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Smallholder Cattle Development in Indonesia: Learning from the Past for an Outcome-Oriented Development Model

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ABSTRACT

Despite numerous programs implemented for beef self-sufficiency in Indonesia, beef demand has steadily increased, while national beef production supplies only half of the national market demand. Smallholder farmers plays a pivotal role in beef sector since more than 90% of cattle production in Indonesia is developed by smallholder farmers. The paper aims to review and recommend a model for smallholder cattle development in Indonesia. The paper collected data from literature review and assess the trajectory of cattle development in Indonesia, focusing on recent national programs to increase the cattle population and how it evolved. The vast majority of cattle production is operated by smallholder farmers characterized by traditional practices and, heavily relying on nature as a feed source, have limited cattle production/productivity. Delivered cattle development programs have had little impact on increasing the cattle population and narrowing the domestic beef market demand gap. Efforts to increase small-scale livestock farming will narrow the supply-demand gap in the beef market and improve farmers' livelihoods. The paper highlighted that despite the implementation of national programs, the heterogeneous agroecological, socio-economic, and cultural conditions across regions should be considered in cattle development programs to achieve sustainable outcomes. Based on previous research for development initiatives, this recommendation is formulated into different models according to the cattle farming systems. Implication of these varying model is that development programs need to consider local conditions and no one-size-fits-all approach.

1. INTRODUCTION

From 2017 to 2021, beef meat imports increased by 70.75% or 14.15% yearly [1]. Waldron et al. [2] predict that the demand will continue growing until 2024, as high as 7% per annum. In 2021, the demand for beef was 700,000 tons, while national production could only meet 50% of it [3]. A lower figure of 45% national supply mentioned by Agus and Widi [4] indicates an even more yawning gap between national production to meet the demand. Basyar [5] argued that the Government of Indonesia's policy to stop beef cattle import from Australia in 2015 has widened the gap. The policy that initially aimed to allow local production to meet the national demand led to increased beef meat prices from US $7 to $9 in big cities like Jakarta.

The gap has consequences to the beef imports reaching US $785 million in 2021, and US $861.6 million in 2022 [1] which affects the foreign exchange reserves and threaten food security in Indonesia. Beef and live cattle imports have also demotivated local cattle farming due to uncompetitive market with imported beef meat which therefore deter farmers income from cattle enterprise, making it a less attractive business [6].

This condition subsequently leads to even a greater dependency on imported beef meat and live cattle.

To date, the beef cattle population accounts for around 18 million in the country, of which 42% are in Java, 20% in Sumatera, 18% in Lesser Sunda, 15% in Sulawesi, and the remaining in other islands of Indonesia [1]. Five main cattle-producing provinces include East Jawa 4.9 million, South Sulawesi 1.4 million, West Nusa Tenggara 1.3 million, East Nusa Tenggara 1.2 million and North Sumatera 0.9 million [1]. The vast majority (90%) of cattle production in Indonesia is operated by smallholder farmers [7]. Cattle ownership per household varies considerably depending on the farming system, between 2-3 head in an intensive cut-and-carry system to around ten head in an extensive grazing system. Three farming cattle systems are commonly practiced across the archipelago that is (1) an intensive cut-and-carry feeding system with cattle in pen most of the time; (2) a semi-intensive tethered and move system; and (3) an extensive grazing system.

Cattle development programs in Indonesia have been started as far back as the 17th century until nowadays, which Basyar [5] neatly outlined. Cattle development programs from the pre- to post-independent era are dominated by importing exotic breeds to mate with local breeds and crossing breeding between local and exotic breeds through artificial insemination. Few, if none, of those programs, took farmer development into significant account despite their pivotal roles in implementing the program. Hence, both sides need to work to achieve better results.

Several studies have reviewed cattle development programs in Indonesia. Agus and Widi [4] reviewed the achievements and pitfalls of cattle development programs since the 1980ies and then proposed strategies and future directions for cattle development on a production basis. Meanwhile, Basyar's [5] study is concerned with the problem of beef production and distribution to supply demand across the nation, hence suggesting alternative policies by considering local institutions, transportation, and communication system. However, those studies only provide technical recommendations for production aspects. Few papers, if none, have assessed how the programs' design, approach, and implementation at different bio-physical, social, and institutional conditions across Indonesia have contributed to the program's achievements. For example, focusing on breeding programs to increase cattle population has not been interested for stallholder farmers due to its invisible benefits in short term [8]. Although in some regions it has increased cattle populations, it has also contributed to negative impacts on environment because of overgrazing that subsequently leads to degrading cattle quality and unsustainable income from cattle enterprise [9, 10].

This paper aims to review past cattle development programs and formulate models for smallholder cattle development in Indonesia by considering varying bio-physical potency, social and institutional conditions to achieve sustainable outcomes. To achieve these aims, our study poses the following research questions: (i) What are the existing beef cattle farming systems in Indonesia and its operational nature? (ii) How were cattle development programs designed and implemented in the past as well as their achievements and weaknesses? (iii) What strategies can be employed to improve cattle development in Indonesia? and (iv) What models can be formulated and recommended for sustainable small holder cattle development in Indonesia?

2. UNDERSTANDING SMALLHOLDER CATTLE FARMING IN INDONESIA

Cattle play significant roles for smallholder farmers as a source of income [4, 11, 12], savings that can be cashed immediately, buffering household economy during harvest failure, insurance, food, and fertilizer [11]. Beef cattle farming systems commonly found in Indonesia include three systems, intensive, semi-intensive, and extensive [13, 14]. Each of these systems will be discussed in more detail below where the intensive system focusses on how this system integrate well in crop-based areas and to adjust with land limitation while the other two systems are generally found in less populated areas relying greatly on nature as source of feed.

2.1 Intensive cut-and-carry feeding system

Cattle-raising management under an intensive cut-and-carry system is generally indicated by two most common features, landless/limited land and crop-based. This system is mainly found in densely populated areas where intensive crop farming plays significant roles as a source of living, such as in Java, Lombok, and some other parts of Indonesia. Farmers rely heavily on crop by-products to feed their cattle [4, 15, 16]. Farmers plant improved grass in rice bunds, backyards, or roadsides [17]. Landless cattle farmers collect feed from communal areas such as river banks, roadsides, irrigation channels, rice bunds, and forests [18-22]. Other farmers purchase fodder to overcome feed scarcity problems, especially during the dry season. The cut-and-carry cattle farming system is also implemented on other islands of Indonesia with more extensive land ownership, such as Sumatera, Kalimantan and Sulawesi, and Timor Island.

