Research Article

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Indicators of swamp buffalo business sustainability using partial least squares structural equation modelling

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Abstract: The objective of this study is to analyse the effect of swamp buffalo *(Bubalus bubalis carabauesis)* sustainability indicators and to examine the relationship between these. The research was conducted in the central area for the development of swamp buffalo in South Kalimantan, namely, Hulu Sungai Utara Regency, in July 2022 with the participation of 145 farmers, who were identified using the multistage sampling method. There were 53 indicators with 9 latent variables, statistically modelled using the partial least squares structural equation modelling method, with evaluation of the outer and inner models. The results show that the information system and economy had a significant effect on human resources (HR), which in turn had a significant effect on the financial and business sustainability of swamp buffalo. The influence of information systems on resources was positive, while economic indicators had a negative influence. HR had a positive relationship with the financial and business sustainability of swamp buffalo. The sustainability indicators in swamp buffalo farming are complex and vary from region to region. Based on the study results, it is expected that the government as policymakers, especially the government of Hulu Sungai Utara Regency, South Kalimantan, pay special attention to the aspects of information systems, the economy, HR, and the financial and business sustainability of swamp buffalo, while also considering other indicators such as ecological, sociocultural, technological, and institutional ones.

Keywords: swamp buffalo livestock, business sustainability, business sustainability indicators, partial least squares-structural equation modelling

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1 Introduction

Swamp buffalo (*Bubalus bubalis carabauesis*) livestock are a source of local wealth in South Kalimantan, so it is vital that they are preserved. South Kalimantan has an agro-ecosystem, which is very suitable for the development of swamp buffalo, with a swamp area of 70842.43 ha, with Hulu Sungai Utara becoming the centre of development for the animals in the region. This is because it contains 46.01% of the swamp land in South Kalimantan or an area of 32594.98 ha [1]. It also has the highest population of swamp buffalo, with 9,037 heads, or 36.57% of the total population of swamp buffalo in South Kalimantan. Its location quotient value was also the highest, at 9.46, compared to other areas in South Kalimantan [2]. Swamp buffalo in the region are used as a source of meat, with the production of 188706.3 kg or 47.57% in 2022 [3]. However, they are not reared to produce milk, as this is limited and only intended for newborn calves.

The potential possessed by South Kalimantan was inversely proportional to its population development and production of swamp buffalo, which in the period 2010–2020 in fact fell by 45.22%. In 2010, the population of buffalo in South Kalimantan was 45,109 heads, while in 2020, only 24,709 cows were remaining, with the production of swamp buffalo meat having fallen by 64.17%. In 2010, production stood at 1,021,079 tons, but by 2020, this had decreased to 365,838 tons [4]. This situation is very concerning and has an impact on the sustainability of swamp buffalo development in South Kalimantan. There is even the possibility of extinction if matters are not handled more seriously and alternative solutions are found for the problems encountered in the development of the buffalo. One of these is that the research location is a very deep swamp area, with a water depth of more than 1 m, which is

stagnant for between 6 and 9 months per year, and hence preventing the cultivation of food crops [5]. This makes it difficult for farmers to determine the right time to do their farming work [6]. Moreover, the government's programmes for swamp buffalo, both central and regional, are very minimal, with routine activities performed by the government being in the form of distributing vitamins and vaccinations once a year. This is in contrast to cattle, which benefit from many programmes in their development. This situation is different from the findings of previous studies, which indicate that climate change is causing farmers to switch to cultivating buffalo as a source of income due to the low risk involved, thus leading to an increase in the livestock population [7].

The sustainability of swamp buffalo business development is influenced by many factors. Indicators in agriculture/livestock sustainability are complex and vary from region to region. Experts have developed various theoretical and practical steps in evaluating agricultural sustainability, but research on the sustainability of swamp buffalo business development has been limited, in comparison, for example, to that on other livestock such as cattle and poultry. Several studies have been conducted to measure sustainability indicators using different aspects such as a comparison of sustainable and conventional agriculture, resource efficiency, technology applications, and information and communication systems [8–11]. Most of the studies related to agricultural sustainability indicators are limited to reviewing economic, social, and environmental aspects in an integrated manner [12]. Moreover, there remains a lack of studies that include a structural representation of the indicators and an evaluation of the interconnection between sustainability indicators, especially in relation to the development of swamp buffalo. Therefore, this research is vital to obtain appropriate indicators of the sustainability of the swamp buffalo business in the province of South Kalimantan, so that the development of swamp buffalo can be sustainable and continuous.

The aims of the study are to analyse the effect of the indicators of swamp buffalo (*B. bubalis carabauesis*) sustainability and to analyse the relationship between these indicators in Hulu Sungai Utara Regency, South Kalimantan. The results of the study are expected to help the government, as the policymaker, in planning, developing, and conserving swamp buffalo.

2 Methodology

2.1 Study area

This study was conducted in a central area for the development of the swamp buffalo cattle business in South Kalimantan, specifically in Hulu Sungai Utara Regency. Varied information was collected to evaluate the sustainability model approach of the swamp buffalo business development, with the use of interviews assisted by tools in the form of structured questionnaires distributed to 145 farmer respondents, identified using the multistage sampling method. The questionnaires employed a Likert scale, with 1 = strongly disagree, 2 = disagree, 3 = doubtful, 4 = agree, and 5 = strongly agree. The study area is shown in Figure 1.

2.2 Data collection

The survey method was employed for the study, with the involvement of primary and secondary data. The primary data were collected by using the interview technique, with the aid of a tool in the form of a questionnaire. Secondary data were collected from various types of literature, including books and journals, as reference material to support the primary data [12].

The research stages consisted of a literature review to develop the models; focus group discussion (FGD) with stakeholders to confirm the variables and indicators to be used; determination of the variables and indicators to be used; preparation of the questionnaires; selection of the respondents for the interviews; distribution and completion of the questionnaires; data entry and processing; and paper preparation.

