

A social-ecological system approach to Bali cattle raising in Timor Island, Indonesia

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Abstract. Firman A, Nono OH. 2021. A social-ecological system approach to Bali cattle raising in Timor Island, Indonesia. *Biodiversitas* 22: 3585-3593. Cattle raising in East Nusa Tenggara play important role in the daily life of local people including to fulfill nutritional needs, to generate cash income, to develop social relationships, and to maintain religious activities. On the island of Timor, the type of cattle mostly kept by farmers is Bali cattle. This type of cattle perfectly suits the environmental and social conditions of the island. The purpose of this study was to investigate the interaction of social-ecological systems (SESs) and other systems that were able to maintain the sustainability of Bali cattle raising in Timor Island. All components in the system that interact with each other were studied through in-depth interviews with informants (15 cattle farmers, five community leaders, five cattle traders, and 10 staff of livestock services district and province levels). The results showed that the SESs approach could provide an explanation on the relationship between resource systems, resource units, governance systems, and users as well as systems that are outside SESs, namely the market and government policies, which altogether were able to improve Bali cattle raising sustainability. Farmers had an important role in Bali cattle raising and their habitat environment. Local and export markets played a role in providing value for Bali cattle raising. The local government maintained the balance of supply and demand for Bali cattle through the East Nusa Tenggara Governor Regulations No. 78 of 2019. Therefore, the research has succeeded in identification of feed resources in savanna and steppe and provide an opportunity to increase the cattle population on the island of Timor. The interaction between farmers and their environment has been well established, however, it is necessary to improve the quality of forage feed in grazing land.

Keywords: Bali cattle, social ecology systems, East Nusa Tenggara, production system

INTRODUCTION

Meat is a protein source originated from animal that is very essential for humans. In many areas of the world, meat is sourced from beef cattle. Beef cattle play several roles in the daily life of people, i.e., to fulfill nutritional needs, to generate cash income, to develop social relationships, and to maintain religious activities. Cattle farming is useful as savings and a very liquid asset because cattle can be sold quickly to traders to get cash money (Doğan et al. 2013; Uba et al. 2015). Cattle have a strong social inseparable part of the life of the agricultural community, for example in Zimbabwe in which the number of cattle owned connotes a signal social status in the community (Moyo and Mlilo 2019). Also, cattle have a strong relationship with religion: e.g., in Muslim countries including Indonesia, cattle are used as sacrificial animals on Eid al-Adha (Winarso 2014; Tuncel and Cevger 2015). According to Kennedy et al. (2018) stated that cows are one of the important symbols for Hinduism and national pride identity in India.

The relationship between human resources and natural resources exists naturally because they are interdependent, e.g., farmers, animals including beef cattle, and their environment. This is the important intellectual basis for the existence of Social-Ecological Systems or SESs between farmers as social beings with natural resources embedded

in them which results in a mutualistic relationship that is reflected in the system (Chable et al. 2020). The SESs recognizes the interaction between humans and their environment and in turn it produces a complex relationship consisting of several subsystems (Liu et al. 2007; Ostrom 2009; Stojonovic et al. 2016). According to Ostrom (2009) and Anderies et al. (2004), there are four subsystems that interact directly in the Social-Ecological Systems, namely the resource system, resource units, governance system, and resource users. It is further stated that resource system is a reserve covering a specified territory containing forested areas, wildlife, and water systems. Resource units are specific resources that exist in each resource system in a particular region, for examples trees, shrubs, plants, and animals. Governance system is an organization that regulates and creates specific rules for use in the management of resource reserves, for example, group of farmer, traditional group, or village government. Last, resource users are individuals or institutions that use this natural resource for various activities. Outside of the SESs, there are other influencing subsystems, namely social, economic, and political, as well as continuously interacting with the ecosystem. SESs are very complex and involve many systems (Bennette et al. 2016; Chable et al. 2020).

In Indonesia, the need for beef meat from year to year has increased quite significantly (Roy et al. 2019). The consumption of meat and meat products in the country

reached 771,000 tons in 2018 and increased to 819,000 tons in 2019 (Directorate General of Animal Husbandry and Animal Health 2020; Firman et al. 2020). The domestic production of beef meat in Indonesia can only fulfill 70% of the national demand while the rest is imported (Ariningsih 2014).

