



An Exploratory Study of Beef Cattle Farming Systems: A Comparative Analysis of Cut and Carry in Java vs. the Pastoral System in Sumba Island, Indonesia

(Studi eksploratif pada sistem pemeliharaan sapi potong: analisis komparatif pada sistem cut and carry di Jawa dengan sistem penggembalaan pastura di pulau Sumba, Indonesia)

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ABSTRACT. This study aims to explore the differences between beef cattle farming systems in Java and Sumba. The research was conducted using a survey method in three districts, two districts in Central Java and one district in Sumba Island, NTT. Data analysis used a descriptive qualitative approach, with the CATWOE Analysis framework to determine the perspectives of stakeholders involved in the beef cattle farming business system. Beef cattle farming in Java has been characterized by a cut and carry system, while in Sumba with a pasture grazing system. The research shows that the main purpose of cattle rearing in Java is to generate income for the family, so more and more are running enlargement and fattening businesses. Cattle rearing in Sumba is prioritized for savings for traditional purposes. Farmers in Sumba predominantly breed cattle without additional feed to save on maintenance costs. Farmers are still faced with the problem of unfairness in pricing. The study concluded that farmers show adaptive ability in allocating their resources to obtain profits. Differences in farming paradigms need to be considered in the preparation of livestock development programs.

Keywords: beef cattle, CATWOE analysis, cut and carry, pasture

ABSTRAK. Peternakan sapi potong di Jawa selama ini dicirikan dengan *cut and carry* sistem, sedangkan di Sumba dengan sistem penggembalaan di pastura. Penelitian ini bertujuan untuk melakukan eksplorasi lebih mendalam tentang perbedaan sistem usaha peternakan sapi potong di Jawa dengan di Sumba. Penelitian dilakukan dengan metode survey di tiga kabupaten, dua kabupaten di Jawa Tengah dan satu kabupaten di Pulau Sumba, NTT. Analisis data menggunakan pendekatan deskriptif kualitatif, dengan kerangka CATWOE Analysis untuk mengetahui perspektif dari para stakeholders yang terlibat dalam sistem usaha peternakan sapi potong. Penelitian menunjukkan bahwa tujuan utama pemeliharaan sapi di Jawa adalah untuk menghasilkan pendapatan untuk keluarga, sehingga semakin banyak yang lebih menjalankan usaha pembesaran dan penggemukan. Pemeliharaan sapi di Sumba lebih diutamakan untuk tabungan untuk keperluan adat. Peternak di Sumba didominasi pembiakan sapi tanpa tambahan pakan untuk menghemat biaya pemeliharaan. Peternak masih dihadapkan pada permasalahan ketidakadilan dalam penentuan harga. Penelitian menyimpulkan bahwa peternak menunjukkan kemampuan adaptif dalam mengalokasikan sumber daya yang dimiliki untuk memperoleh keuntungan. Perbedaan paradigma beternak perlu untuk diperhatikan dalam penyusunan program pembangunan peternakan.

Kata kunci: CATWOE analysis, cut and carry, penggembalaan, sapi potong

INTRODUCTION

Beef farming in Indonesia is crucial to the country's meat production. However, it is a complex and constantly changing industry, mainly due to the dominance of smallholders. Approximately 6.5 million rural farmers engage in beef farming, which accounts for around 90% of the country's total cattle production. Smallholder beef cattle farming is a significant part of the industry (A. Agus & T. S. Mastuti Widi, 2018).

However, smallholders' productivity tends to be low which is often caused by inadequate feeding, disease, and limited use of production technology (Hadi *et al.*, 2002; Patrick, Marshall, Ambarawati, & Abdurrahman, 2010). In 2022, the beef cattle population in Indonesia is about 18.6 million head, which increased from 17.4 million head in 2020. Nevertheless, this population is unevenly distributed across the country. The majority of beef cattle in Indonesia are found in Java, accounting for 42% of the national population. The eastern region of the country follows with approximately 35% (Statistics Indonesia, 2023a).

The demand for beef in Indonesia is increasing steadily at a rate of approximately 4%

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per year (Ali Agus & Tri Satya Mastuti Widi, 2018). Domestic beef only supply 45% of the total national demand (Bremer *et al.*, 2022). Increased human population, changing consumer food preferences and consumption patterns plays significant role in boosting food demand (Hovhannisyan & Devadoss, 2020). Human population is projected to exceed 278 million in 2023 steadily increases from 255 million in 2015, from which more than 50% of the country's population live in Java Island. This makes Java the most densely populated island in the country, with more than 1.000 persons per kilometer square (Statistics Indonesia, 2023b). As the major consumers of country's beef, Java need to import live cattle from the eastern Indonesia. Sumba island is one of the major suppliers of live cattle to Java.

