Distric.

Materials and Methods

This research was conducted from April to November 2022 at the Kalang buffalo farm in the swampland of Daha Utara District, Hulu Sungai Selatan Regency, South Kalimantan Province. The tools used were stationery, cameras, and questionnaires, while the materials used were buffaloes raised under the kalang system in the swamp ecosystem.

Overview of research locations

Daha Utara district is one of the sub-districts in Hulu Sungai Selatan Regency. North Daha Utara district has 19 villages, almost 17% of which are lowlands that are watery in the rainy season and dry in the dry season. Daha Utara district is passed by two large rivers from Hulu Sungai Tengah Regency and Hulu Sungai Utara Regency, with rainfall in February amounting to 503.4 mm. The area map of Hulu Sungai Selatan Regency is presented in Figure 1. The area of Daha Utara district is 268.11 km^2 or 14.85% of the area of Hulu Sungai Selatan Regency. The population of Daha Utara district, based on data from the Central Bureau of Statistics in 2021, is 31,935, consisting of 16,228 male and 15,707 female residents. Geographically, Daha Utara District is bordered by Hulu Sungai Utara District to the north, Hulu Sungai Tengah District to the east, and Daha Utara District to the south and west. An administrative map of the Hulu Sungai Selatan District is presented in Figure 1.

Daha Utara District has four groups of swamp buffalo cattle. However, in this study, surveys and interviews were carried out on three groups of buffalo cattle, namely the Maju Bersama group in Pahargan Village, the Karya Harapan group in Teluk Haur Village, and the Tunas Harapan Bersama group in Hamayung Village. Group members who are respondents are active members who care for buffalo with swamp ecosystems that live in the village. The population of swamp buffalo in Daha Utara District can be seen in Table 1.

Overview of kalang buffalo farming with swamp ecosystems in Daha Utara district with semi-intensive rearing. Buffaloes are released at 7 am and return to Kalang at 5 pm. Feed is generally forage such as hiyang rice (*Oryza ropipohjon*), sumpilang (*Cynodon dactylon* L. Pars), supan-supan (*Mimosa pudica*) and ilung (*Eichhornia crassipes*). Feeding is done by grazing. Livestock health management is conducted in consultation with UPTD Animal Health Center field officers. In addition, field officers also conduct active service activities in the form of vitamin administration, deworming, examination of reproductive disorders, and health counseling.

Research methods

Kalang buffalo breeders were selected purposively as respondents based on predetermined criteria. These breeders raise buffalo using a canal system in a swamp ecosystem in the Hulu Sungai Selatan area. The buffaloes used belonged to the respondent farmers and were purposively selected if they had given birth at least once. Local government, community leaders, traders, butchers, and livestock instructors are the experts involved. Research was carried out in four stages:

Phase I: Problem identification and stakeholder analysis

Phase I research aimed to describe the problem and determine relevant stakeholders in the kalang buffalo production system with swamp ecosystems in Hulu Sungai Selatan District, South Kalimantan. The research was conducted with literature review and expert discussions at the Faculty of Animal Science UGM, and FGDs were conducted at Wetkawa (Wisata Edukasi Kerbau Rawa) in North Daha Sub-district, Hulu Sungai Selatan District, South Kalimantan.

This stage begins with conducting a literature review, followed by expert discussions or experts, and then the results are confirmed through Focus Group Discussion (FGD) activities. Focus Group Discussion (FGD) was conducted to confirm the results of the literature study and expert discussion and obtain alternative input or problems not found in the literature study and expert discussion. Problem identification in the FGD was carried out using Strength and Weakness (SW) analysis. Researchers will then divide them into Strengths, Weaknesses, Opportunities, and Threats (SWOT) indicators.

Phase II. EES Issue Determination

This stage aims to determine the issues in the pillars of sustainability, namely economic, ecological, and social, that are relevant to the kalang buffalo production system with swamp ecosystems. The material in this study is an expert or expert in livestock production systems or ruminant sustainability. The EES issues used to assess the sustainable development (SUSD) of the Kalang buffalo production system were selected based on SWOT. After literature review and expert consultation, the SWOT issues from the four analysis pillars were combined into several key issues.