East Nusa Tenggara is one of the live cattle suppliers for Indonesia. The province is known as the national cattle barn because the total supply of live cattle consists of 49,000 – 71,000 heads per year during 2014-2019, or contributing to 10.76% of total cattle population in Indonesia with 649,000 heads (Livestock Service of East Nusa Tenggara Province 2020). The supply of live cattle from the province of East Nusa Tenggara indicates the economic value generated from this sector.

Research in the field of animal husbandry with the SESs approach has never been carried out. Bali cattle are a genetic source from Indonesia which has advantages in adaptability to new environments and tropical climates, high fertility rates, high carcass, and meat percentages, have a brick red or dark brown coat color and black adult males, and the specific feature of the coat color is the white bottom and legs, and is resistant to ticks and worms (Susilorini et al. 2008; Zulkharnaim et al. 2010; Ni'am et al. 2012; Akma et al. 2016; Warmadewi et al. 2017; Hikmawaty et al. 2018).

The purpose of this study is to investigate and analyze the interrelationships of SES elements, i.e. the resource system, resource units, governance system, and resource users, and other systems (marketing and government policy) in supporting the Bali cattle raising on the island of Timor, East Nusa Tenggara. The SESs approach is used as the basic framework to reveal the Bali cattle raising in the

studied area to understand the resource systems in providing feed for Bali cattle production systems, resource management by local organizations or institutions and Bali cattle raising systems by farmers.

MATERIALS AND METHODS

Study area

There are 6 districts in the island of Timor, Indonesia, namely Kupang City, which is also the capital of the East Nusa Tenggara, Kupang District, Timor Tengah Selatan District, Timor Tengah Utara District, Malaka District, and Belu District. Kupang City, Kupang District and Timor Tengah Utara District were selected as the study areas for this research (Figure 1). The three areas were chosen because of the representation of the largest Bali cattle population from the largest (Kupang District: 254,759 heads) to the smallest (Kupang City: 7,619). The Timor Tengah Utara District was chosen because it had an intermediate Bali cattle population (161,889 heads; Central Statistics Office of East Nusa Tenggara Province 2020). Kupang District is located on lowland with an altitude of 0 - 500 m above sea level with an annual temperature between 25°C to 34°C (Central Statistics Office of Kupang district 2020). Timor Tengah Utara District is located at an altitude of fewer than 500 m above sea level with an annual temperature between 26°C to 32°C (Central Statistics Office of Timor Tengah Utara District 2020). Kupang City is located at an altitude of 0 - 50 m above sea level with an annual temperature between 35°C to 42°C.