The theoretical model of the study was determined in advance based on a literature review, with expert opinion sought in the FGD. A total of 53 indicators were identified and then integrated into nine latent variables for the sustainability of swamp buffalo business development, covering the aspects of ecology, economy, institutions, technology, socioculture, information systems, finance, human resources (HR), and business sustainability (Table 1). All the indicators were modelled statistically using the partial least squares (PLS) program with the structural equation modelling (SEM) method. All the indicators of swamp buffalo sustainable development were analysed with a structured model using the PLS-SEM method. PLS-based estimation is one of the main SEM methods to reveal interactions between endogenous multilevel indicators or variables [13]. PLS-SEM is an excellent method for analysing causal relationships and is widely adopted in many disciplines, such as agriculture, environment, natural resource management, forestry, food science, and psychology [14], as well as being employed for building models for the development of agriculture [15]. The path optimisation method

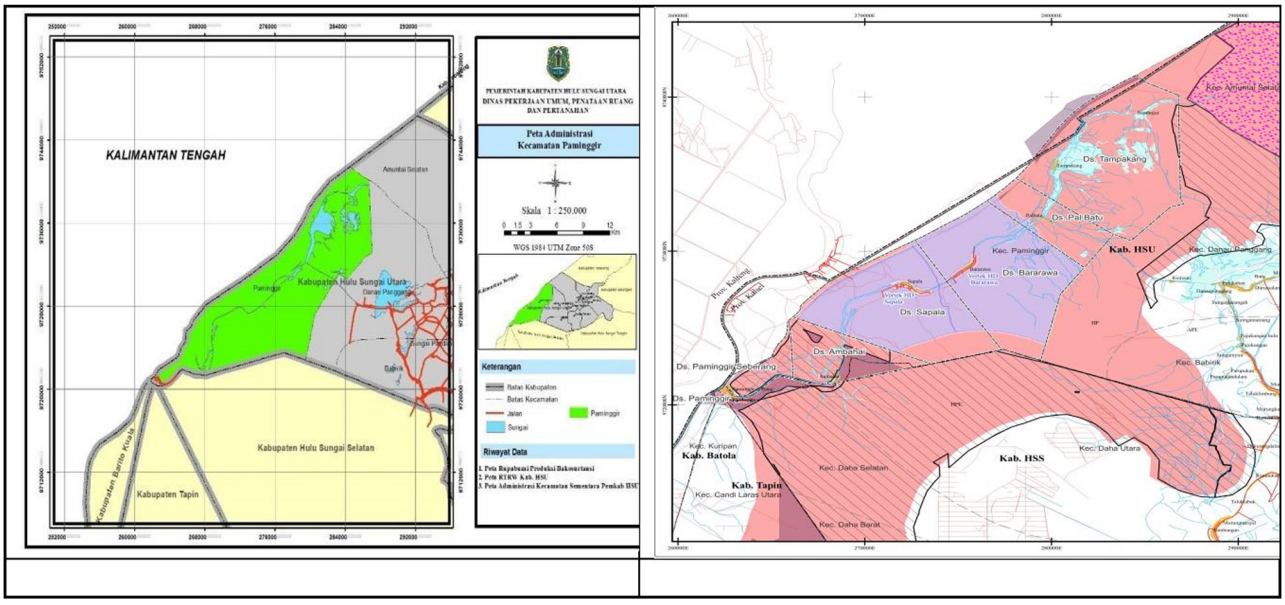

Figure 1: Research study area (Source: Google Map Arch).

was considered feasible as a partial model because the Agile PLS-SEM formula usually calculates the smallest correlation [16]. The research stages are presented in Figure 2, and the study model plan is presented in Figure 3.

2.3 Model development

Experts have developed various theoretical and practical steps for evaluating agricultural sustainability, but research on the sustainability of swamp buffalo business is limited, compared to that on other livestock such as cattle and poultry.

Reviewing in this study has been done by previous studies, which found that there were limitations in determining indicators and integrating latent variables. In addition, the results of the sustainability model varied. Therefore, this research is important to obtain an appropriate model for the sustainability of the swamp buffalo business in the Hulu Sungai Utara Regency. Consequently, a model for such sustainability was developed through a literature review and expert opinion, with 53 indicators determined and integrated into nine latent variables. This indicator was chosen to be closely related to the sustainability of the swamp buffalo business in Hulu Sungai Utara district, South Kalimantan. The study was then conducted as described in Figures 2 and 3.

The model development was conducted by evaluation of the outer and inner models to test the study hypotheses. These were as follows:

H1: Cultural indicators affect HR.
H2: Ecological indicators affect HR.
H3: Economic indicators affect HR.
H4: Information system indicators affect HR.
H5: Institutional indicators affect HR.
H6: Technology indicators affect HR.
H7: Indicators affect finance.
H8: Indicators affect business sustainability.

2.4 Data analysis

The empirical data were obtained from the farmers' information and after collection were recorded according to each indicator. They were then analysed using SEM-PLS, which is able to handle formative or reflective measurement styles. Reflective measures were used as endogenous structural properties and shifts in the structural model predictor (transend). Reflective indicators were drawn when single-headed arrows went from latent constructs to indicator variables. The study employed a reflective technique [17].

3 Results and discussion

3.1 Outer evaluation model

3.1.1 Convergent validity test

This study model has reflective indicators. The convergent validity test was performed using the average variance