Phase III: Identification and determination of sustainability indicators

This stage identifies and translates relevant issues into measurable sustainability indicators (SI). Translating EES issues into SIs uses a two-step process, the first step of which explores possible SIs through a literature review and discussions with experts; the second step, the final SIs are identified, based on four selection criteria: valuable, relevant, informative, and have a target value (de Vries and de Boer, 2010).
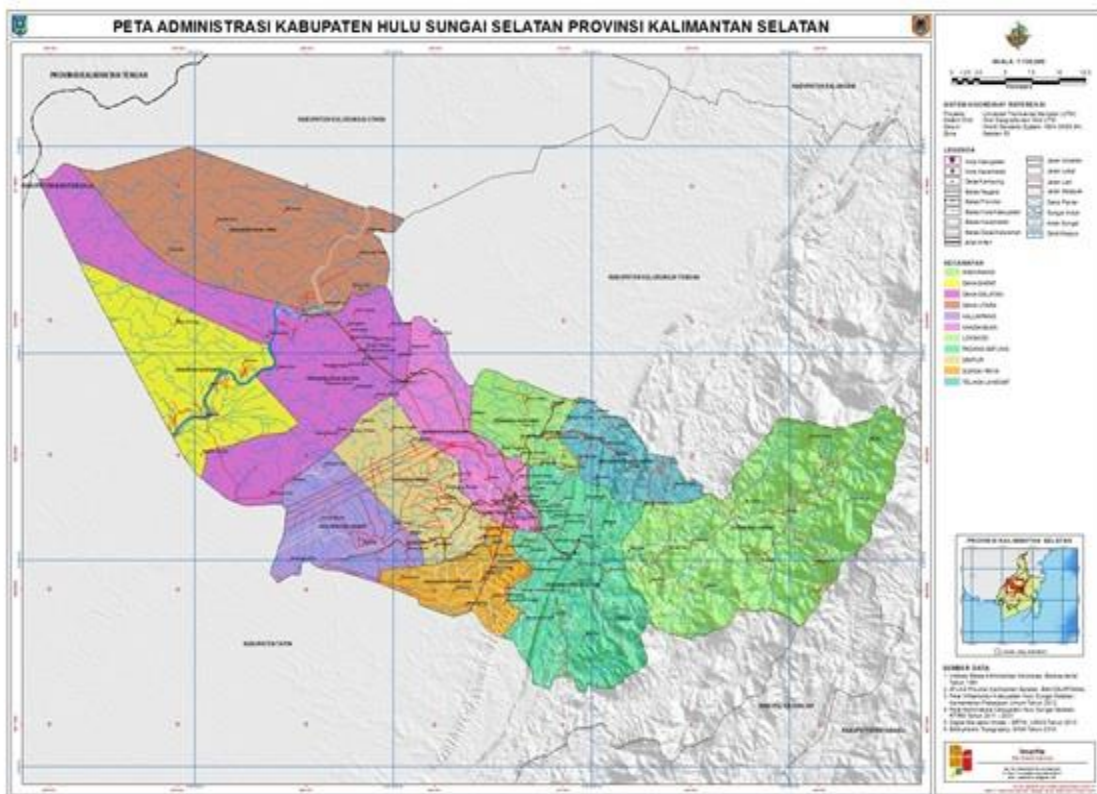

Figure 1. Map of the South Hulu sungai selatan district.

Table 1. Population of Swamp buffalo in Daha Utara district

Group name	Number of livestock			Total
	Male	Female	Cattle <1 year	
Maju Bersama	10	70	23	103
Karya Harapan	7	61	12	85
Tunas Harapan Bersama	12	65	25	102
Total	29	196	60	290

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Results and Discussion

Problem description

Buffaloes in South Kalimantan, especially in wetland areas (swamps), have lived in harmony with the socio-culture of the community for hundreds of years as much as 64% of the buffalo population in South Kalimantan, especially in Daha Utara District area, is semi-intensively reared on swamp land. An important issue in the production system in North Daha Sub-district is the decline in productivity due to a decrease in the carrying capacity of swamp land.