Due to limited land area, smallholders in Java commonly use the zero-grazing feeding system for their cattle, known as cut and carry system. The cut and carry system are widely adopted by smallholders who have limited land area. The cattle are kept in sheds, and the farmers get grass from various sources such as forests, fallows, rangelands, roadsides, wastelands, and cultivated areas after harvest. They carry the grass to their cattle for feeding on daily basis (Devendra, 2007). Therefore, the cut and carry system is considered as labor intensive farming. Consequently, the cattle ownership per farmer tends to be low due to the limited ability to provide daily forages. This practice requires sufficient knowledge of the farmers to determine the types of forages, the quality, and the required amount of forages per day.

Contrasted to Java, the human population density in Sumba is one tenth of in Java, therefore Sumba still have sufficient land area to support beef farming. The Sumba people rely heavily on livestock for their livelihood, as various religious and local ceremonies require animals for both meat and other purposes. Due to the vast area available for pasture, most of beef farmers in Sumba are pastoralist. Within pasture farming, cattle are mostly and, in many cases, always, graze in the pasture with very little or even without any feed supplementation. Consequently, pasture management become essential element contributed to farming success. Pasture farming requires less labor, therefore farmer are able to handle more cattle as compared to cut and carry system. However, without proper pasture management, the pasture farming system is regarded as fragile to social conflict and lead to

the degradation of the pasture quality, which will further affect the farming productivity.

The importance of this study lies on its effort to identify and explore how the cut and carry as well as pasture farming systems work. The first step to tame the complexity of a system towards system analysis is to canvas the everyday activities of the farming. This article aims to explore the systems of beef farming in Java and Sumba Island. Systems thinking perspective was used to analyze the complexity of the systems. In systems thinking perspectives, dynamics of the beef farming in Sumba will have effect on the beef farming in Java.

MATERIALS AND METHODS

Participants and Sampling Technique

The study has been undertaken in two different farming systems; zero grazing and pastoral system. Zero grazing beef farming systems represented by farmers in Kabupaten Banjarnegara and Kabupaten Banyumas in Central Java Province, whereas pastoral farmers are represented by farmers in Kabupaten Sumba Barat Daya in East Nusa Tenggara province. Cluster sampling has been employed to select the sample from which 45 farmers were selected; 30 farmers of zero grazing farming, and 15 of pastoral farming system. Zero grazing involves keeping cattle in a confined space, such as a barn or feedlot, and providing them with feed and water (Greenwood, 2021), therefore it also known as cut and carry system. Pastoral system refers to keeping cattle on pasture or rangelands, where they graze on natural vegetation. It is a traditional farming system that has been used for centuries in many parts of the world (Oosting *et al.*, 2022).

Research Design and Data Analysis

This study utilizes a qualitative approach based on systems thinking design. Systems thinking is a holistic approach that considers the entire system, rather than just its individual components (Arnold & Wade, 2015; Setianto, Hidayat, & Yuwono, 2019). It is crucial to take into account all relevant factors when assessing products or actions to avoid making decisions that do not fully consider the complexity of production systems and the potential consequences of those decisions. Failure to do so can result in serious oversights and unintended negative impacts (Bremer *et al.*, 2022). The steps of the research were as follows: 1) Identify the daily activities of the farmers which includes other activities outside

beef farming, the resources available related to the activities, and the pressures related to the activities and resources. 2) Investigating the problematic situations of the beef farming systems. 3) Structuring the identified problematic situations. A combination of direct observation, semi structured interviews, and series of focus group discussions have been conducted to understand the complexity of the beef farming systems.

Analysis of the mental model was developed based on CATWOE analysis of the Soft System Methodology (Ackermann, 2012). The goal of the analysis is to identify how the systems works and sustain. The CATWOE analysis can be used in beef farming to analyze the big picture of the business and make decisions and define strategies. The six factors studied in the CATWOE analysis are: 1) Customers: The average beneficiaries' profile, their needs, and preferences. 2) Actors: The players in the process, including suppliers, employees, and partners. 3) Transformation: The transformation at the core of the system, such as the production process. 4) Worldview: The beliefs, values, and attitudes that shape the farming. 5) Owners: The biggest owners, their agreement, and any problems. 6) Environmental: Everything related to environmental issues, such as the impact caused by the company, policies, opportunities, and threats.