Table 1: Exogenous and endogenous dimension variables

No.	Variable	Notation	Indicator	Notation
1	Ecology	X1	Availability of feed/forage	X11
			Availability of land for buffalo cattle	X12
			Availability of buffalo herding land	X13
			Utilisation of livestock waste for fertiliser	X14
			Utilisation of agricultural waste for buffalo feed	X15
			Land use change	X16
			Availability of drinking water for the buffalo	X17
			Diseases that attack buffalo cattle	X18
			Buffalo death	X19
2	Economics	X2	Buffalo livestock business profits	X21
			Buffalo livestock business scale	X22
			Buffalo cattle marketing	X23
			Access to financial institutions for buffalo business	X24
			Increase in buffalo livestock production	X25
			Increase in buffalo livestock population	X26
3	Institutional	X3	Role of central and regional governments in buffalo development	X31
			Agricultural organisational institutions	X32
			Group dynamics	X33
			Role of extension agencies	X34
			Availability of input–output markets	X35
			Role of financial/capital institutions	X36
			Marketing institutions	X37
4	Technology	X4	Seed selection	X41
			Feed technology	X42
			Housing system	X43
			Livestock health	X44
			Availability of males	X45
			Technology needs	X46
5	Socioculture	X5	Family participation in buffalo business	X51
			Availability of labour for the buffalo business	X52
			Level of community empowerment in independence	X53
			Potential land conflicts	X54
			Collaboration/gotong royong in buffalo farming	X55
6	Information system	X6	Accessing signals from providers	X61
			Use of communication tools for sources of information	X62
			Application use for buffalo marketing	X63
			Use of applications for buying and selling of buffalo livestock	X64
7	HR	Z	Knowledge and skills of breeders	Z11
			Farmers' motivation	Z12
			Farmers' education	Z13
			Farmers' experience	Z14
			Farmers' age	Z15
8	Finance	Y1	Income from buffalo farming business	Y11
			Savings amount	Y12
			Debt amount	Y13
			Number of buffalo calves born per year	Y14
9	Sustainability of buffalo farming business	Y2	Ownership of cages	Y21
			Ownership of means of transportation	Y22
			Ownership of means of communication	Y23
			Land ownership	Y24
			Residential ownership	Y25
			Number of livestock cultivated	Y26
			Ownership of venture capital for buffalo livestock	Y27

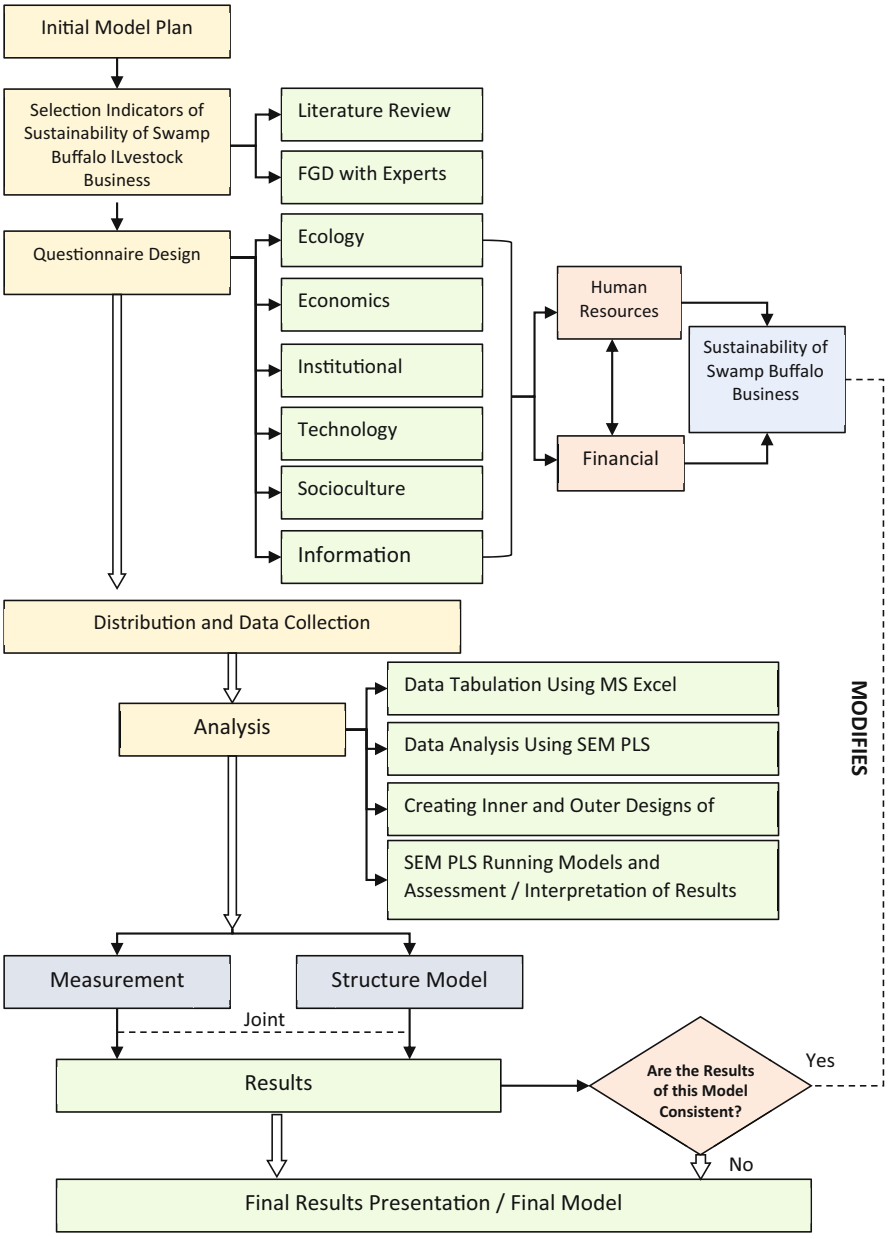

Figure 2: Research stages.

extracted (AVE) value and outer loading. In this study, an indicator was declared valid if it had a loading factor of more than 0.6 and an AVE of more than 0.5 (Table 2). The results of the path coefficient, outer loading, and R^2 are presented in Figure 4, where it can be seen that all the outer loadings were greater than 0.6. The convergent validity results are presented in Table 2.

The analysis results shown in Table 2 indicate the outer loadings and AVE values. All the variables have an AVE value >0.5, and all the indicators have an outer loading value >0.6; the AVE values meet the convergent validity requirements, namely, being greater than 0, so the model indicators have convergent validity. The results of this analysis indicate that the model shown in Figure 4 is that produced for the study. In the initial study, 53 indicators were used. The results of the analysis obtained 27 indicators that had an outer loading value of >0.6 and AVE of >0.5, which met the validity requirements (Table 2).