However, these cattle do not necessarily belong to farmers. The majority of cattle farmers in Java and Lombok manage others' cattle in a profit-sharing scheme, profit sharing in fattening enterprise or getting calves in turn for production [23, 24]. In Lombok, for example, one of the essential beef cattle pockets in Indonesia, more than 60% of cattle farmers manage someone else's cattle. Some farmers prefer to manage others' cattle to restrain selling temptation. Farmers tend to sell cattle more quickly when they own it while trying to keep it when it belongs to someone else.

Moreover, limited capital has hampered these peasant farmers from owning cattle. Although small-scale credit scheme for cattle farming has been available in the last five years, farmers still need more access to credit. Among hindering factors include no/lack of collateral, fears of losing collateral due to being unable to pay back the loan, and lack of information [25]. Hence, farmers must boldly take bank credit to establish and develop their cattle enterprise.

The advantages of intensive cut-and-carry *cattle farming system* include efficient land use, feeding, control, handling and enabling waste use for compost to support farming in a mixed crop-livestock systems [26, 27]. Nonetheless, this system requires higher farming capital, labour and infrastructure for housing and waste management. Some pockets of farmer groups have shown that innovation uptake on improved cattle management has enhanced their farming productivity. Unfortunatley, the innovation spread has been limited due to varying factors including lack of awareness, limited access to information and limited access to inputs as pre-requirement to implement the innovations.

2.2 Semi-intensive farming system

This system is understood when cattle are left freely grazing but farmers still control the animal in certain period of time. Semi-intensive system may be in the form of raising cattle in tethered and moved mode, integrated cattle grazing with food crop cultivation or with estate crop plantation. This system is commonly found outside Java with sufficient land to herd cattle such as Sumatera, Kalimantan, West and East Nusa Tenggara and generally integrated with crops or estate crop plantations. At the same time, the other 31.82% and 22.73% raise cattle in extensive and intensive systems, respectively, with average cattle ownership ranging from 1-3 head per household. In Nusa Tenggara, integration with food crops cultivation mostly practiced by grazing cattle herds after food crop harvest (corn or rice), while tethered and moved mode is generally practiced in Timor Island. In tethered and moved mode cattle are tethered using a relative long rope in the morning which will give chance for cattle to graze and be moved in the afternoon depend on the availability of feed.

Integration of beef farming and crops or estate crop plantation in a semi-intensive system provides an excellent opportunity for beef development, especially for scale expansion owing to its potency as a feed source. It contributes to 85.8% of farmer household income [28]. With a total oil palm plantation of 14.663.600 ha [29], this system could support another 23.461.760 more cattle in Indonesia. Reciprocally, cattle can reduce costs for weeding and fertilizing plantations [30].

Amidst the incredible potency of a semi-intensive system for beef cattle development in Indonesia, challenges remain related to production, reproduction, farmer human resource, and access to inputs and services. The advantage of a semi-intensive cattle rearing system is that it can reduce feed costs when cattle are grazing, and reduce labor to raise livestock for other productive activities. On the other hand, the disadvantage is that farmers still have to provide quality feed to meet their nutritional needs [31-33]. Unfortunately, most farmers only provide forage, leading to low productivity.

Low production rates are characterized by slow growth due to quality feed insufficiency, especially in the dry season, long calving intervals, and high calf mortality rates have been classical problems. According to study [34], reproductive management significantly correlates to farmers' income, accounted for more than 80%, meaning that poor reproductive management will result in farmers large losses [35]. If the farmer's income is only enough for his family's living expenses, then the fulfillment for cattle needs is decreasing, resulting in low cattle productivity. Bremer et al. [36] argue that the palm oil-cattle integration system is complicated for smallholders due to limited land and free grazing practices. Grazing cattle tend to be uncontrolled due to labor shortage and confined within individual farmers' land, which needs to be improved to meet cattle nutrition requirements. Therefore, efforts and regulations are required to enable land access for semi-grazing cattle.

Meanwhile, reproduction issues are still tantamount to cattle development in Indonesia. A similar condition was found in Sumbawa Island of WNT, where mature good bulls are usually sold first for emergency cash needs leading to degraded bull quality and inbreeding. Unfortunately, this issue has been overlooked. Instead of optimizing the high reproduction trait of Bali cattle using natural mating of quality bulls, the development programs have put more attention into artificial insemination. This problem will be discussed further in the section on cattle development programs in Indonesia.

2.3 Extensive grazing system

The extensive grazing system is cattle farming with minor human intervention and relies significantly on nature as a source of feed [37]. In the extensive grazing system, cattle can be left freely during the daytime, returned to crush yards at night, or grazed throughout the year. Dutch introduced cattle in Nusa Tenggara of Indonesia as part of the colonial government's ethical policy. Bali cattle were introduced first on Timor Island in 1912, Ongole cattle to Sumba Island, and Madura cattle on Flores Island in 1909 - 1915 [38], as shown in Table 1.

Table 1. Historical events of Bali cattle development in West Timor

Year	Conditions
1912s	Bali cattle was introduced in West Timor
1930s	*Leuchaena leucocephala* was introduced
1940s	The cattle population is concentrated among the elites
1950s	The vast increase in cattle population, vast invasion of *Lantana camara,* redistribution of cattle, and environmental problems emerged
1960s	Beef cattle are the main commodity exported from Timor
1970s	Cattle have the highest population in the Mutis mountainous areas.
1980s	Psyllic problems for Leuchaena, Psyllic resistance Leuchaena was introduced
1990s	Local species of forages were identified, and over-exploitation of native species of forages
2000s	Quality degradation of Bali cattle

Source: Adapted from Ngongo

Among the three cattle types mentioned above, Bali cattle are considered the most productive cattle. They have relatively better productivity and endurance in their genetic condition without being crossed [39]. Bali cattle became the primary commodity exported from Timor to Hong Kong and Singapore until the 1960s, after which domestic demand, primarily from Java, dominated cattle marketing. Since then, Bali cattle in Timor have become the primary source of cash income for most farmers in Timor.