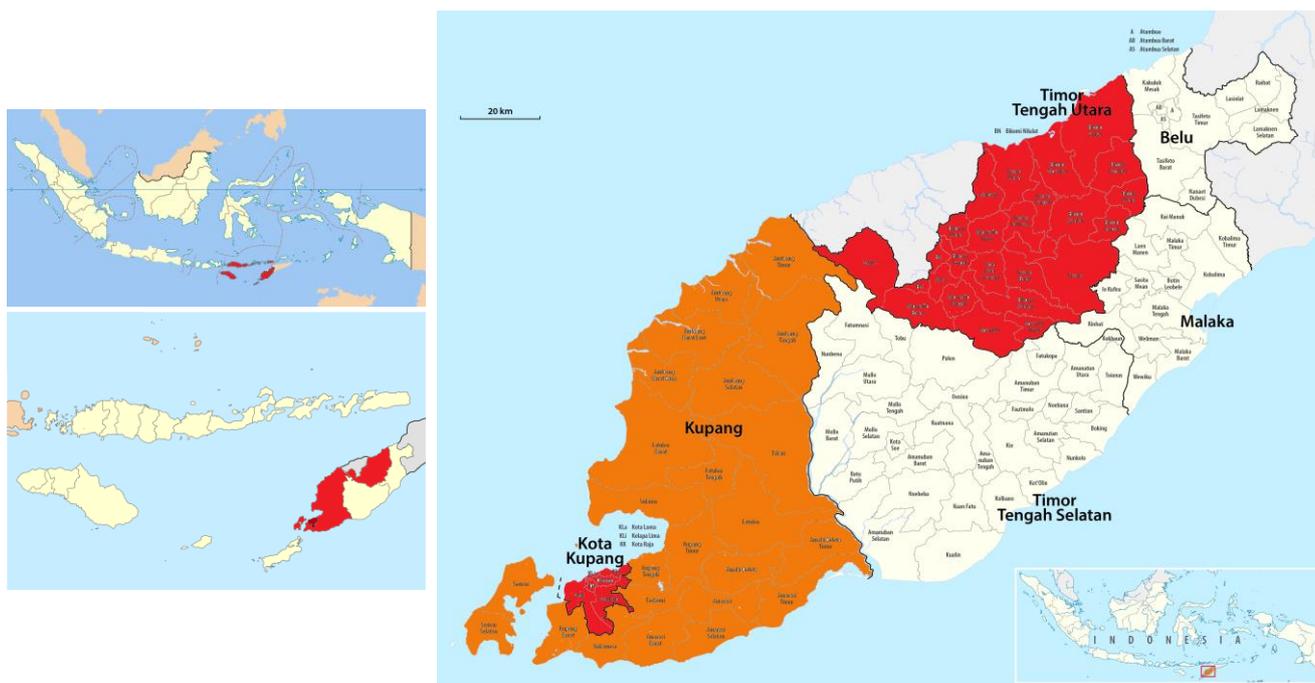


Figure 1. Three study areas in the island of Timor, East Nusa Tenggara, Indonesia, i.e. Timor Tengah Utara District, Kupang District, and Kupang City

Procedures

The research was conducted from 2019 to 2020. There were two procedures applied in this study, namely literature review and exploratory research. Initially, literature reviews were conducted in academic publications, especially in scientific journals that focus on cattle research in East Nusa Tenggara, and the local government reports. We identified the literature related to community culture of raising cattle, livestock breeding systems, grazing environment, weather and climate conditions, local government policy, and live cattle marketing systems. Based on the results of literature review, the research was concentrated in the island of Timor because this area has been designated for Bali cattle raising. There were three locations on island of Timor chosen as study areas, namely the Timor Tengah Utara District, the Kupang District, and the Kupang City.

The second procedure was exploration research. This research is qualitative research in order to understand what phenomena are experienced by research subjects (informants) by digging in-depth information related to the research objectives (Moleong 2008). Because this research was qualitative research, the information obtained was based on the informants. Interview methods and focus group discussions were used to obtain information and data from the selected informants. Open questions related to SES were asked to informants using a questionnaire including inquiries related to resource systems (savanna or steppe areas, water sources, and animals that live in savanna or steppe areas), resource units (plants or trees that live in savanna areas and steppes, the types of animals in the area, and the amount and flow of water in the area), governance system (organizations that regulate savanna and steppe areas that are used as grazing areas), and users (breeders or companies that graze livestock in the area). In addition, other questions were structured to support SESs questions, such as community culture of raising cattle, livestock systems, grazing environment, weather and climate conditions, local government policies, and live cattle marketing systems.

Based on Martha and Kresno (2016), there were three informants considered in this study, namely key informants (staff of animal husbandry services in provinces and districts/cities), main informants (farmers and leaders), and supporting informants (cow traders). Key informants recommended farmers, community leaders, and local and export traders to be interviewed from each district/city. The informants interviewed were 15 cattle farmers (five farmers from the Timor Tengah Utara District; seven farmers from the Kupang District; and three farmers from the Kupang City), five community leaders (two community leaders from the Timor Tengah Utara District; two community leaders from the Kupang District; and one community leader from the Kupang City), five local and export live cattle traders (one local live cattle trader from the Timor Tengah Utara District; two local live cattle traders from the Kupang District; and three export live cattle traders from the Kupang City), and ten staff of livestock service in province and district level (four staff of livestock service of the province; two staff of livestock service of the Timor

Tengah Utara District; two staff of livestock service of the Kupang District; and two staff of livestock service of the Kupang City). Henceforth, data and information obtained from informants were then analyzed and compiled to reveal the SESs on Bali cattle raising.