Swamp ecosystems are characterized by the presence of aquatic vegetation such as *Oryza sativa forma spomtanea* L (local name Padi hiyang), sumpilang (*Cynodon dactylon L. Pars*), supan-supan (*Mimosa pudica*), and water hyacinth (*Eichhornia crassipes*). In Daha Utara district, kalang floats above the river, made of ironwood arranged and fenced (Agusliani and Dharmaji, 2017).

Kalang buffalo live in a swamp ecosystem and swim to find food as reported by (Yusnizar *et al.* 2015) that the swimming distance of swamp buffalo can reach 75 km^2. The swamp buffalo population has declined recently due to low productivity and reproductive performance. Farmers traditionally raise buffalo, relying on local resources. However, swamp areas are threatened by sedimentation and shifts in land use, leading to reduced forage availability.

The main problem with the buffalo farming system is land conversion which causes conflict between farmers, ranchers, the community, and the government. The local government considers the livestock sector less contributing to regional income because it only focuses on land use for agriculture or plantations. Farmers have felt insecure for decades regarding ownership of land for buffalo production. This situation also resulted in a decrease in the buffalo population. The reduced population is expected to have a multiplier effect on the welfare of breeders (economic dimension), sedimentation in the swamp ecosystem (environmental dimension), and changes in the local wisdom of the local community (social dimension).

Stakeholder identification and analysis

Stakeholders are determined based on their relevance to the issues raised. Primary and secondary stakeholders were identified through a literature review and during the FGD. Primary stakeholders consist of buffalo breeders, the central government as policymakers at the national level, and local governments as policymakers at the regional level and policy implementers. Secondary stakeholders include scientists, traders, butchers, farmers, and consumers. Stakeholder identification and analysis are presented in Table 2.

Farmers are important in the buffalo meat production system, income, savings, and social status improvement. On the other hand, IBM's import policy issued by a central order in 2016 has reduced the local buffalo population and meat production. The policy was issued to lower beef prices, make beef more affordable for the public, and diversify sources of beef imports. As a result, IBM's import volume continues to increase. Since 2016, the national buffalo population has decreased by 16.3% and buffalo meat production by 22.3% (Sumantri and Chang, 2021).

On the other hand, the Department of Agriculture and Livestock, the local government's representative, is concerned with increasing the buffalo population by intensively assisting in management practices. Land use arrangements impact decreasing the buffalo population because development planning prioritizes the plantation and agricultural sectors. This causes the livestock sector to be limited and declining. It is suspected that the livestock sector contributes little to regional development due to the ownership of small breeders. If this continues, the livestock sector as a food producer from animal sources will decline,

Table 2. Identification and analysis of stakeholders in the production of Kalang buffalo in Daha Utara district

Stakeholder	Important to system	Interest
Primary		
Breeders	The main character	Income, savings, social status
Local government	Policymakers at the regional level in terms of: - Development of Kalang buffalo - Spantial planning and land use - Conservation of swamp ecosystem - Permission of land use and ownership	- Increase in buffalo population - Synchronize the livestock sector and other sectors, such as plantation and fisheries. - Swamp ecosystem conserved
Secondary		
Scientist/academic	Conducting varied studies on buffalo production as a baseline consideration for policymakers	Publications and research papers
Trader	Trade	
Butcher	Slaughtering	Profit
Meat sellers	Determine meat supply and consumer preferences.	Profit
Farmer	Expand their farmland in swamp land	Profit
Consumer	Buffalo meat consumption	Consumer preference for buffalo meat

as Nziguheba *et al.* (2022) stated that land degradation threatens food production, especially in smallholder farming systems.

Scientists/academics, traders, butchers, meat sellers, farmers, and consumers are secondary stakeholders. They play a supporting role in hindering buffalo development. Meat traders or meat sellers can support buffalo development by determining buffalo meat supply. Buffalo meat consumption in South Kalimantan has increased with imports of Indian buffalo meat (IBM), from 38 tons in 2017 to 675 tons in 2019, mainly for meatball production, catering, and restaurants. South Kalimantan's buffalo meat production needs to contribute 10.21% to beef production or double the national contribution of only 5.11%. This indicates a large market potential for buffalo meat (Sumantri and Chang, 2021).