The fast increase in the Bali cattle population combined with extensive free grazing system in Timor, however, has also brought negative consequences to the fragile semi-arid ecosystem of Timor i.e., increasing overgrazed areas of native pastures and damage to the forest areas. Previous study argues that the extensive areas of secondary vegetation and grassland in ENT, particularly in Sumba and Timor, reflect widespread deforestation from shifting cultivation and poorly managed livestock grazing pressure, which was subject to improvement [40]. Low and short rainfall, as the nature of the semi-arid environment, limited sufficient forage availability, which is also not supporting the fast increase of the Bali cattle population. Farmers' responses to control the *Lantana camara* by burning it in pastureland and providing new and palatable grass have further deteriorated the savannah environment.

In response to providing forages for cattle and at the same time, improving the soil fertility/environment, the Dutch colonial introduced Lamtoro (*Leucaena leucocephala*), which the program was extended after the independent era so-called "lamtoronisasi" [10, 41], and the land of a million cattle (Bumi

Sejuta Sapi), cattle-castor tree-sea weed (PIJAR), and maize-Leucaena-cattle (JALAPI) programs in WNT. Forage development, particularly Leucaena, received significant external (Australia) input of research and aid, The psyllid resistance cultivar (*Leucaena leucocephala* cv. *Taramba*) has improved forage availability, and it has made a significant contribution to improving cattle performance and farmers' income in Timor and eastern Indonesia in general [42] as well as contributing to reducing the pressure to the native grasslands.

The advantage of an extensive cattle farming system labour and cost efficient for providing feed and supervising livestock, while livestock waste can fertilize the grazing land. Conversely, the disadvantage is that it requires large areas, higher risk of contracting disease as compared to intensive system, higher risk of inbreeding makes it difficult to obtain good livestock genetics, and risks of theft and natural disaster [43, 44].

The impact and response of cattle farming households to the economic fluctuations of each system is quite different. Households running intensive cattle farming experience a greater impact if there are economic fluctuations in cattle agribusiness, especially to cattle price, than semi-intensive or extensive systems. This is because (1) intensive system farmers incur greater input costs, hence price fluctuations both on input prices and cattle selling prices will lead to significant impact to household economy; (2) intensive systems generally put cattle as main source of household income, while the semi-intensive and extensive systemsusually have other sources of income as a buffer for household economic resilience. Households with intensive systems are more prone to economic fluctuations. They tend to be strichter in following the business calendar. Often they continue selling cattle even prices fall for costs maintenance only. Conversely, households running semi-intensive or extensive cattle systems do not sell cattle during low prices, unless households need cash to meet current needs. Thus, if there are economic fluctuations, especially price changes, semi-intensive and extensive business systems are more resilience than intensive systems.

3. LESSONS FROM THE PAST CATTLE DEVELOPMENT PROGRAMS

Increasing beef demand by years in Indonesia has required government intervention through national cattle development programs to reduce import dependency and gradually move toward beef meat self-sufficiency. Several programs have been launched to boost cattle production and productivity to achieve this goal. This section discusses the achievements and pitfalls of those programs and how they can be improved in the future in light of efficacy and effectiveness. According to Agus and Widi [4], these programs could have been more effective in meeting the constantly increasing demand for beef. Hence, a more serious effort is needed to reduce the gap between supply and demand for beef. In order to assess the past cattle development programs, this paper employs literature study of previous studies and report documents of the respected program in regards to production, population, and social aspects.

The beef cattle development program carried out by the government from mid-1970 to 1980, known as the Pelita III program achieved unsatisfying results indicated by a trend of decreasing beef cattle population. The program was mainly handing out cattle aid to poor farmers, but it was merely moving cattle from market to recipient farmers with little focus on improving cattle production and population. The role of framers was only as program recipient, often with little if none, technical assistance on improved cattle management. Yet, lessons from previous program were not taken as similar pattern of program was repeated again in the next livestock distribution and development program funded by foreign funding support including *International Fund for Agriculture Development*-IFAD in Sumatera Island, *Asian Development Bank*-ADB in South Kalimantan, and *Southeast Sulawesi Transmigration and Area Development Program-SESTADP* in Southeast Sulawesi province.

The program of *International Fund for Agriculture Development* (IFAD) disbursed a budget of 850 million rupiah for the implementation of this program. This program was only implemented in Sumatra and Bengkulu [45]. The project scheme provided 11 cattle, 10 cows and 1 bull to each village in the transmigration area under revolving arrangement so the benefits can be taken in turn by all villagers. Unfortunately, poor monitoring and evaluation systems, and exacerbated by lack of farmer capacity strengthening both in technical and group organization has left the program into poor achievements.

Another program to increase cattle population in South Kalimantan was funded by *Asian Development Bank*-ADB costing a budget of 1.7 billion rupiah [45]. Meanwhile, the SESTADP program in Southeast Sulawesi costed 1.1 billion rupiah. The general feature of these programs was distributing cattle as draught power to assist farmers cultivating the farm land, again in revolving scheme. Cattle distribution and breeding program in transmigration areas at that time was directed as an effort to utilize land resources [46]. Cattle breeds for these development programs consisted of local cattle as well as imported breeds. The local breed was dominated by Bali cattle, Peranakan Ongole (PO), and Sumba Ongole (SO) cattle. Unfortunately, the achievement was quite similar to the other programs with poor results due to similar challenges. This was indicated by the continuous growing gap between cattle production and demand in across the nation. At about the similar period in mid-1980, the Indonesian Government introduced artificial insemination program using local and imported frozen cement to improve cattle quality of and cover the shortage of domestic feeders. This program was reported to have positive result in increasing cattle population during 1980-1989 with an average of 8.6 million head/year or 5.1% year. Meanwhile, beef production averages 228.5 thousand tons/year, with growth of 1.7%/year [47]. Yet, this achievement was not able to close the gap between national cattle production and demand.