The next procedure is the determination of the carrying capacity of livestock in each district/city. Mathematical analysis was used to measure the carrying capacity in the grazing land. To measure the amount of available forage on grazing land, the following formula was used (Juarini et al. 2011):

$$\text{Potential amount of forage dry matter} = 6.4601 \times \text{land area of tons/dry matter/year}$$

Dry matter of feed means that the result of the division of fractions derived from feed ingredients after deducting the water content. Based on Afrizal et al. (2014) shows that one adult cattle are the same as one animal unit. However, since the data on the population of each cattle in each district was a mixture of male, female, heifer, and calf, therefore one cattle is assumed to be equal to 0.7 animal units (Santoso and Prasetyono 2020). Minimum feed requirement for cattle is 1.8 tons of dry matter production (DMP) per animal unit per year (Santoso and Prasetyono 2020). Potential forage in dry matter production (column b) is $6.4601 \times \text{land area}$ (column a) tons of DMP/year (Juarini et al. 2011). The formula for calculating the carrying capacity of cattle is potential forage in dry matter production or column b (tons of DMP/year) is divided by 1.8 tons or minimum cattle feed requirement (Suhaema et al. 2014 and Yuniar et al. 2016 cited by Santoso and Prasetyono 2020; Silaban et al. 2015 cited by Firman et al. 2018).

RESULTS AND DISCUSSION

Social-ecological system of Bali cattle raising in Timor Island

Our study has identified all the systems that interact within the social ecology systems (SESs) in the Bali cattle rearing in the island of Timor and systems outside the SESs that also affect the SESs. The results of the identification and exploration of Bali cattle raising using the SESs approach can be articulated as in Figure 2. The image was modified from the SESs disclosed by Ostrom (2009) adjusted to the results of the study..

According to Ostrom (2009), in these SESs, all subsystems interact and influence each other: resources systems, resources units, governance systems, and users. This indicates that there is a coherence between humans and nature, where the social and ecological systems are interrelated or mutually connected and integrated. In the study areas, (i) the resource system is grazing land in the form of savannas and steppes as well as river flows, (ii) resource units in the form of plants, trees, and forages that can be used for animal feed, and Bali cattle that live in the savanna and steppes, (iii) the governance system is an unwritten rule: e.g., boundaries of ownership of savanna

and steppe lands, as well as a sign of cattle ownership on a cow's thigh, that has been mutually agreed upon and passed down from generation to generation, and (iv) the users are farmers who use the savanna and steppe land to raise Bali cattle. The outcome as a result of the interaction between subsystems is the sustainability of the resources system in the provision of animal feed and an increased population of Bali cattle which is then utilized by the cattle market system. The government issues policies to maintain supply and demand for live cattle through provincial government regulations.

Resource system

The results of the study found two sources of reserves in the resource system, namely grazing land in the form of savanna and steppes, and rivers. The existence of grazing land is the main requirement for raising Bali cattle on the island of Timor and the existence of land is an important resource for the life of Bali cattle and the resource units on the land (Arnoldus et al. 2019). Most of the grazing land on the island of Timor is in the form of savanna and steppe areas which is quite large. The existence of this land is used as a potential animal feed provider for cattle. Kupang District has a very large extent of grazing land, therefore the capacity for cattle farming is larger than the Timor Tengah Utara District and Kupang City (Table 1, Figure 3). The extent of grazing land can be positively correlated with the number of cattle that can be grazed (see Table 2).

Unfortunately, the island of Timor has a hot climate with air temperatures range between 21 - 42 C, where Kupang City has the highest average level of air temperature. This is also supported by very low annual rainfall between 85-139 mm per year. The river flows are very important for the life of living things such as plants, trees, and animals. Kupang District has the highest number of rivers which provides an opportunity for more water reserves compared to others. Figure 3 shows the situation in the savanna and steppes during the dry season between April to December. The picture was taken in October 2019.