RESULTS AND DISCUSSION

Overview of the System

The study was conducted in three distinct locations: Kabupaten Banyumas and Banjarnegara in Central Java's Java Island, and Kabupaten Sumba Barat Daya in Sumba Island's East Nusa Tenggara Province. Java Island is known for its high population density, with more than 1000 people per square kilometer. This poses a challenge for beef farmers in Java, who have limited space for forages and often face shortages. As a solution, many farmers have turned to fattening beef (N. A. Setianto, D. C. Cameron, & J. B. Gaughan, 2014), which requires less forage and generates income more quickly. Cattle in Java are often raised in mixed farming systems where they are integrated with crops like rice, corn, and soybeans (Widyas *et al.*, 2022). Most of the beef farmers in Java are smallholders with farm size ranged between one to five heads per farmer. Australian commercial cross dominates the breed.

This is due to several reasons as follows: plenty of steer available in the market, well-adapted to concentrates, and considered to have a better gain weight.

Meanwhile, Sumba Island in East Nusa Tenggara boasts ample land area that supports pastoral systems. Cattle in Sumba graze freely on natural, unimproved common pasture area. In some area the cattle were herded during the day and are penned at night for safety (Mayberry *et al.*, 2021). In fact, East Nusa Tenggara is a major supplier of live cattle to Java (Jefirstson Richset Riwukore, 2020). Sumbanese farmers prefer the cow calf operation in traditional pasture areas, without the need for additional feed, in order to minimize costs. The local Sumba Ongole dominates the breed as it have been well adapted to the local environment.

In the level of thinking, all those observable elements lie on the tip of the iceberg of the systems thinking hierarchy. In order to deepen the understanding of the systems, this study used CATWOE analysis. Participatory approach was used to obtain perspectives from farmers, local government, and cattle traders.

CATWOE Analysis

CATWOE analysis endorse multi stakeholders' perspectives which include the perspectives of the customers of the systems, the actors, and the owners of the systems. CATWOE Analysis were used to investigate the situations of the beef farming systems in both locations as shown in Table 1. CATWOE helps to identify the key players and beneficiaries and brings together the various perspectives which helps analysts carefully assess how any intervention will affect the systems performance. The result of CATWOE analysis is presented in Table 1.

The household head is responsible for all farming activities, including the allocation of farming resources. As for education, in Java approximately 40% of household heads have finished elementary school (year 6), nearly 25% have completed junior high school (year 9), while the remaining members have obtained a higher level of education (year 12 or more). Farmers in Sumba less-exposed to formal education. Most of the farmers finished elementary schools. Education helps farmers to adopt and adapt to the new technology (Paltasingh & Goyari, 2018). The finding suggest that farmers need to be facilitated by extension services to improve the productivity.

Table 1. CATWOE analysis of beef farming system

Element	Java	Sumba
Customers	Farmers household, cattle traders, government.	Farmers household, cattle traders, government.
Actors	Farmers.	Farmers.
Transformation	Raise cattle to generate cash, dominated by fattening.	Herd cattle as saving for cultural needs and generate cash, dominated by breeding.
Worldview	Fatten the cattle to gain revenue for the household. Revenue stream become one of the most important indicator of farming success.	Way of life, saving for immediate need which mostly for social and cultural ceremonies. Ability to fulfill the cultural obligation become one of the most important indicator of farming success.
Owners	Head of the groups, farmers.	Head of the groups, farmers.
Environment	Zero grazing, forages shortage, price uncertainty, access to fair market, pricing policy, forages are dominated by cultivated grass.	Untreated natural pasture, grazing competition, nutrient sufficiency, social conflict, cattle theft, forages sources rely solely in the pasture.

In both locations, almost 70% of households, agriculture was the primary source of income, with livestock serving as a secondary source. However, in Sumba, although livestock is serving as secondary source of income, the primary function of livestock is to fulfill the social and cultural needs of the community. Cultural ceremonies in Sumba often involve the slaughter of numerous animals, including buffaloes, pigs, cattle, goats, and poultry. Typically, two to five livestock are slaughtered for each ceremony, which is significantly higher than the number slaughtered in Java. Additionally, it is customary to give animals as gifts at weddings or as a sign of respect at funerals. The number of animals slaughtered is often indicative of one's social status in the community (Delon, 2018).