Meanwhile, the Government policy to open live cattle import in 1996 has stimulated feed lotting by private businesses with the main targets of supplying beef meat in the domestic market, increasing the value added of local cattle rather than importing, and encouraging rural and smallholder cattle enterprises. Unfortunately, many beef development programs were implemented on a project basis with little attention to farmer capacity development at the individual and organizational levels. Consequently, when the project has finished, farmers, especially the smallholder ones, remain in similar conditions with few changes in cattle farming practices, scale, and management skills.

Cattle farmers in Indonesia is dominated by smallholders practicing traditional management that lead to low

productivity. At the same time, cattle farming plays crucial roles to support farmer's household economy, provider animal protein food, and as source of organic fertiliser. Therefore government programmes need to focus not only on the cattle, but also on the farmers as the main actor. Research reported by Zulkifli [48] shows that greater farmer participation in the program implementation lead to positive impacts, including enhanced ability to manage farmer group, increased scale of cattle ownership, access to capital, and ability to access market information and technology.

The other government programme launched by the Ministry of Agriculture from 2017 to 2023 was known as SIWAB, a local abbreviation stands for all cows must get pregnant. The main aim was to increase cattle population through artificial insemination (AI) programme and natural mating. However, it seemed to focus on the AI and imposed this aproach across the country, even in the grazing systems that is unsuitable for AI. According to Adnyana et al. [49] to improve the success of AI, intensive counselling on livestock reproductive management is needed, so that farmers have more knowledge and understanding of AI. Firman et al. [50] reported on their research that the SIWAB/ SIKOMANDAN programme has good results because frozen semen can be distributed very well, good pregnancy rates, normal S/C rates, and high calf birth rates. However, the study was conducted in intensive system with more controllable cattle. Results would be different for intensive grazing systems where cattle are rather challenging to be handled and controlled.

To avoid failure in conducting a programme, according to Lisson et al. [51] the approaches that need to be taken when conducting a development programme are (1) benchmarking the existing farming system; (2) identifying problems and developing strategies to overcome them; (3) modelling the impact of the selected strategies on production, labour and finance; and (4) field testing. Another study reported by Sari et al. [52] support the development programme of beef cattle farming can be done by strengthening human resources and institutions, strengthening facilities and infrastructure, accelerating access to adoption and technological innovation, strengthening marketing strategies, and strengthening cooperation. This needs to be done so that the cattle development programme can be achieved according to targets and objectives, in addition to the main objectives of increasing livestock productivity, increasing farmers' capacity and welfare and achieving meat self-sufficiency.

Research reported by Valerio et al. [53] in NTB found that there are significant obstacles that cause poor innovation in the beef sector, namely farmers' human resource, limited funds for agricultural research and development, under developed beef supply chain, and the lack of incentives for farmers. With respect to future problems and challenges, the government's main concern should be to fulfil the demand for meat from consumers and the smallholder farmers' perspectives. The strategies according to Agus and Widi [4] include development and use of suitable breeds for tropical conditions for sustainable breeding programmes; empowerment of farmers to have access to information and services in terms of technology, capital, information, and markets; production systems and their development to meet demand.

Table 2. Food crop waste production is based on digestible dry matter (DDM), feed concentration index (FCI), and carrying capacity of food crop waste by province in Indonesia in livestock unit (LU)

No.	Province	Production of Digestible Dry Matter from Food Crop Waste in Various Commodity						Total Production			Carrying Capacity (LU)
		Rice (tons/year)	FCI	Corn (tons/year)	FCI	Soybean (ton/year)	FCI	DDM (tons/year)	%	FCI	
1	Aceh	988,386.08	1.03	38,460.94	0.35	1,739.13	1.64	1,028,586.15	2.83	0.96	902,268.55
2	North Sumatra	1,222,920.13	1.28	284,888.81	2.56	237.73	0.22	1,508,046.67	4.16	1.41	1,322,847.95
3	West Sumatra	802,626.65	0.84	112,977.94	1.01	12.81	0.01	915,617.40	2.52	0.86	803,173.16
4	Riau	131,671.37	0.14	5,788.13	0.05	77.86	0.07	137,537.36	0.38	0.13	120,646.81
5	Jambi	186,731.94	0.19	9,696.00	0.09	244.37	0.23	196,672.31	0.54	0.18	172,519.57
6	South Sumatra	1,497,632.39	1.56	54,188.81	0.49	610.49	0.58	1,552,431.70	4.28	1.45	1,361,782.19
7	Bengkulu	160,772.41	0.17	9,897.19	0.09	195.58	0.18	170,865.18	0.47	0.16	149,881.74
8	Lampung	1,457,342.78	1.52	281,775.00	2.53	356.28	0.34	1,739,474.06	4.79	1.63	1,525,854.44
9	Bangka Belitung	41,093,56	0.04	124.88	0.00	0.04	0.00	41,218.47	0.11	0.04	36,156.55
10	Riau Islands	567	0.00	88.69	0.00	0.54	0.00	656.23	0.00	0.00	575.64
11	Jakarta	2,044.04	0.00	-	-	-	-	2,044.04	0.01	0.00	1,793.02
12	West Java	5,513,465.09	5.75	179,987.44	1.62	3,591.45	3.39	5,697,043.98	15.70	5.34	4,997,407
13	Central Java	5,755,589.43	6.01	602,323.31	5.41	4,711.52	4.45	6,362,624.26	17.53	5.96	5,581,249.35
14	Yogyakarta	333,029.86	0.35	56,078.25	0.50	683.24	0.64	389,791.35	1.07	0.37	341,922.24
15	East Java	5,840,324.52	6.10	1,149,593.06	10.32	12,523.43	11.82	7,002,441.01	19.30	6.56	6,142,492.11
16	Banten	960,514.53	1.00	2,225.63	0.02	264.66	0.25	963,004.82	2.65	0.90	844,741.07
17	Bali	360,392.17	0.38	7,613.06	0.07	263.5	0.25	368,268.73	1.01	0.35	323,042.75
18	West Nusa Tenggara	844,291.92	0.88	179,994.94	1.62	4,538.81	4.28	1,028,825.67	2.84	0.96	902.478.66
19	East Nusa Tenggara	430,807.20	0.45	128,452.69	1.15	131.22	0.12	559,391.11	1.54	0.52	490.693.95
20	West Kalimantan	457,844.15	0.48	19,451.63	0.17	95.72	0.09	477,391.50	1.32%	0.45	418.764.47
21	Central Kalimantan	236,021.69	0.25	1,535.44	0.01	45.81	0.04	237.602.94	0.65	0.22	208.423.63
22	South Kalimantan	614,074.05	0.64	24,094.69	0.22	382.49	0.36	638,551.23	1.76	0.60	560.132.66
23	East Kalimantan	141,833.81	0.15	1,571.06	0.01	55.14	0.05	143,460.01	0.40%	0.13	125.842.11