Resource units

According to Ostrom (2009), resource units are plants and animals that grow in the resource system. In the context of study, the plants that grow on the savanna and steppes include weeds/wild grass or forages, shrubs, calliandra, *Leucaena leucocephala* (known as lamtoro), *Gliricidia sepium* (known as gamal), *Sesbania grandiflora* (known as turi), various banyan (*Ficus benjamina*), Indian jujube (known as bidara), ambarella tree (known as kedondong), *Garcinia atroviridis* (known as asam gelugur), *Acacia leucophloea* (known as kabesak or pilang), kapok tree (*Ceiba pentandra*), and *Hibiscus rosa-sinensis* (known as kembang sepatu). The results of this identification are one of the novelties that we found from forage plants that grow in savanna and steppes. Some of the pictures of these plants can be seen in Figure 4.

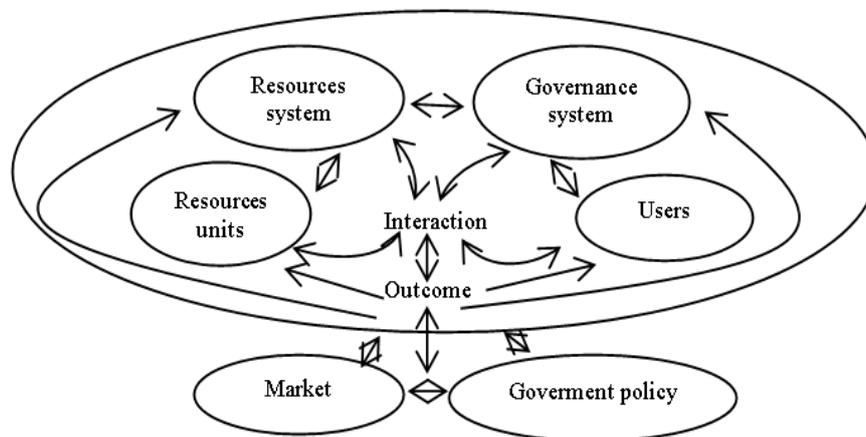


Figure 2. The social-ecological systems in Bali cattle raising (modified from Ostrom 2009)

Table 1. Grazing land, air temperature, and rainfall in the studied areas in Timor Island, East Nusa Tenggara, Indonesia

Districts	Potential area of grazing land (hectares)	Air temperature range (°C)	Average rainfall (mm per year)	Number of rivers as water reserves
Timor Tengah Utara	178,727	26 - 32	85	5
Kupang	331,850	21-34	94	8
Kupang City	3,564	35 - 42	139	1

Source: Central Statistics Agency East Nusa Tenggara Province (2020)

Table 2. Potential availability of forage feed and cattle capacity in each district/city

Districts	Potential area of grazing land (ha)	Forage potential in dry matter (tons/dry matter/year)	Carrying capacity of cattle (animal units)	Cattle population in 2020 (animal units)	Potential remaining capacity (animal unit)
Timor Tengah Utara	178,727	1,154,594	641,441	129,511	511,930
Kupang	331,850	2,143,784	1,190,991	203,807	987,184
Kupang City	3,564	23,024	12,791	6,095	6,696



Figure 3. Grazing land in Timor Island, East Nusa Tenggara, Indonesia: A. Kupang District, B. Timor Tengah Utara District



Figure 4. Vegetation in savanna and steppes on the studied areas in Timor Island, East Nusa Tenggara, Indonesia: A. Shrubs, B. Weeds, C, Lamtoro or *Leucaena leucocephala*, and D. *Calliandra calothyrsus*



Figure 5. Bali cattle in the studied areas in Timor Island, East Nusa Tenggara, Indonesia: A. Male, B. Female