In Java, agriculture was the income generating activity for farmers. Agriculture in this case includes a wide range of activities, such as rice cultivation, corn farming, groundnut cultivation, soybean farming, and fish farming. Due to the limited land, farmers commonly grow two or three types of crops on the same plot of land, such as rice with corn, soybeans, or fish farming, or fish ponds with chili and sweet potatoes. Rice was the primary crop produced, and the land could be cropped three times a year with different crops, such as rice-rice-corn/groundnuts or rice-corn/groundnuts-rice. In case of predicted dry weather, the farmers would opt for rice-groundnuts-corn. These activities support the argument that farmers are efficient in allocating their limited resources (Ubabukoh & Imai, 2023).

In Sumba, agriculture was not only the income generating activity, but also for subsistence need, particularly corn. Farmers kept their corn to secure their household need for staple food for at least six month of corn stock. This practice has been passed over generation as a

strategy to survive during dry season. Commonly, traditional house in Sumba has three floors. First floor which is the ground floor mainly used for storage and keep the animal, such as pig, goat, and poultry. The second floor made from timber or bamboo is the living area for the household, and the third floor is used as storage to keep the food such as corn or dried cassava. The practices of the local to secure the food for the family. However, the next thing that should be considered to ensure the whole family receive balanced nutrient (Sibhatu & Qaim, 2017).

Agriculture was deemed crucial for household security by farmers, who strategically combined various commodities to ensure a steady food supply. Livestock has important role in the livelihoods of farmers. Livestock have multi-faceted roles, not just for economy, but also social and cultural (Herrero *et al.*, 2013). In Java, a staggering 90% of farmers considered rice the most vital product for their household. Livestock, on the other hand, were primarily raised for commercial purposes rather than personal consumption, making beef a rare commodity on farmers' tables. On the contrary, in Sumba, livestock was primarily raised for cultural purposes rather than economic reasons. The community consumed meat during cultural ceremonies, and raw meat was brought over for the family. These local wisdom practices ensured protein intake for the communities. It was clear that livestock play important roles in rural household.

Regarding to the source of income. Agriculture was the primary source of income for the farmers both in Java and Sumba, as it provided a relatively consistent income due to its seasonal pattern. Although cattle could bring in large amounts of cash instantly, it was not considered the primary source of income as it could not

provide regular income. Only less than 30% of farmers sold their cattle regularly, usually around 3-4 times a year. In most cases, farmers sold their cattle only twice a year, during the peak seasons in Indonesia which are the Idul Fitri and Idul Adha feasts. Whereas in Sumba, cattle primarily serve as a household buffer for cultural needs and school expenses. However, social and cultural needs is more prioritize than economic or education.

Based on the results, it can be inferred that smallholders prioritize household food security above all else. Consequently, they assess all of their activities based on their potential to contribute to household food security. Any other endeavors that generate income, such as livestock or fish farming, are viewed as supplementary. In terms of labor allocation, less than a quarter of households utilize family labor aside from the household head. The household head is the primary labor source, and if additional labor is required, external labor is employed. This is largely due to the fact that most of the farmers' sons are not inclined to work on the farm.

The Farming

Within the beef farming industry, farmers generally pursue one of two types of farming, namely breeding or fattening, depending on their specific objectives. Breeding aims to produce calves, with cows serving as a means of household security or savings. The primary focus is not on generating consistent income. During this process, the sole feed provided to the livestock is forage and/or rice straw, without any additional concentrate. In contrast, fattening focused on weight gain as the primary objective, with regular income being the main purpose of the farming. Fatteners viewed their cattle as an economic commodity, a regular source of cash, rather than as a means of saving. They commonly provided additional feed such as wheat pollard, rice bran, cassava starch, and/or coconut meal to increase weight gain.

For breeding purposes, a cow-calf operation typically prefers artificial insemination (AI) over natural insemination. AI using exotic breeds such as Simmental and Limousine is preferred as it produces a better-priced calf. This is made possible by the availability of AI services in all sub-districts, which enables cows to be inseminated without delay.