24	North Kalimantan	22,494.45	0.02	193.5	0.00	81.28	0.08	22,769.23	0.06	0.02	19.973.01
25	North Sulawesi	134,970.24	0.14	56,341.88	0.51	242.67	0.23	191,554.78	0.53	0.18	168.030.51
26	Central Sulawesi	510,814.71	0.53	24,585.56	0.22	481.7	0.45	535,881.97	1.48	0.50	470.071.91
27	South Sulawesi	3,037,102.17	3.17	286,577.63	2.57	2,439.07	2.30	3,326,118.86	9.17	3.12	2.917.648.12
28	Southeast Sulawesi	318,448.69	0.33	12,776.44	0.11	464.6	0.44	331,689.74	0.91	0.31	290.955.91
29	Gorontalo	135,287.93	0.14	120,658.50	1.08	116.27	0.11	256,062.70	0.71	0.24	224.616.40
30	West Sulawesi	190,627.87	0.20	18,902.06	0.17	153.11	0.14	209,683.05	0.58	0.20	183.932.50
31	Maluku	67,821.08	0.07	2,615.06	0.02	25.66	0.02	70,461.81	0.19	0.07	61.808.60
32	North Maluku	17,081.40	0.02	2,199.00	0.02	17.24	0.02	19,297.64	0.05	0.02	16.927.76
33	West Papua	14,906.52	0.02	424.5	0.00	52.24	0.05	15,383.25	0.04	0.01	13.494.08
34	Papua	146,382.79	0.15	1,249.88	0.01	127.85	0.12	147,760.52	0.41	0.14	129.614.49
	Indonesian	**32,575,914.62**		**3,677,331.56**		**34,963.54**		**36,288,209.72**	**100**		**31,831,762.91**

Source: primary data, analyzed (2022)

4. CATTLE DEVELOMPMENT IN INDONESIA, WHAT DOEST IT TAKE?

Looking at the current conditions of cattle farming in Indonesia which is dominated by smallholder farmers in various systems as described in Section 1 and learning from the ups and downs of previous national and regional cattle development programs, a reflection should be made for the following and future development programs. Most cattle development programs aim to improve productivity first and subsequently to improve farmers' livelihood, which also means covering biophysical and human components involved in cattle enterprise. This section discusses critical components to support cattle development programs in Indonesia to achieve more significant opportunities for sustainable impacts. These include feed and feeding, reproduction, animal health management, and economic and human components.

4.1 Feed and feeding management

Feed and feeding management determine 70% of cattle farming performance [40]. This condition is exacerbated because Indonesia lies in a tropical region with a long dry season, causing a fast decrease in forage quality in some cattle pocket's areas such as WNT and ENT. At the same time, potential feed sources such as crops and estate crop by-products are available abundantly yet underutilized in many parts of the country. This section will explore key factors attributable to cattle development in Indonesia from the feed source and availability perspective, available innovations, and production capacity. On the one hand, an extensive grazing system allows cheap cattle production yet has low productivity influenced by the bio-physical quality of the grazing area, duration in accessing grazing land, and rotational grazing [54-56]. On the other hand, an intensive cut-and-carry system has shown sufficient nutrient provision by farmers but has limitations on farm scale expansion. Therefore, this discussion is also about feeding strategies and practice changes needed across different cattle farming systems that enable sustainable development, as indicated by improved productivity and farmers' livelihood.

Indonesia has different cattle feed sources across the three different framing systems. The extensive system relies on nature as the primary feed source for grazing cattle. For example, average fresh forage production in grazing areas in Western Indonesia accounts for 2.87 tons/ha during the wet season compared to 2.31 tons/ha during the dry season [57]. While in the Eastern part of Indonesia, it is 5.35 tons/ha during the wet season as opposed to only 1.39 tons/ha during the dry season [58]. In regards to vegetation, grazing land in Western Indonesia is dominated by grasses of *Brachiaria decumbens, Cynodon plectostachyus, Panicum maximum*, and legumes of *Centrocema pubescent, Stylosantes guyanensis* [57].

Meanwhile, a semi-intensive system gathers forages from the grazing and crop farming areas. This system is characterized by introducing various improved grasses and legumes adaptable to local conditions. Farmers plant fodder for labor savings and conserve feed in simple methods whenever needed. According to Stür et al. [59], labor-saving is a major driving factor for adoption in animal feed innovations. Among the preferred improved grasses include Elephant Grass (Pennisetum purpureum), Odot grass (*Pennisetum purpureum* cv. Mott), King Grass (*Pennisetum purpupoides*): Legum Stylo (*Stylosanthes guianensis*), Legum Centro (*Centrosema pubescens)* [60-65].

On the other hand, since intensive smallholder cattle farming is primarily integrated with crop farming, some primary feed sources in this system include rice straw [66-68]. Utilization of crops by-products as cattle feed provides a great potency to enhance farmers' ability to expand farm size, as shown in Table 2, which will lead to increased cattle population. Table 2 shows the production of several crops by-products in Indonesia and their potency to support cattle farming.

In the intensive cattle farming system, farmers start recognizing innovations for feed management to improve productivity, such as silage, hay, and mineral blocks. Several studies have shown that feed treatment improved feed quality and digestibility. Ammoniated rice straw supplemented by legumes improves rumen microbes and increases the degradability of xylose, galactose, and mannose by diluting hemicellulose partially, hence increasing rice straw intake [69, 70]. Meanwhile, maize straw and *Stylosanthes* silage in 50%: 50% composition is an alternative for beef cattle [71]. Moreover, urea molasses block supplementation in grazing areas improves the digestibility of; maize straw [72, 73].