It was found that the ecology variables had four indicators in building the model, namely, the availability of forage, the availability of land for looking for feed, the availability of land for grazing, and diseases that attack buffalo livestock. Natural pastures are a source of food, but little attention has been paid to their sustainability

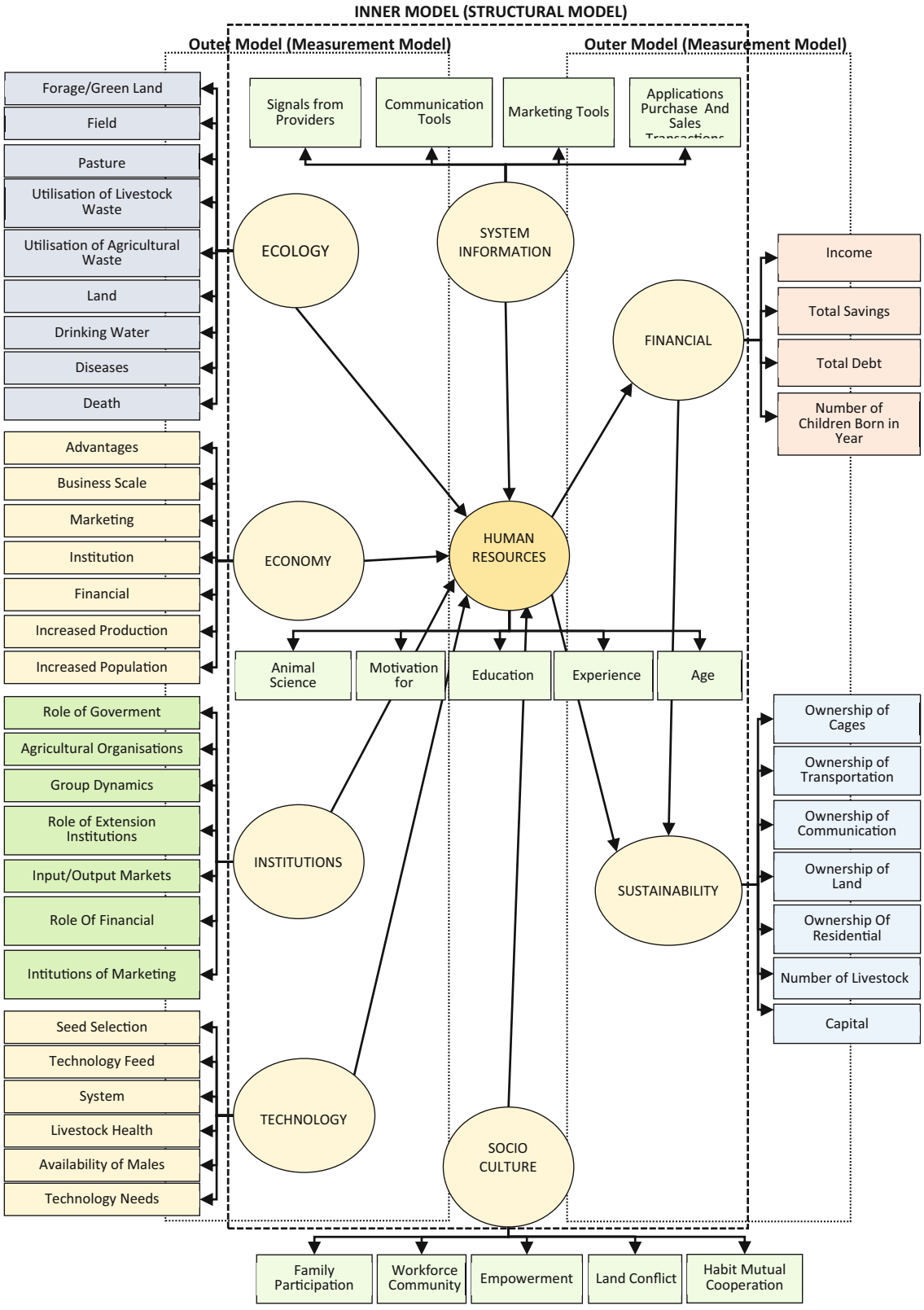

Figure 3: Initial model plan.

Table 2: Outer loading and AVE

Latent variables	Indicator	Outer loading	AVE
Ecology	X11	0.724	0.524
	X12	0.762	
	X13	0.664	
	X18	0.741	
Economy	X21	0.856	0.596
	X23	0.736	
	X25	0.826	
	X26	0.654	
Institution	X31	0.629	0.545
	X32	0.817	
	X34	0.810	
	X37	0.679	
Technology	X41	0.764	0.512
	X42	0.681	
	X43	0.737	
	X44	0.675	
Socioculture	X51	0.759	0.508
	X52	0.690	
	X55	0.688	
Information	X62	0.830	0.591
	X64	0.702	
Finance	Y12	0.797	0.603
	Y13	0.755	
Sustainability	Y23	0.865	0.663
	Y25	0.761	
HR	Z11	0.785	0.638
	Z12	0.812	

due to differences in attitudes, social norms, and perceptions of landowners' behaviour [18]. Grazing or pasture is an important factor in providing feed for livestock, which will then produce food for humans in the form of meat and milk [19]. Pasture of a sufficient land area will support the availability of feed for livestock needs. This is supported by [20], who argues that efficient and available feed is important to strengthen the three conventional pillars of sustainability (environmental, social, and economic). However, land and other natural resources are a limiting factor, so it is necessary to find more efficient ways to cultivate more animals per hectare [21]. Rusdiana *et al.* [22] state that infectious diseases are one of the obstacles to reproductive and production performance in buffaloes, causing enormous economic losses. This implies that disease can affect the sustainability of the livestock business.

The economic variables have two indicators to support the buffalo business sustainability model, namely, business profits and the marketing of buffalo livestock. The conditions at the study sites indicate that the profits derived from the buffalo farming business are able to support family and regional economies. The marketing of buffaloes does not experience problems even though the research location is in a remote place. This shows that the demand for buffalo meat is relatively high and of interest to consumers. Widaningsih *et al.* [23] found that increasing the scale of the livestock business is a good strategy to save on input costs, generate more income, and meet the market demand. The previous study found that the increased economic efficiency of the buffalo business influences on the variable profit of the breeder [24]. Female buffaloes raise cattle breeders' profit to Rp.7,889,000/year, with a higher R/C of 1.02. The factors that influence buffalo business income are the scale of the business, the age of the breeder, and the number of calves, while the factors of the number of buffalo, education, experience, and fixed costs have no effect on income [25]. There are four marketing channel patterns for swamp buffalo in South Kalimantan: direct marketing, one-level marketing, two-level marketing, and three-level marketing [26]. The one-level marketing pattern has the highest marketing efficiency value compared to the other three. The marketing agencies that receive the highest profit are the wholesalers.