Currently, farmers in Java have shifted their preference towards fattening rather than breeding. This trend has been confirmed by discussions with

inseminators and data from the local livestock service office. The shift is attributed to several factors such as the increasing importance of cattle to farming households and farmers' knowledge and skills, particularly in relation to feed composition and preservation. However, the primary reason is that farmers believe that fattening is more profitable than breeding. This shift is likely to have some consequences. According to farmers, the significance of cattle has changed over time. Initially, they were considered a social instrument that helped save and provide security, but now they are seen as a source of income. This transition was confirmed by 88% of the farmers.

In Sumba, cattle were considered as saving and security tool as well as for social status. Farmers did not have a regular selling plan and would sell their cattle whenever they needed immediate cash. As a result, these farmers tended to be insensitive to price changes. More than 85 percent of the interviewed farmers reply that they prefer cow-calf operation as opposed to fattening. Cow-calf considered as cheaper operation than fattening.

Usually, farmers who tend to depend on the sale of their cattle for their livelihood sell their cattle two to three times annually. However, as most of these farmers operate on a small scale and have limited financial resources, they are highly affected by fluctuations in the price of cattle. When the price of cattle increases, they tend to purchase more cattle, hoping to benefit from the upward trend. Conversely, when prices decrease, farmers are more likely to sell their cattle in fear of further losses (Aimin, 2010). This sensitivity to price can result in significant losses for farmers who are often subject to market forces that are beyond their control.

During interviews in Java, it was found that approximately 25% of the farmers were utilizing the cow-calf system, which involved breeding to some extent. These farmers belonged to a group that received a government grant which made breeding a compulsory practice. It was discovered through discussions with the group secretary, who was also responsible for cattle marketing, that the farmers preferred to purchase pregnant cows. Once the newborn calves reached the age of 6-7 months, both the cows and the calves were sold to purchase other pregnant cows. This allowed for a yearly cash inflow for the group while still following the program guidelines. Additionally, when asked about their preferences, the farmers stated that they preferred fattening. However,

since the cow-calf system was a requirement of the grant program, the group operated it to comply with the guidelines.

Regarding the feeding practices, all farmers in Java used the cut and carry system. Cut and carry system is a feeding system used in livestock farming where forages is cut daily and fed to housed cattle (Seruni, Aguilar, Cai, Gold, & Roshetko, 2021). The cattle were housed all year round, and fresh forage and rice straw were obtained daily from the surrounding areas. Farmers occasionally added supplements such as rice bran, onggok (a cassava starch processing byproduct), and/or wheat pollard. They had already grown *Pennisetum purpureum* (elephant grass) as a source of forage, but the amount was insufficient to meet their daily forage demands. Farmers had to cut the grass from the forest or the river bank, or use rice straw as a substitute, either fresh or ammoniated.

In the contrary, farmers in Sumba used extensive traditional pasture farming. The common pasture area is available and accessible for farmers all year round, but mostly during the rainy season. Within the common pasture area, cattle were competing with other animal such as horses, buffaloes and goats. All farmers have relatively large land area as compare to farmers in Java. However, as their land rely mostly from natural rainfall, the productivity is low. Therefore, during dry season as the agricultural activity ends, and farmers used their fallow land as private pasture. This practice highlights how farmers cleverly allocate their resources to maximize the benefit to the household.

The Market

Farmers in Java and Sumba have several options when it comes to buying or selling cattle, such as local cattle traders, local markets, or neighboring farmers. However, local traders are often the preferred choice due to their convenience and cost-effectiveness. By working with local traders, farmers can avoid the problem of transportation. The types of vehicles used for transporting cattle to and from the livestock market, including small pickups, medium pickups, light trucks, and trucks with a maximum load capacity of 3, 4, 8, and 14 cattle, respectively. The cost for transportation depends on the vehicle capacity. For local transport from or to the local markets which are mostly located less than 30 km from farms, the cost started from Rp150,000-200,000 for the small pickup, Rp200,000-250,000 for the medium pickup, Rp300,000-400,000 for

the light truck and Rp400,000-500,000 for the truck. By doing their transactions through local traders, farmers did not need to worry about the transportation cost.

In the cattle trade, pricing practices can be unfair towards farmers who often fall victim to inaccuracies in determining the weight of their cattle. This is due to the lack of reliable measurement scales, which forces traders to base their pricing estimates on the appearance of the cattle (N. A. Setianto, D. Cameron, & J. B. Gaughan, 2014). Unfortunately, this task is left solely to the traders, who possess the expertise and skill to accurately predict the body weight of the cattle just by examining their body condition. Consequently, farmers' cattle are often undervalued by traders, leading to unjust pricing practices in the trade. Therefore, in Java there are growing tendency to use the body weight as the fair pricing. The price is determined using per kg body weight. However, these practices is dominated by bigger farmers as it requires farmers to invest body weight scale.