4.2 Strategies to overcome feed scarcity

Feed scarcity is a chronic problem that impedes cattle production, productivity, and hence population in Indonesia [68]. Amidst this challenge, the integrated crop-cattle farming system commonly practiced by most smallholder farmers in Indonesia provides an excellent opportunity to overcome this problem. An integrated crop-livestock system is a promising option for achieving sustainable farming objectives for

economic and environmental benefits [74-77]. Limited conventional feed sources can be overcome by utilizing crops by-products in simple, concentrated, or complete feed. Rice is Indonesia's main crop that, produces 77% rice straw and 10% rice bran out of the total production as a potential feed source [78]. Additionally, cassava starch or coconut meal are other potential available feed that can be added to the ration [79, 80].

Crops by-products such as cattle feed are available nationwide, as shown in Table 2. This Table depicts East Java as the highest crop by-products producer, followed by Central Java, West Java, South Sulawesi, and Lampung. This potential feed availability reflects feed support for further cattle development in Indonesia, which can be projected using the Feed Concentration Index (FCI). Table 2 indicates that merely utilizing crop by-products as cattle feed will support up to 31,8 million cattle, which means an open space to expand the population for another 18 million cattle on top of Indonesia's current 13.8 million cattle population. The province with the highest FCI has a more significant opportunity to expand the cattle population under the integrated crop-cattle farming system.

Despite the abundant crop by-products availability, this potency still needs to be utilized. Farmers still burnout maize and rice straws in many parts of Indonesia. Reasons often mention saving labor for the next crop planting round, not knowing it is cattle feed and lack of infrastructure to conserve it. This condition indicates two implications for optimizing crop residue as cattle feed. First is improving farmers' knowledge and skills, which will be discussed in the section on farmer human resources, and the second is the consequences of such practice that need to be addressed. Smallholder farmers require options for increasing the quantity and quality of forages in livestock diets. However, these options need to be integrated with current food-production systems rather than replacing them. In particular, new forage or feed systems must complement, rather than compete with, important staple grain crops such as rice and maize [81].

4.3 Animal health and reproduction management

4.3.1 Animal health management

Animal health management plays another critical role in a productive cattle enterprise. Cattle farming can increase farmers' economic income and reduce poverty. A study shows that high-productivity cattle also incur more healthcare expenses [82]. However, these costs are still compatible compared to the impacts caused by disease infection and outbreak [83]. Meanwhile, asymptomatic diseases resulting from nutritional deficiencies can lead to decreased productivity and poor reproduction performance in cattle [84].

Furthermore, calves from infected cows will experience slowed growth, delayed sexual maturity, and decreased milk production [85]. Infection with bacteria, viruses, and fungi causes high mortality in calves within the first 48 hours of life [86]. Given the significant economic loss due to diseases, cattle health management is inevitable to reduce morbidity and mortality [87]. Understanding and practice of cattle health management vary among smallholder farmers in Indonesia.

Indonesia currently has 18,053,710 beef cattle kept by approximately 5,736,153 farmers in 7,230 sub-districts [88-90], meaning that 2,410 PUSKESWAN are needed. There are currently 2124 PUSKESWAN across Indonesia. Apart from medical veterinarians, there are also livestock extension workers at the ground level to support smallholder cattle farmers and deliver information on good cattle management practices. Unfortunately, their number is far from sufficient. To put this into context, East Java Province, with 3,424,270 cattle farmers, only has 216 livestock extension workers [89], which means only 3.53% of farmers receive extension services. This condition illustrates the urgent need for these staff to facilitate farmers in developing their knowledge and skills in beef cattle management for improved productivity and livelihood.

The extensive system accelerates the spread of Septicaemia Epizooticae (SE) and Gastrointestinal Parasites. Therefore, it is necessary to control the spread of infectious diseases in groups or regions, not individually [91]. Based on identifying intensive, semi-intensive, and extensive maintenance systems, the government must create a map and designate it as a cattle breeding area prone to contracting and spreading disease. These crucial factors are anticipated to receive prompt attention to combat infectious diseases. Vaccination can control infectious diseases [92]. According to Tago et al. [93], losses due to infectious diseases can be prevented or slowed by implementing a distance restriction zone if vaccination is unavailable. The government can also control infectious diseases by identifying the structure of the traditional beef cattle trade network susceptible to infectious disease transmission [93, 94].

4.3.2 Reproduction management

Reproduction management is another key to productive beef cattle enterprise, especially in breeding. The beef cattle production cycle generally consists of mating, gestation, calf birth, nursing, weaning, and feedlot/backgrounding until the beef cattle are ready for market. From this cycle, reproduction is essential to beef cattle production's success. The birth of calves in production cycles is essential for producing sires and bulls for meat production. Reproduction failure is a common cause of declining beef cattle populations [95]. Therefore, reproduction efficiency is one of the keys to increasing profits in the cattle business [96].

The implementation of reproduction management in Indonesia is also hampered by reproduction disorders which range from 11-57% [97]. This high range of reproduction disorder hinders population development in Indonesia and causes enormous economic losses for farmers. Research in 2018 in South Sumatra Province reported reproductive disorders, including ovarian hypofunction, endometritis, pyometra, ovarian cysts, silent heat, villitis, vaginitis, and fetal mummification [98]. Meanwhile, the most common reproductive disorders found across Indonesia were ovarian hypofunction and repeated breeding [99-101]. In general, the main cause of reproductive disorders is insufficient feed, both in terms of quantity and nutritional quality. Unbalanced nutrition, especially when the cow is experiencing a severe phase of the reproduction cycle, such as pregnancy or lactation, is the leading cause of this reproduction disorder. When dry matter intake does not meet energy needs, a negative energy balance occurs, which affects reproduction activity [102]. This condition is common in smallholder farms, especially cattle without supplemental feed [103]. Other causes of reproductive disorders are limitations in farmers' knowledge, postnatal care, veterinarians, the number of livestock health facilities [98], sanitation and biosecurity.