The institutional variables have four indicators with an outer loading >0.6 (Table 2), namely, the role of the central and regional governments in buffalo development, the agricultural institutions, the role of extension institutions, and marketing institutions. Conditions at the research location indicate the need to increase these roles and attributes. The support and the role of the central and regional governments in the development of buffalo livestock are vital. This is in accordance with the research of Elahi *et al.* [27], who showed that government support is needed for sustainable agricultural development, including by means of education, coaching, training to improve farmers' abilities, creating agricultural development programs, helping farmers to access capital, and building facilities and infrastructure. Agricultural institutions, including livestock groups and extension institutions, marketing, and other institutions, are very supportive of the progress of agricultural development. According to Warriach *et al.* [28], the development of the services of extension institutions includes increasing the awareness of breeders of making better use of grazing lands to obtain sustainable grass production. Marketing institutions are also an important factor to support the sustainability of buffalo livestock business [26].

The technology variable has four attributes (Table 2), which contribute to building a sustainable model for the buffalo livestock business, namely, the selection of seed, feed technology, housing systems, and livestock health. At the research site, these were managed soberly, for seeds, breeders used existing livestock, to be developed, especially broodstock. If the parents show low productivity, they will be sold and replaced with others with good

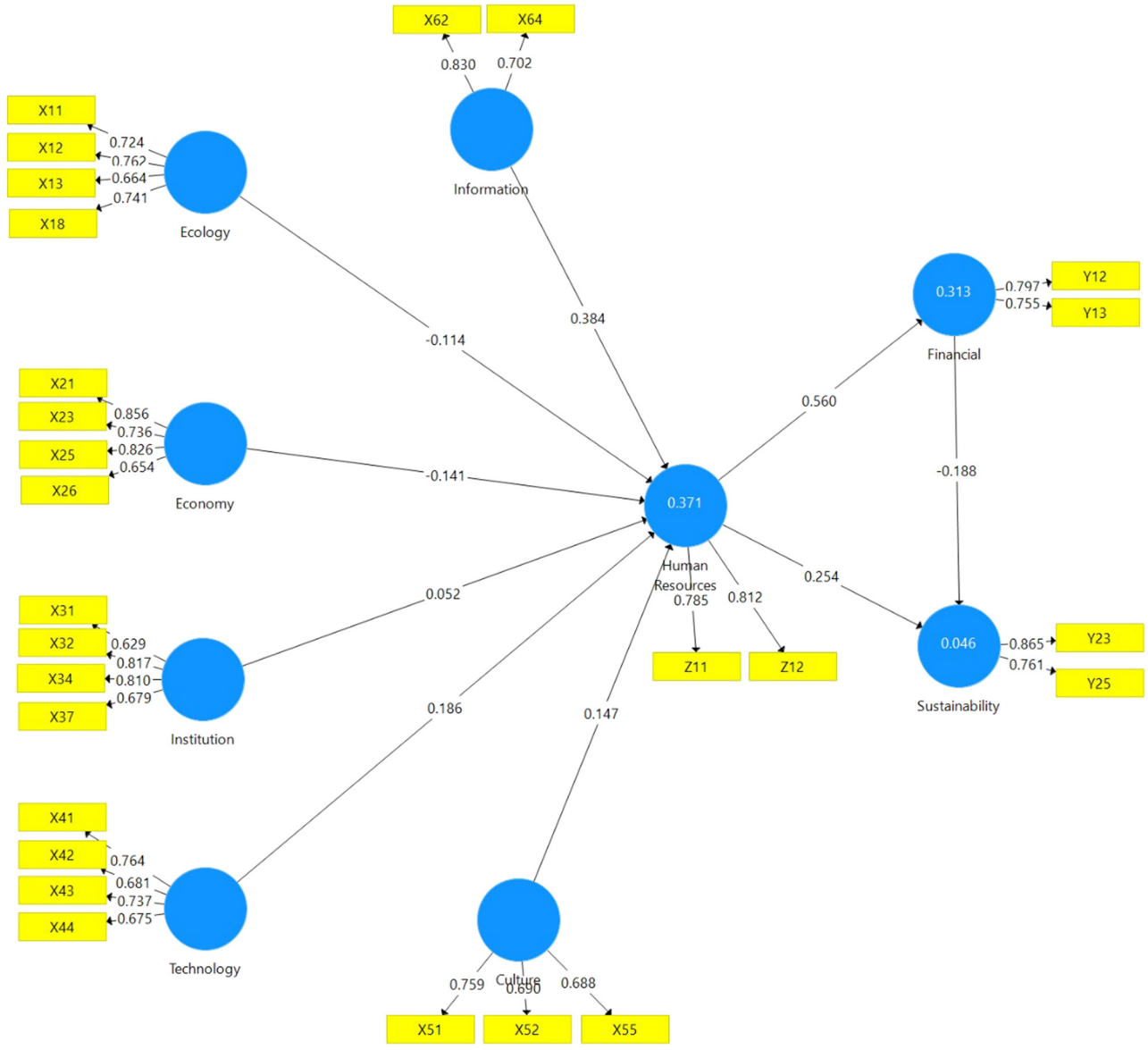

Figure 4: Results of the path coefficients, outer loading, and R^2.

exterior characteristics. Seed selection is made by looking at the physical appearance of the offspring. The feed given is forage or grass that grows in the swamp areas, without any other additional feed. Feed processing technology is not conducted, and no use of agricultural waste is made because the region is far from the food crop centre areas and breeders believe that the forage growing in the swamp areas is sufficient. The housing system used is the *kalang*, which is a pen built over swamp water. The cattle are in the corral from evening to morning, after which the livestock are released to the pasture. Diseases are generally diarrhoea in young buffalo, while adult buffalo suffer from heartworms and sura. Buffalo livestock play an important role as a source of livelihood and food, but their performance is less than optimal. This was supported by Saputri *et al.* [29], who found that the problem of reproductive efficiency is due to poor feed management and lack of livestock selection. The use of technology in agriculture is increasingly necessary, in line with technological developments [30]. According to Prasetyia *et al.* [31], to improve and increase the role of buffaloes, genetic improvement technology is needed, together with the promotion of appropriate technology, infrastructure development, and assistance to breeders to overcome technical and business problems. Although currently most of the maintenance of buffaloes is conducted extensively, efforts to improve

genetics need to be made, including estrus protocols and ovulation synchronisation; commercial artificial insemination; embryo transfer; *in vitro* embryo production; and nucleus transfer [32]. Moreover, according to Widodo *et al.* [33], with the rapid technological advances and climate change, raising swamp buffalo is a strategic choice to increase the income of small farmers. The development of buffalo livestock through genomic selection is a good strategy to select animals with optimal productivity and adaptability to hot and humid climates. With the availability of quality livestock breeds, quality feed, suitable cages, and disease prevention, the sustainability of the buffalo farming business can be achieved. In addition, Derks *et al.* [34] recommend that the government introduce small-capacity agricultural machines to small farmers to process agricultural waste, as animal feed is one of the technologies that supports business sustainability.