Tables 4 and 5 present the results of the SWOT analysis of the Kalang buffalo production system in the swamp ecosystem in Daha Utara District, collected from various stakeholders actively discussed during the FGD.

Most stakeholders agree that buffalo production benefits breeders economically provides red meat for the community, and protects the swamp ecosystem and socio-cultural traditions. Buffaloes are well adapted to local conditions, can utilize low-quality feed, and can be reared extensively. This is considered the productive power of the buffalo. At the regional level, buffalo productivity can be an alternative to reduce dependence on the extractive sector, which will be seen as an opportunity. However, buffalo production only relies on local resources, without any improvement. This is limited by distance and shrinkage of grazing land.

During the FGD, it was stated that the reproductive characteristics of Kalang buffaloes are good. This can be interpreted to mean that raising buffaloes is easy, as buffaloes are bred naturally by grazing or stocking. The local government also assessed the potential reproductive performance of buffaloes as good. However, it was found that buffaloes are difficult to handle individually, making health care difficult. Fasciolosis disease caused by Fasciola hepatica infection is commonly found in swamp buffaloes and causes death, especially in the coral system (Widi *et al.,* 2021).

Table 3 presents an analysis of strengths and weaknesses. The high preference of the people of Daha Utara district for buffalo meat is considered an opportunity for the buffalo farming sector. Buffaloes are preferred due to their easy management. Table 4 presents the analysis of

Table 3. SWOT/SW analysis of the buffalo production system in the swamp ecosystem in Daha Utara district

Stakeholders	Strengths	Weaknesses
Primary Stakeholders		
Breeders	• Buffalo as savings • Local identity • Red meat supply • Easy management • Good reproduction • Male buffalo provide more benefits • Not easy to get sick	• Lack of attention from the government • Lack of animal health assistance • More disease during rainy season • Disease in buffalo calves • Long reproductive cycle • Less popular
Local government	• As animal source food • Income for breeders • Suitable for swamp areas • good shepherding • Easy management • Good body size • Good reproduction	• Lack of human resources • Activities are still traditional • Health care is difficult to address individually • Not resistant to high temperatures • High calf mortality during high tide
Secondary Stakeholders		
Scientist / academic	• Well adapted to the climate • Good reproduction • Converts low quality feed well	• semi-intensive system

Table 4. SWOT/OT analysis of the buffalo buffalo production system in the swamp ecosystem in Daha Utara district

Stakeholders	Opportunities	Threats
Primary Stakeholders		
Breeders	• High demand on religious festivities • High preference for meat because the price is cheaper than beef • Easy to sell	• Shortage of lands • Competition with agriculture • Conflict with the agricultural sector • Limited feed resources
Local goverment	• Estrus synchronization to minimize silent heat • Artificial insemination • High demand for meat	• Water pollution • Habitats are reduced • inbreeding • Productive female slaughter
Secondary Stakeholders		
Scientist / academic	• Potential as agrotourism • Breeding and fattening potential • Post-harvest processing	• Shifts in land use • inbreeding • Livestock theft • There is no legal protection for breeders • Low availability of feed sources due to shifts in land use and sedimentation

opportunities and threats. The high preference of the people in Daha Utara sub-district is considered an opportunity for the buffalo farming sector, which is preferred for religious celebrations.

Identification of EES Sustainability Issues

Table 5 presents the indicators for the sustainability of the buffalo production system in Daha Utara District, and Table 6 describes the selected indicators for economic, environmental and social aspects.