Based on the current reproduction management in smallholder cattle farms in Indonesia, a strategy is needed to

accelerate the increase in cattle population. The most crucial factor in reproduction management is mating management to produce calves. Therefore, appropriate reproduction innovation interventions supported by government policies can significantly improve reproduction management. Since the main problem of reproductive disorders correlates with feed insufficiency, it is necessary to implement a feeding strategy to increase the reproductive performance of cows [104]. The three main strategies that can be implemented are: (1) to implement a mating calendar where a late gestation period coincides with an increased forage availability time; (2) to wean calves at a decreased forage availability time to reduce cow's burden and allow correcting their body condition for the next reproduction cycle; (3) and to implement tactical feeding which is providing high-quality feed for weaned calves and low-quality feed such as rice straw for empty cows. This strategy can be combined with the application of Assisted Reproductive Technology (ART) such as estrus synchronization and AI.

The mating system in a smallholder cattle farm in Indonesia generally uses bulls owned by farmers or AI [105]. The implementation of AI provides more benefits by controlling both interbreeding and inbreeding. However, in general, the implementation of AI is also constrained by farmers' need for knowledge regarding estrus detection and the uneven distribution of facilities and infrastructure to support AI in Indonesia. Under these conditions, then natural mating is more profitable [106].

Frozen semen distribution has been a challenge in Indonesia since production is mainly concentrated in the island of Java. There are two main insemination centers in Java owned by the central government: Lembang Artificial Insemination Center and Singosari National Artificial Insemination Center (SNAIC). The remainders are smaller in scale owned by local governments and private sector. These conditions make AI outside Java become challenging to implement. The costs will be more expensive due to distribution and maintenance costs of frozen semen. Apart from that, the presence of inseminator officers is not evenly distributed across the archipelago. Therefore, the proposed solutions to this condition are: 1) The government needs to encourage private companies that produce frozen semen; 2) The government needs to develop certified AI centers in each region; 3) The government needs to increase the number of inseminator officers in cattle farming areas throughout Indonesia.

Meanwhile, sperm sexing is necessary to produce beef cattle of a particular sex. Sexed semen in cattle refers to semen that has been processed to separate and collect sperm based on their sex chromosomes, specifically the X and Y chromosomes. This technology allows for more controlled breeding, allowing farmers and breeders to choose the sex of the calves: males for fattening and females for breeding. Frozen semen from sex has been produced by SNAIC and has been distributed throughout Indonesia [107]. Even though the price of frozen semen from sexing is more expensive than regular frozen semen, it is still affordable for small breeders for government generally subsidy. There are no national reports regarding the success of sperm sexing in Indonesia. While the technology has advanced, the success rates of sexed semen are not 100%. The accuracy of sex selection can vary depending on breed and the sexing method. On a research scale, the success of separating spermatozoa to produce male calves in SNAIC was reported to be more than 90% in the Simental crossbred [107] and 78% in the Ongole crossbred [108]. Male calves are more economically profitable for smallholder beef cattle farmers than females because they have a higher selling value.

4.4 Social and economic aspects

The social-economic aspect is another vital element in achieving productive and profitable cattle farming. Hence, understanding this aspect is crucial to develop smallholder cattle farming with diverse social and economic conditions in Indonesia. Smallholder cattle farming is an integrated farming business with other farming enterprises such as food crops, horticulture, estate crops, and other livestock enterprises. For example, cattle farming is integrated with food crops in Java, North Sulawesi, Bali, and West Nusa Tenggara, with oil palm in Sumatra and Kalimantan, with estate crops in East Nusa Tenggara, Southern Sulawesi, and Papua. However, this multi-commodity farming is still spatial and has yet to reach the Integrated Farming System (IFS) stage, indicated by the realization of zero waste.

Farmers generally have two main objectives in rearing cattle, production, and investment objective. The production objective is to earn capital from cattle sales, contributing to household total income to meet family needs. On the other hand, an investment objective is intended as capital that can be used anytime for other purposes such as children's schooling, building houses, and social and cultural needs expenditure. Farmers' decision to sell cattle is influenced by several factors, depending on the economic level of the farmer and business orientation. When farmers need cash for school fees or social expenditures (burial, marriages, and other cultural ceremonies), cattle will usually be sold to meet these needs regardless of prices. In cattle marketing, four marketing patterns are commonly found across the country, as described in Figure 1. They are (a) farmers sell directly at the farm gate with buyers coming to collect; (b) farmers sell cattle to the slaughterhouse; (c) farmers sell cattle in livestock markets, and (d) farmers sell cattle to other farmers.

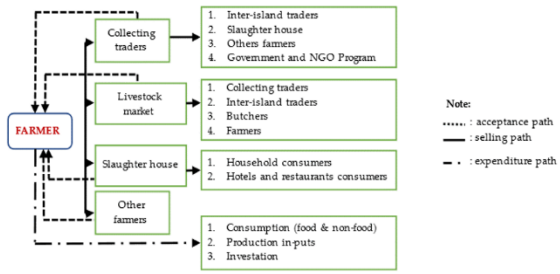

Figure 1. The flow of cattle farming and marketing at the household level in Indonesia
Source: primary data, analyzed

Some farmers prefer selling cattle at the farm gate for several advantages, including minimum transportation costs, less risk for unsold cattle, and saving time for other activities. However, this option also comes with disadvantages as buyers generally dominate price deals, especially when farmers are in a needing position for unavoidable circumstances. Through the procurement process, collectors will sell cattle to inter-island traders, slaughterhouses, other farmers, and the government and NGOs. Meanwhile, selling cattle to livestock markets has advantages such as direct access to market price information.

Regarding capital availability for cattle enterprise, smallholder farmers are characterized by low capital owned with varying features in access to banks or other capital sources. Extensive cattle farmers have less access to banks than their semi-intensive counterparts. Farmers with extensive systems even can access capital from various sources such as banks, cooperatives, and moneylenders. This relates to their business turnover as bank/lender considerations in providing credit. Accessing Bank for some farmers can take much work for its formal requirements and processes. Hence, despite the higher interest, they prefer another source like cooperatives with more familiar and visiting staff. In the future, cattle business development needs to be supported by cheap and easily accessible financing schemes for farmers. This policy's implementation is expected to positively impact beef production by reducing feed, feeder, and distribution costs [74].