The sociocultural variable has three attributes, whose outer loading value is >0.6 (Table 2), namely, family participation in the buffalo business, the availability of labour, and the existence of cooperation. Conditions at the study sites indicated that both family and non-family kindergarten workers were available, who could support the sustainability of the buffalo farming business. Cooperation and mutual cooperation in agricultural and general activities were also evident, supporting business development and sustainability [35–41].

The HR variable has two indicators valid for the model building, namely, farmers' knowledge/skills and farmers' motivation. The success of sustainable agricultural development depends on the involvement of beneficiary HR and participation. Farmers' involvement at every stage of the programme will increase its success, and those who participate optimally will receive optimal benefits [34]. Muhammad *et al.* [40] reported that the factors influencing sustainable agriculture are education, distance to irrigation sources, rural areas, farm income, and access to credit. Therefore, farmers need to be supported by various programmes, such as ones on counselling, farming credit, production price incentives, and the provision of good irrigation facilities. The financial variable is supported by two indicators, namely, the amount of savings and the amount of debt.

The informatics system variable also has two indicators contributing to the building of the model, namely, the use of communication tools for sources of information and the use of applications for buying and selling buffalo livestock. Currently, sources of information are being developed not only directly but also indirectly through technology. Among these, computer technology, sensors, cloud computing, machine learning, and artificial intelligence have changed several industries, making processes easier and leading to greater profits and efficiency [42]. Hence, it is necessary to explore how such advanced technology can help achieve greater efficiency and profits in animal husbandry [21].

3.1.2 Discriminant validity

In addition to convergent validity, discriminant validity was also investigated. The parameters of discriminant validity tests are known as the Fornell–Larcker criterion [43]. The Fornell–Larcker criterion results are presented in Table 3.

Table 3 illustrates that the diagonal value is greater than those below, and the Fornell–Larcker criterion was met. In addition, the indicators used to measure the variables were valid because their values have the highest compared to other indicators. Therefore, it concluded that the variables and indicators used in the study conform to discriminant validity.

3.1.3 Reliability

The parameters used to assess reliability were Cronbach's alpha and composite reliability. According to Abdillah *et al.*

Table 3: Fornell–Larcker criterion

	Sustainability	Culture	Ecology	Economy	Financial	Information	Institution	HR	Technology
Sustainability	0.814								
Culture	0.116	0.713							
Ecology	−0.184	0.037	0.724						
Economy	−0.008	0.004	−0.020	0.772					
Finance	−0.046	0.248	−0.177	−0.228	0.776				
Information	0.087	0.211	−0.220	−0.089	0.328	0.769			
Institution	0.053	0.229	−0.088	0.116	0.016	0.184	0.738		
HR	0.149	0.286	−0.189	−0.170	0.560	0.535	0.151	0.799	
Technology	0.100	0.269	0.029	−0.020	0.413	0.391	0.005	0.376	0.715

Table 4: The value of composite reliability

Latent variable	Composite reliability
Continuous	0.797
Culture	0.756
Ecology	0.814
Economy	0.854
Finance	0.752
Information	0.742
Institution	0.826
HR	0.779
Technology	0.807

[44], based on Chin (1995), an indicator is said to be reliable if its composite reliability value is greater than 0.7. The composite reliability results are presented in Table 4, which shows that the variables used have a composite reliability value higher than 0.7, so it can be concluded that the indicators that measure the variables are reliable.

3.2 Inner model evaluation

The parameters used to evaluate the inner model in PLS-SEM were determinant coefficients (R^2 test) and path coefficients, or *t*-values. The value of R^2 was used to measure the level of variation in changes from independent to dependent variables. The R^2 value of the variable for swamp buffalo business sustainability was 0.046 or 4.6%; the R^2 value of the financial aspect variable was 0.313 or 31.1%; and the R^2 value of the HR variable was 0.371 or 37.1%.

The $Q2$ value was used to calculate the overall goodness of fit (GOF), whose value was 0.588, meaning the study model was fairly good because the value was greater than 50%. After calculating the GOF, the next step was the hypothesis testing with path coefficients. The hypothesis in this study was two tailed. Therefore, it was accepted if it had a *t*-statistic value higher than 1.96 and a *p*-value of 0.05. The values of the *t*-statistics are presented in Figure 5.

The results indicate that there is a relationship between four variables. Information systems have a positive influence on HR, while economy has a negative influence on HR. However, HR have a positive relationship with finance and the business sustainability of swamp buffalo. The relationships between the variables are presented in Table 5.

The table shows that information systems have a significant influence on HR, with a positive effect of 0.384, meaning an increase in information systems will increase HR. Information systems are very important in the sustainability of livestock business in today's digital era. Communication, transactions, exchange of information, and transfer of knowledge are fundamental in almost every aspect of animal husbandry, so information systems make a major contribution to the transition for sustainability in agriculture [23,45]. Farmers are faced with a weak bargaining position due to the lack of knowledge of pricing and marketing. If a farmer needs money to cover his urgent needs, his livestock will be sold at an unreasonable price. This situation can be minimised if farmers understand and employ digital marketing effectively. This is in line with the research of Moussa and El Arbi [46], who found that information systems increase the capacity and capabilities of HR. Another study by Ma and Zheng [47] demonstrates that smartphone-based information sources can help reduce the excessive use of pesticides and chemical fertilisers, preserving the environment and human health. Nyamekye *et al.* [48] found that the farmer-to-farmer information systems contributed the most to knowledge creation.