Farmers often prefer purchasing cattle that they find appealing and sell them when in need of cash. The criteria for selecting these cattle are generally based on their physical appearance, such as color and body shape, which is more a matter of personal taste and preference than economic viability. This preference for good-looking cattle is rooted in the historical and social significance of cattle as not just a source of income, but also a point of pride for farmers. However, this approach can result in farmers overvaluing their cattle, particularly those that are aesthetically pleasing, leading to unfavorable buying and selling conditions for smallholders. Additionally, during the school entrance period, between June and August, when farmers require cash, traders tend to offer low prices, exacerbating the already difficult situation for farmers.

In the livestock market, both in Java and Sumba, cash transactions are the typical mode of payment as opposed to bank transfers. While a mobile bank unit is available on-site, most transactions are still conducted in cash. Despite the risks associated with cash transactions, traders contend that physical currency is more compelling than the mere figures on a bank form, enabling them to negotiate a better deal. Moreover, farmers find it more practical to have immediate access to cash on hand.

Within the livestock market, there was a notable broker-type individual referred to as a *tukang panteng*. Their primary responsibility was

to guide each animal upon arrival from the truck and engage in negotiations with farmers to determine a selling price. Typically, they would establish the initial price and then proceed to search for potential buyers while leading the cattle throughout the market. In exchange for their services, they would receive compensation equal to the variance between the final selling price and the initially agreed-upon price. This broker existed both in Java and Sumba.

CONCLUSIONS

Farmers in both locations have the capability to efficiently allocate their limited resources to gain optimum benefit for the household. The differences of beef farming systems in Java and Sumba could not be concluded based on the observable element such as the feeding system of cut and carry versus pastoralist. Deeper thinking level revealed that the farming motivation is also different. Farmers in Java are more practical, the paradigm is that cattle are a commodity which can produce income to the household, whereas in Sumba cattle is a way of life, an obligation of the culture to fulfill their social demand. This opposing paradigm need to be considered when designing an intervention program.

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REFERENCES

- Ackermann, F. (2012). Problem structuring methods 'in the Dock': Arguing the case for Soft OR. *European Journal of Operational Research*, 219(3), 652-658. doi:10.1016/j.ejor.2011.11.014
- Agus, A., & Mastuti Widi, T. S. (2018). Current situation and future prospects for beef cattle production in Indonesia - A review. *Asian-Australasian journal of animal sciences*, 31(7), 976-983. doi:10.5713/ajas.18.0233
- Aimin, H. (2010). Uncertainty, Risk Aversion and Risk Management in Agriculture. *Agriculture and Agricultural Science*
- Procedia*, 1, 152-156. doi:https://doi.org/10.1016/j.aaspro.2010.09.018
- Arnold, R. D., & Wade, J. P. (2015). A Definition of Systems Thinking: A Systems Approach. *Procedia Computer Science*, 44, 669-678. doi:https://doi.org/10.1016/j.procs.2015.03.050
- Bremer, J. A., Lobry de Bruyn, L. A., Smith, R. G. B., Darsono, W., Soedjana, T. D., & Cowley, F. C. (2022). Prospects and problems: considerations for smallholder cattle grazing in oil palm plantations in South Kalimantan, Indonesia. *Agroforestry Systems*, 96(7), 1023-1037. doi:10.1007/s10457-022-00759-2
- Delon, N. (2018). Social norms and farm animal protection. *Palgrave Communications*, 4(1), 139. doi:10.1057/s41599-018-0194-5
- Devendra, C. (2007). Perspectives on animal production systems in Asia. *Livestock Science*, 106(1), 1-18. doi:10.1016/j.livsci.2006.05.005
- Greenwood, P. L. (2021). Review: An overview of beef production from pasture and feedlot globally, as demand for beef and the need for sustainable practices increase. *Animal*, 15, 100295. doi:https://doi.org/10.1016/j.animal.2021.10.0295
- Hadi, P. U., Ilham, N., Thahar, A., Winarso, B., Vincent, D., & Quirke, D. (2002). Improving Indonesia's beef industry. *ACIAR Monograph*. Canberra: Australian Center for International Agriculture Research (ACIAR).
- Herrero, M., Grace, D., Njuki, J., Johnson, N., Enahoro, D., Silvestri, S., & Rufino, M. C. (2013). The roles of livestock in developing countries. *Animal*, 7, 3-18. doi:https://doi.org/10.1017/S1751731112001954
- Hovhannisyan, V., & Devadoss, S. (2020). Effects of urbanization on food demand in China. *Empirical Economics*, 58(2), 699-721. doi:10.1007/s00181-018-1526-4
- Jefirstson Richset Riukore, A. Y., Asnath Maria Fuah, Luki Abdullah, Rudy Priyanto, Bagus Priyo Purwanto, Priyo Purwanto and Yohanes Susanto,. (2020). Production Capacity and Beef Consumption in the