Based on the area of grazing land (Table 1), the amount of available forage feed in the form of dry matter can be calculated. The availability of forage is to predict the number of cattle capacity in each district/city. The result for the availability of forage and the carrying capacity of cattle from each district/city can be seen in Table 2. Kupang District has a large enough capacity for cattle so that the potential for additional cattle is still available as many as more than 500,000 animal units. Meanwhile, Kupang City has the smallest capacity, which is only 12,791 animal units and the potential for additional cattle is only 6,696 animal units. Agricultural and grazing lands in Kupang City are very limited because their areas have been converted into settlements. However, there are still agricultural and grazing lands on the border area with Kupang District and along the coast that can be used for grazing Bali cattle. Semi-intensive farming system is an alternative choice of farmer to raise Bali cattle in Kupang City. Using this system, Bali cattle are released in the morning (07.00 am) from the paddock to the grazing land, during the day controlled by the farmer, and then the cattle are herded back to the paddock in the afternoon (16.00 or 17.00). According to Table 2, the Provincial Livestock Service Office can focus on increasing population of Bali cattle in the Kupang District and the Timor Tengah Utara District, while the City of Kupang is focused on holding areas for Bali cattle that are ready to be marketed outside the province.

Another resource unit is cattle. The existence of beef cattle raising in the island of Timor has been carried out for a long time and ingrained with agricultural life. Bali cattle was introduced on Timor Island in 1912 by the Dutch colonial government and concentrated on island of Timor since 1919 (Thalib 2002). The success of Bali cattle in adapting to the island of Timor is due to the regional carrying capacity, such as the availability of forage (grass and legumes) and the abundance of savanna and steppe areas (Priyanto 2016; Firman et al. 2020). Bali cattle dominate animal population in the savanna and steppe. Generally, farmers release Bali cattle to live wild in the savanna and steppes. There is no territorial limit for a herd of cattle from one family's ownership to explore other areas that are owned by another family. The characteristic that can distinguish Bali cattle belonging to one family from another is the family mark on the cattle's thigh. The pictures of female and male Bali cattle can be seen in Figure 5.

The results of discussions and interviews with cattle farmers in the studied areas, there are three cattle raising systems implemented by farmers, namely the extensive, semi-extensive, and intensive system. The extensive system is the system for raising cattle that are grazed in the grazing fields as long as they are kept, especially in areas where natural resources such as pastures, steppe and savanna (Rauf et al. 2015; Nastic et al. 2017). More than 80% of farmers raise beef cattle with a grazing system in savanna and steppe. The average farmer has more than 50 beef cattle consisting of bulls, cows, heifers and calves with grazing fields covering an area of more than 20 hectares. Each cattle has a mark/stamp on its thigh as a sign of

ownership in one of the family farmers. With this extensive system, farmers leave all their maintenance to nature. It means that cattle develop naturally and have very little treatment from farmer (Firman et al. 2020). Based on observations and in-depth discussions with informants, the extensive system occurs in Bali cattle rearing (Matondang and Rusdiana 2014).

A semi-intensive system is conducted by releasing the cattle in the morning to evening and at night the cattle are herded to the paddock. Only 15% of farmers use this system in districts of Kupang and Timor Tengah Utara (sources of information from the Livestock Service Office staff of the Kupang district and Timor Tengah Utara in 2019). Then, the last raising system is intensive system. The system has been introduced by Livestock Service Office of East Nusa Tenggara Province since 2015. Intensive system is the raising of cattle that are kept in cages continuously and farmers are more involved in this system, especially in the term of feeding, cage cleaning, disease handling and bathe livestock (Suryana 2009; Volkandari et al. 2020). The local government has promoted the system for fattening purposes because only farmers meet the criteria will be assisted by local government to get financial access. It is predicted that less than 5% of farmers use this system, especially in Kupang District and Kupang City (Personal communication, 2019). The extensive system is mostly carried out by farmers because farmers are not too involved in maintenance. Livestock maintenance is more emphasized on natural friendliness in providing a source of feed for livestock. Extensive systems are also carried out in the Sub-Saharan region, especially in the dry and semi-arid zones with rainfall rates of less than 600 mm per year (Otte and Chilonda 2002).

In the studied areas, the productivity of Bali cattle on grazing land in the East Nusa Tenggara is largely determined by the season. This area is very famous for its long dry season, which reaches 8-9 months. Bali cattle productivity on grazing land is determined by average daily gain. The average daily gain of Bali cattle on grazing land without additional feed is between 60-175 grams/head/day (Widahayati 2010; Imran et al. 2012). However, the average daily gain of Bali cattle increases 0.6-0.7 kg/head/day with additional feed (Mastika 2002). Bali cattle are among those with a good carcass percentage. The percentage of carcass produced by Bali cattle ranges from 50-52% of body weight (Ismail et al. 2014).