The indicators for each identified and selected issue in Tables 5 and 6 have been determined because they meet the required criteria in a relevant, realistic, and valuable manner. When determining indicators for the sustainability of production systems, indicators on sustainability issues must be relevant, realistic, and of value. The indicators set for each impact each level (hierarchy), namely at the farmer, regional, and global levels, to make it easier to translate through

the conceptual framework. On economic issues, livestock income indicators have an impact on the farm and regional levels, while the performance of buffaloes is only at the farmer level. Several indicators have had a good impact on environmental issues at the farmer level to the global level. Meanwhile, on social issues, the animal welfare indicator is the only indicator that impacts the livestock and regional levels, while the indicators for land use conflicts and regional regulations are at the regional level, which is the responsibility of policymakers in the area or region. Important components for monitoring sustainability are: 1) Participatory approach to identify and select sustainability issues and indicators; 2) Availability of data to empirically assess and evaluate indicators of the sustainability of the production system (Widi *et al.,* 2021). This study is intended to focus on the first component and was carried out with great care to prepare for the second component and the next phase, namely assessing

Table 5. Identification of EES indicators for the sustainability of the buffalo production system in Daha Utara district

Indicator	Definition
Economy	
Gross margin (GM) (Rp/ h)	GM (Finance revenue minus variable costs) per hour per day
Buffalo Performances	
Growth	
Live/ Body Weight (Bb) Buffalo (kg)	Live weight of 2-year-old female buffalo
Weaning weight (kg)	Live weight at weaning
Reproduction (calf crop (%))	Calves weans that survive in a year as a percentage of the total population of buffaloes
Environment	
Total land use (m^2/kg BW/day)	Total grazing area required for maintenance of buffalo units in a day
Soil fertility	The number of macro and micro elements of the soil where the buffalo are reared
Swamp sedimentation	The average amount of sediment contained in the swamp area
Water quality	
Waste management	Buffalo farm waste processing methods
Social	
Farm size (head)	Number of buffalo kept by farmers
Feeding system	Feeding method
Mating system	Mating method
Housing	Cage construction and structure
Recording	Recording system in place
Allocation of maintenance time (h/day)	The time needed to raise buffalo in a day
Social status	The function of the buffalo in the life of breeders
Land use conflicts	There are many lands use conflicts between raising buffalo and other activities such as agriculture, plantations and fisheries.

Table 6. Selected indicators on EES issues

Indicator	Definition
Economy	
Gross margin (GM) (Rp/h)	GM (Finance revenue minus variable costs) per hour per day
Live/ body weight (Bb) buffalo (kg)	Live weight of 2-year-old female buffalo
Weaning weight (kg)	Live weight at weaning
Reproduction (calf crop (%))	Calves weans that survive in a year as a percentage of the total population of buffaloes
Environment	
Total use of grazing land (m^2/livestock unit/d)	Total grazing area required for maintenance of buffalo units in a day
Waste management	Buffalo farm waste processing methods
Social	
Farm size (head)	Number of buffalo kept by farmers
Feeding system	Feeding method
Mating system	Mating method
Housing	Cage construction and structure
Recording	Recording system in place
Allocation of maintenance time (h/day)	The time needed to raise buffalo in a day
Social status	The function of the buffalo in the life of breeders
Land use conflicts	There are many land use conflicts between raising buffalo and other activities such as agriculture, plantations and fisheries.

and evaluating the contribution of each indicator of sustainable swamp buffalo production system to overall sustainable development. More robust procedures for selecting indicators are needed to validate indicators' information (Dale and Beyeler, 2001). A further challenge in designing a swamp buffalo production system is selecting indicators that can comprehensively and reliably represent the complexity of the production system, its current environmental state, economic and social role, and its transition to sustainability.

Conclusions

The research concluded that there are problems related to the production system of the Kalang buffalo in the swamp ecosystem, namely a decrease in productivity which causes a decrease in the carrying capacity of the swamp land. The selected primary stakeholders are buffalo breeders and the local government, while the secondary stakeholders consist of scientists/academicians, traders, butchers, butchers, farmers, and consumers. The selected indicators on EES issues are economic indicators, namely gross margin (GM), body weight (BB), weaning weight, and reproduction (calf crop (%)); environmental indicators, namely the total use of grazing land and waste treatment; and on social indicators, namely the number of livestock, feeding procedures, mating systems, housing, recording, maintenance time allocation, social status, and land use conflicts.

Acknowledgments

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