- Nusa Tenggara Timur Province, Indonesia. *Journal of Animal and Veterinary Advances*, 19(5), 38 - 42. doi:DOI: 10.36478/javaa.2020.38.42
- Mayberry, D., Hau, D. K., Dida, P. R., Bria, D., Praing, J., Mata, A. D., . . . Nulik, J. (2021). Herbaceous legumes provide several options for increasing beef cattle productivity in eastern Indonesia. *Animal Production Science*, 61(7), 698-707. doi:<https://doi.org/10.1071/AN20545>
- Oosting, S., van der Lee, J., Verdegem, M., de Vries, M., Vernooij, A., Bonilla-Cedrez, C., & Kabir, K. (2022). Farmed animal production in tropical circular food systems. *Food Security*, 14(1), 273-292. doi:10.1007/s12571-021-01205-4
- Paltasingh, K. R., & Goyari, P. (2018). Impact of farmer education on farm productivity under varying technologies: case of paddy growers in India. *Agricultural and Food Economics*, 6(1), 7. doi:10.1186/s40100-018-0101-9
- Patrick, I. W., Marshall, G. R., Ambarawati, I. G. A. A., & Abdurrahman, M. (2010) Social capital and cattle marketing chains in Bali and Lombok, Indonesia., *ACIAR Technical Reports* (pp. 78). Canberra: Australian Center for International Agriculture Research.
- Seruni, A. P., Aguilar, F. X., Cai, Z., Gold, M. A., & Roshetko, J. M. (2021). Parcelized Cut-and-Carry Agroforestry Systems for Confined Livestock. *Small-scale Forestry*, 20(1), 119-143. doi:10.1007/s11842-020-09460-7
- Setianto, N. A., Cameron, D., & Gaughan, J. B. (2014). Structuring the problematic situation of smallholder beef farming in Central Java, Indonesia: using systems thinking as an entry point to taming complexity. *International Journal of Agricultural Management*, 3(3), 164-174.
- Setianto, N. A., Cameron, D. C., & Gaughan, J. B. (2014). Everyday Flux of Smallholder Beef Farming: System Overview of the Beef Farming Situation Under a Government Grant. *Animal Production*, 16(1), 39 - 47.
- Setianto, N. A., Hidayat, N. N., & Yuwono, P. (2019). Modeling smallholder beef farming: a systems thinking's step by step approach. *IOP Conference Series: Earth and Environmental Science*, 247(1), 012013. doi:10.1088/1755-1315/247/1/012013
- Sibhatu, K. T., & Qaim, M. (2017). Rural food security, subsistence agriculture, and seasonality. *PLOS ONE*, 12(10), e0186406. doi:10.1371/journal.pone.0186406
- Statistics Indonesia. (2023a). Beef Cattle Population by Province. Retrieved September 03, 2023, from Statistics Indonesia <https://www.bps.go.id/indicator/24/469/1/populasi-sapi-potong-menurut-provinsi.html>
- Statistics Indonesia. (2023b). Mid-Year Human Population Retrieved September 3, 2023, from Badan Pusat Statistik
- Ubabukoh, C. L., & Imai, K. S. (2023). Are farmers 'efficient but poor'? The impact of crop choices on technical efficiency and poverty in Nigeria. *Journal of Agricultural Economics*, 74(1), 191-213. doi:<https://doi.org/10.1111/1477-9552.12501>
- Widyas, N., Widi, T. S. M., Prastowo, S., Sumantri, I., Hayes, B. J., & Burrow, H. M. (2022). Promoting Sustainable Utilization and Genetic Improvement of Indonesian Local Beef Cattle Breeds: A Review. *Agriculture*, 12(10), 1566.