Governance system

Based on the results of discussions with several informants of farmers, the governance system applied in the Bali cattle farming in the studied area is in the form of unwritten rules in the management of grazing land to regulate the resource system owned by each farmer. This arrangement is made for each farming family to understand the rules that have been passed down from generation to generation. Therefore, there are no grazing boundaries, such as fences, on each of their lands. However, they have land boundary characteristics for each farmer, such as banyan trees or other signs. The sign of the boundaries of

the land has been known by each farmer and his family. Likewise, with the cattle they own, each farmer has a stamp of ownership on the thighs of the cattle that they have by giving a certain mark. The stamping is done when the cattle reach 1 year old. Each farmer already knows the stamp on each farmer, even though in the field one group of cattle will unite with another group of cattle. If there is a cow that gives birth to a calf that does not yet have a stamp on its thigh, it has been agreed that if the calf follows its cow, the calf becomes the property of the family that owns the cow.

Therefore, every rule or norm made by the farmers is intended to avoid misunderstandings about the resources that are cattle and the land their own. Generally, these rules or norms are made unwritten rules, but every family knows the unwritten rules and is informed from generation to generation. Norms are unwritten rules that are made to be obeyed because they are considered noble and sacred to the community (Demmalino et al. 2021).

Users

In the context of the study, users are individuals or companies that carry out activities on grazing land. The results showed that most of the farmers engaged in grazing land. Cattle and grazing land are very important sources of capital for the livelihoods of farming communities (Liu et al. 2018) on the island of Timor. Specifically in the Kupang District and Timor Tengah Utara District, the range of grazing land ownership is between 20 - 100 hectares per farmer and the number of cattle kept is 50 - 150 heads (Table 3). Generally, farmers have formal education up to elementary school and the number of family members is dominated by 1-5 family members. Bali cattle rearing contributes 50-60% to the family income of farmers and the rest comes from agriculture, labor, and others.

Bali cattle has been carried out for quite a long time on the island of Timor. The activities have been done from generation to generation. The relationship or interaction between farmers, cattle, and grazing land has been creating for quite a long time because farmers respect and protect their environmental resources. The results of discussions with informants, farmers tend to renew forage resources for cattle, namely by planting lamtoro trees (Figure 6). This tree is very resistant to hot climates and its leaves can be eaten by cattle (Revell et al. 2019). The friendliness of the agricultural community towards nature and the environment is indigenous knowledge. This local wisdom has been able to maintain and develop Bali cattle on the island of Timor. Indigenous knowledge is a key for sustainable agriculture (Nnadi et al. 2013). Some

indigenous knowledge that blend into the culture of Timorese community (dominated by the Timorese and Dawan tribes) to sustain Bali cattle rearing, such as (i) the male must give 1 to 3 bulls to the female family before the wedding celebration, (ii) in both tribes it is known as a patrilineal system where the wife will releasing his surname to the husband's clan, then the husband must hand over 1 bull to the woman's family, and (iii) after the funeral of the deceased, the family must provide beef food to the guests who are mourning the deceased's family. In addition, cattle are also used as a source of savings and sacrificial animals (especially for Muslims). Therefore, traditional and religious activities are part of the sustainability of Bali cattle rearing and also have an economic value for beef cattle farmers.

Market

The potential market for live cattle in East Nusa Tenggara can be divided into two markets, namely the domestic and inter-islands or outside of East Nusa Tenggara Province (Roy et al. 2019). According to Livestock service of East Nusa Tenggara (2020), the live cattle demand for domestic market is relatively large, which is over 68 thousand heads of slaughter per year. Meanwhile, the inter-islands demand for live cattle has increased from year to year. Therefore, the average expenditure of live cattle for domestic and inter-island reaches 135 thousand heads per year. It was also reported that the live cattle trade for domestic and inter-island levels in the districts of Kupang and Timor Tengah Utara, as well as Kupang City is as shown in Table 4. Based on Table 4, live cattle sales outside the province were higher than the demand for live cattle at the domestic level. This could be used as evidence that the island of Timor is a supplier of live cattle outside the province.