The indicators used in this study were considered feasible and make a contribution to the sustainable development of the swamp buffalo business in Hulu Sungai Utara Regency, South Kalimantan. The results of the statistical analysis show that four variables affected such sustainability, namely, information systems, economy, HR, and business sustainability, while the other five variables, ecology, institution, culture, technology, and finance had no statistical effect. Information systems and economy have a significant effect on HR, while HR significantly affect the financial and business sustainability of swamp buffalo. Therefore, the first four variables contribute greatly to the sustainability of swamp buffalo farming business, while the others have a factor loading, which is sufficient to contribute to such sustainability and sufficient to guarantee the effectiveness of the measured model.

A sustainability transition is defined as a long-term, multidimensional, and fundamental transformation process in which a socio-technical system shifts to more sustainable production and consumption practices, with the main objective of increasing agricultural productivity [49]. The transition to agricultural sustainability refers to structural changes related to new, more sustainable production and consumption practices. Therefore, innovative solutions and appropriate technology are needed in the form of information systems [50] and of information and communication technology that assist sustainability in agriculture, food, processing, distribution, and consumption systems, as well as integration and coordination of the food chain [11].

The results of this study enrich those of previous ones, in which information systems were proven to improve HR by empowering small-scale farmers in developing

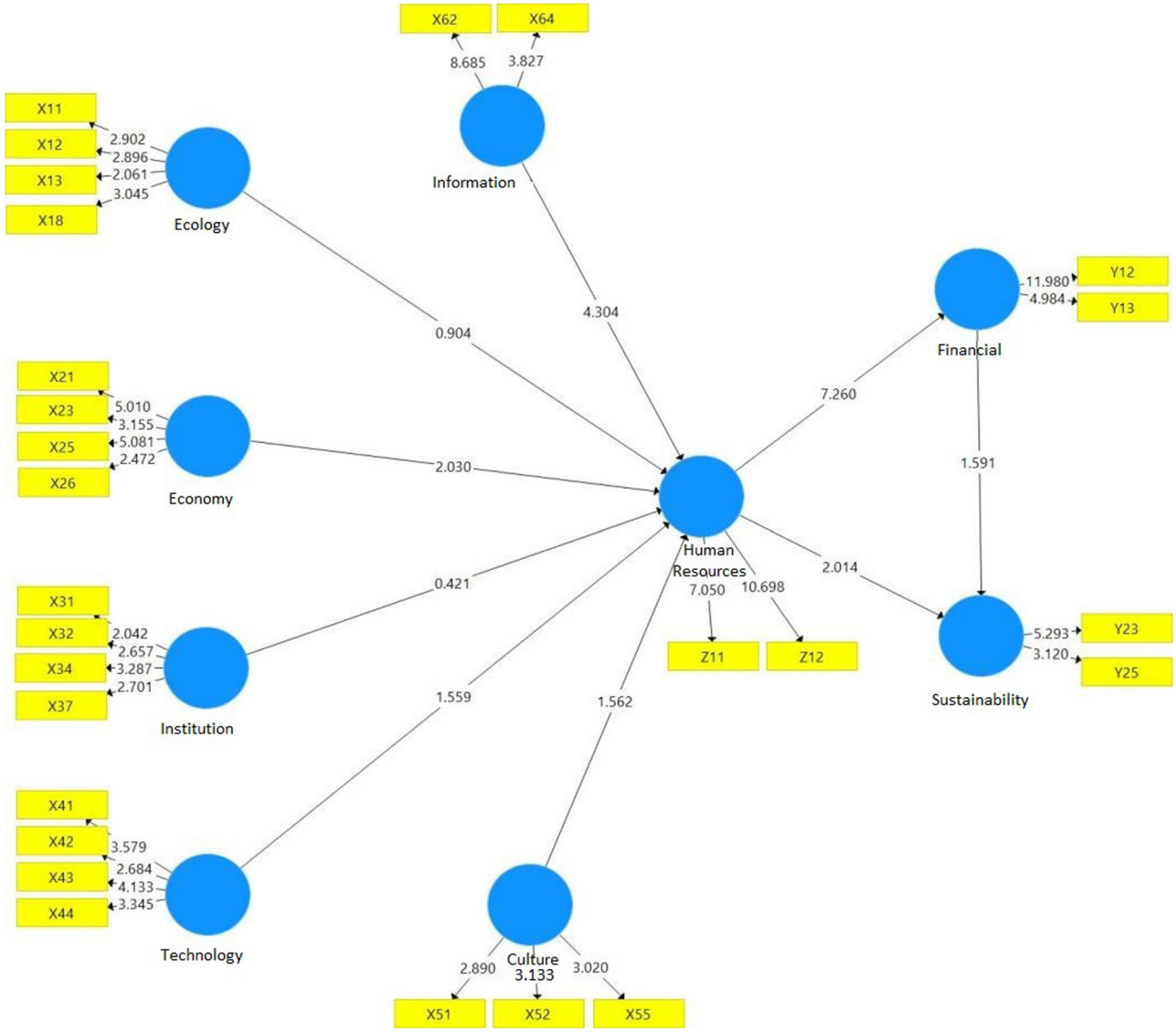

Figure 5: T-statistics.

Table 5: Relationship between variables in swamp buffalo livestock business sustainability

	Original sample (*O*)	Sample mean (*M*)	Standard deviation (STDEV)	*T* statistic (|*O*/STDEV|)	*P*-value
Culture → HR	0.147	0.163	0.094	1.562	0.119
Ecology → HR	−0.114	−0.114	0.126	0.904	0.366
Economy → HR	−0.141	−0.147	0.070	2.030	0.043*
Information → HR	0.384	0.358	0.089	4.304	0.000*
Institution → HR	0.052	0.043	0.125	0.421	0.674
Technology → HR	0.186	0.184	0.119	1.559	0.120
HR → Financial	0.560	0.559	0.077	7.260	0.000*
HR → Sustainability	0.254	0.259	0.126	2.014	0.045*
Financial → Sustainability	−0.188	−0.198	0.118	1.591	0.112

* Level of significance *P*-value = 0.05.

countries and increasing their connectivity [51], and empowering farmers as innovators by their access to information that leads to innovation [52]. In developing countries, information systems are widely used by extension and consulting services; for example, to access market information via short message service, smartphone applications, and integration with social media [53,54]. Farmers can access financial services such as savings, credit, insurance, payment facilities, and remittances that they need at a low cost [53,55]. Therefore, information and communication technology can improve resource efficiency and productivity in the food system [56–58].

In this study, the economic variables are shown to have a significant effect on HR, but with a negative effect of 0.141, meaning that if the economy improves, HR will decrease. This situation demonstrates that not all economic improvements will always be followed by an increase in HR. This research has focused on the condition of swamp buffalo farmers in Hulu Sungai Utara Regency, South Kalimantan. Their economic condition can have a positive effect or a negative effect, depending on how each individual reacts to it; it can be used as a motivator to increase livestock productivity or make farmers complacent about their existing welfare. If an improved economy makes farmers complacent, this will have a negative impact on the sustainability of their livestock business. Therefore, education and counselling are very important as reminders of this. So that farmers do not become negligent with what they already have and continue the effort to improve the productivity of their livestock [29], and the role of the extension worker as a facilitator is the basis for increasing the capacity of farmers by upgrading their knowledge, skills, and attitudes [30]. Extension workers have the ability to facilitate and to strive for easy access to information resources, technology, and other resources. The negative influence relationship is due to the absence of equal distribution of the results of economic improvement felt by the swamp buffalo farmers. The results of this study are in line with those of Prasetyia *et al.* [31], that economic growth has a negative influence on HR, which is due to the lack of equitable distribution of the benefits of economic growth, a situation especially felt by residents in rural areas. The negative influence of economic resources on HR can be viewed from another angle. Farmers who are economically well established will refuse to become wage labourers. In a village with good economic conditions, it will be difficult to find agricultural workers. In addition, there will be a fall in the interest of the younger generation to work in agriculture, including animal husbandry. This is because the agricultural sector has a less prestigious image than other sectors, with underdeveloped technology and the inability to provide adequate income [59]. The reduced interest of the younger generation in agricultural business needs to be tackled by government policies that develop the interest of the younger generation in the agricultural sector, including the strengthening of digital-based agriculture [60–62].

HR have a significant influence on finance, with a positive influence of 0.560, meaning that increased HR will improve finances. Likewise, there was a significant influence of HR on the sustainability of swamp buffalo business, with a positive effect of 0.254, meaning that an increase in HR will increase such sustainability. The results of this study enrich other research results, namely, that breeders' HR are one of the key factors in the success of the livestock business and play a very important role in its development and sustainability. According to Amam *et al.* [63], high- and low-quality HR can affect the accessibility of resources in a business system. Furthermore, it has been argued that resources can increase opportunities for livestock business development [64]. Another study by Oduniyi *et al.* [65] found that HR factors that significantly influence the adaptive capacity of livestock to be sustainable are the use of labour and other sources of income.

The results of this study also show that sociocultural, ecological, institutional, and technological variables made a sufficient contribution to the sustainability of the development of swamp buffalo business in Hulu Sungai Utara Regency, South Kalimantan Province, although they did not affect HR. In relation to sociocultural aspects, swamp buffalo have been cultivated for generations by farmers in the regency, so their experience of raising cattle is very long. Therefore, social and cultural aspects were not the main study focus, as they were considered entrenched. This is in line with studies of Dawson *et al.* [66] and Adenle *et al.* [67], who showed that in the sustainability of agriculture in developing parts of the country, sociocultural aspects were often neglected. Sustainability in the livestock production sector relates to the ability of the system to meet the current demand for livestock products, without jeopardising the use of resources by future generations and minimising negative externalities [68]. Based on this, for a livestock system to be sustainable, it must be able to meet its economic, social, and current and long-term environment [65]. Furthermore, in terms of ecology, Hulu Sungai Utara Regency is a suitable area for the development of the swamp buffalo business, as it has a swamp area of 46.01% [1], an ecological condition that does not affect the work of breeders, as they have lived in swamp settlements for generations. From an institutional perspective, breeders in the regency have joined livestock groups and have been provided with guidance and facilities from the central/regional government. The technology for increasing

the productivity of swamp buffalo is already available. This is in line with research by Alpianor *et al.* [69] that an important factor in the development of swamp buffalo business is that it is a hereditary business system; the experience of breeders is extensive, and buffaloes have adapted together with the existence of farmer group institutions. In addition, an opportunity factor is the availability of technology to increase the productivity of swamp buffalo.

Sociocultural, ecological, institutional, and technological indicators are strengths and opportunities, as well as challenges to the development of swamp buffalo business in the future, so they must be considered and optimised, as they make a sufficient contribution to the sustainability of such development, especially in North Hulu Sungai Regency, South Kalimantan Province.

4 Conclusion

Aspects used in this study were considered feasible and make a contribution to the sustainability of the development of swamp buffalo business in Hulu Sungai Utara Regency. Based on the results of the statistical analysis, four indicators were shown to affect such sustainability, namely, the information systems, economy, HR, and business sustainability variables. Information systems will increase HR. Information systems are also very important in the sustainability of livestock business in today's digital era, having been proven to improve HR.

Economic variables have a significant effect on HR, but a negative one, meaning if the economy improves, HR will decrease. This situation demonstrates that not all economic improvements will be followed by an increase in HR. HR have a significant positive influence on finance, meaning that increasing HR will improve finances.

Sociocultural, ecological, institutional, and technological variables make a sufficient contribution to the sustainability of the development of swamp buffalo business in Hulu Sungai Utara Regency, although they do not affect HR. In terms of ecology, the regency was shown to be a suitable area for the development of the business.

The resulting research model for the sustainability of the buffalo livestock business was built with 9 variables and 27 indicators. The model, which is recommended for the government as policymaker, especially the government in Hulu Sungai Utara Regency, emphasises the information system variables, the economy, HR, finance, and the sustainability of the buffalo farming business, but without ignoring other variables, such as ecology, socioculture, technology, and institutions. Sociocultural, ecological, institutional, and technological indicators are strengths and opportunities, as well as challenges to the development of swamp buffalo business in the future, so must be considered and optimised.

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