Table 3. Identification of cattle farmers as informants in study areas

Identification	Criteria	%
Ages	15 ≤ 40 years old	20.00
	> 40	80.00
Formal education	≤ elementary school	93.33
	> elementary school	6.67
Cattle ownership	50 - 100 heads	66.67
	> 100 heads	33.33
Family members	1-5 persons	20.00
	> 5 persons	13.33

Note: n = 15 informants

Table 4. Number of live cattle trade in domestic and inter-island markets, in the districts of Kupang and Timor Tengah Utara as well as Kupang City, 2018-2020

Districts	2018		2019		2020	
	Domestic	Inter-Islands	Domestic	Inter-Islands	Domestic	Inter-Islands
	(heads)					
Kupang	12,950	18,500	12,950	18,500	12,250	17,500
Timor Tengah Utara	11,316	18,860	10,811	18,560	5,100	8,530
Kupang City	345	300	210	300	245	200

Source: Livestock service of East Nusa Tenggara Province (2020)

The market demand for live cattle, both domestic and outside the province, provides an indication of market guarantees for beef cattle farmers. This market guarantee provides economic value for farmers in their efforts to carry out breeding management, livestock raising, and cattle business sustainability, especially Bali cattle. According to Naidoo (2008), economic valuation plays an important role in the economic value of biodiversity in developing countries. Economic value of biodiversity is included use values and non-use values (Demir 2013). Therefore, the total economic value (Kumar 2010 cited by Matthew et al. 2019; Niesembaum 2019) generated from breeding and raising Bali cattle is the sum of domestic and export cattle sales, the need for traditional and religious ceremonies.

Government policy

Another element that plays a role in the working of the social-ecological systems in Bali cattle raising is government policy. The local governments (in this case are the Livestock Service Office at the provincial and district levels) have a role in regulating the interaction among these systems. The results of discussions with livestock service staff at the provincial and district levels stated that the government made several program interventions for the sustainability of Bali cattle, namely the provision of Bali cattle bull, artificial insemination, strengthening forage feeds especially the lamtoro (*Leucaena leucocephala*) tree planting program, and providing water sources in grazing fields. The discussion at Provincial Livestock Service Office was directed at strengthening Bali cattle raising and improving the feed environment using local government expenditure (Nyamushamba et al. 2017).

In the context of supply and demand for live cattle, the provincial government issued Governor Regulation No. 78 of 2019 concerning control of the entry, export and distribution of livestock, animal products and their associated products in East Nusa Tenggara Province. This regulation regulates the entry and exit of livestock and livestock products to and from the province. Especially for live cattle trade, the regulation states that some of the criteria that must be met so that cattle can be exported out of the province are: the cattle being sold are bulls with a minimum weight of 275 kg for Bali cattle, productive cows are prohibited to trade even in the domestic or export market, and traders must build partnerships with farmers in order to farmers get marketing certainty and granted by traders. One of the objectives of this regulation is to save Bali cattle germplasm in the province of East Nusa Tenggara.

The opinion of inter-provincial traders said that it was very difficult to fulfill all the criteria in the governor's regulation because generally the bulls raised by farmers rarely reached weight above 275 kg for Bali cattle. In addition, traders cannot guarantee the market continuously because it depends on the demand for live cattle outside the province. Therefore, traders directly buy cattle from farmers with cash according to market demand. However, they will gradually comply with all the criteria set out in the rules.

It can be concluded from this study that the interactions among systems within SESs, such as resource systems, resource units, governance systems, and users encourage the sustainability of Bali Cattle raising in the island of Timor. The research demonstrates the ability of a social-ecological systems framework in identifying feed resources in savanna and steppe in the island of Timor. The island is still able to increase the population of Bali cattle because the carrying capacity is still quite large. Farm families, as users, have made unwritten rules that other families have understood from generation to generation to protect their livestock and land. Market is one of the economic valuations in Bali cattle raising.

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