5. A PROPOSED MODEL OF SUSTAINABLE SMALLHOLDERS CATTLE FARMING

Developing a model for smallholder cattle development in Indonesia is to boost cattle population and beef meat production and, more importantly, to sustain the model. Sustainability is determined by three factors, economy, society, and ecology [109]. Based on this sustainability concern, this paper proposes a model for smallholder cattle development in Indonesia, as depicted in Figure 2.

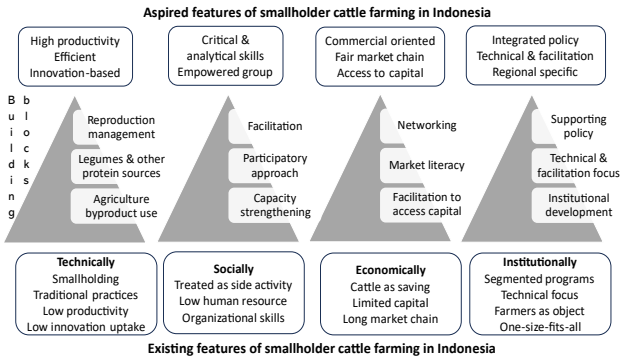

Figure 2. A proposed model for smallholder cattle development in Indonesia

The challenges for smallholder cattle development in Indonesia are intertwined with four aspects, technically, socially, economically, and institutionally that bear its existing challenges, as shown in Figure 2. Therefore, the proposed model for cattle development here must be seen as an integrated model that cannot be separated fractionally. This model offers pathways and building blocks that must be established at each aspect to achieve the aspired future of productive smallholder cattle farmers.

Technically, cattle farming in Indonesia is dominated by smallholder enterprises largely managed under the traditional low-input systems [7]. Although innovation has been available to improve productivity, farmers often need to pay more attention to it due to limited access to information, limited resources to implement, or simply due to an existing mindset. These constraints are exacerbated by the social features of farmers who consider cattle farming a saving and side job. Therefore, it is managed with little attention as it will be sold in a sudden capital need. Moreover, most of these farmers came from low educational backgrounds that operate individually, restricting their technical knowledge and skills in improved cattle management.

While smallholder cattle farmers technically and socially are in unfavorable conditions, institutions in charge of cattle development are often in a similar stage. Cattle development programs often focus on the technical aspects in a fractional segregated manner with little attention to farmers' capacity development. For example, a reproduction management program goes solitarily with forage development and disconnected with extension activities for farmer and group capacity development. Farmers often serve as the program's targets without genuinely understanding the program. The program's focus is achieving predetermined outputs, as in the paper. Hormone synchronization movement is another puzzling example of this fractional program. Skinny cows that experience reproduction disturbance are often treated with hormones to get heat, while the fundamental problem can be a nutritional deficiency.

Given the existing features of smallholder cattle farming in Indonesia, it is evident that a holistic and integrated approach will be the key to any cattle development initiatives. This integrated approach must consider local conditions as supporting and hampering factors for cattle development. Agro-ecosystem conditions in a different region serving as the primary feed source must be considered an essential reference in developing the program. Therefore, the approach in the Western region of Indonesia, dominated by oil palm plantation, can be different compared to Java Island and similar regions, which are mostly covered with crops throughout the year, as also a different approach for the Eastern part of Indonesia, which is predominated by grassland. In context, grazing grassland in East Nusa Tenggara, Sumbawa, Sulawesi, and Sumatera has supported an extensive cattle farming system.

Conversely, crops producing regions like Java, Bali, and Lombok has fostered intensive system. Lastly, the mixed region between grassland and upland crops has nurtured the semi-intensive system. These three systems require distinct approaches and innovations to enhance smallholder cattle productivity based on the opportunity, as elaborated below. One thing to be underlined is that in those three systems, the underpinning innovations must work on reproduction, feeding, and animal health management.

5.1 A model for intensive cattle farming system

The intensive cattle farming system is standard in populated crop-based farming regions such as Java, Bali, and Lombok. A model for cattle development in intensive regions is depicted in Figure 3. Figure 3 shows that crops by-product have been widely used, yet protein sources remain challenging. The cheapest option of protein source is by planting tree legumes which apparently have high protein content and provide it to cattle by cut-and-carry feeding system. In some pockets of rainfed areas with relatively large land ownership like in East Nusa Tenggara and Sumbawa Island, planting *Leucaena leucocephala* in monoculture system has shown to be effective in supporting cattle fattening enterprises (ACIAR project report, 2019). This tree legume supplementation can be combined with maize by product such as maize stover that are available abundantly during harvest season. The still challenge is harvesting, drying and storing

this feed source due to labor shortage. Farmers still leave the maize stalk dry in the field and leave cattle to graze it. As a result, quality of the maize by product plummet rapidly and only available in a short period. Hence, simple mechanization to harvest and process this biomass will have significant value for feed provision throughout the year. Meanwhile in irrigated rice field, feeding tree legume of *Sesbania glandiflora* have significantly improved cattle performance (ACIAR project report, 2019). This legume can be planted in the rice bund with minor effects on the crops. The other alternative protein source is bean by-product but with extra cost consequences. This extra cost for some farmers can be an additional burden. Therefore, income diversification from cattle farming will assist farmers significantly. Pirani et al. [109] assert that smallholder enterprises must change production patterns to survive.

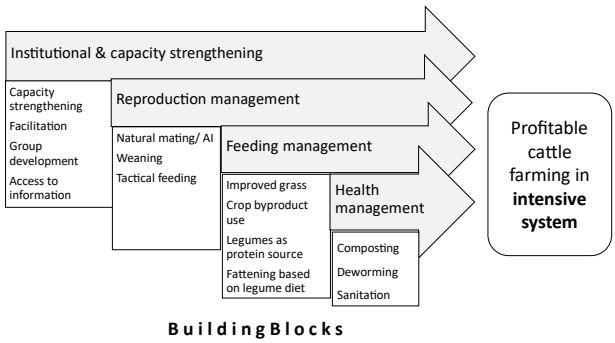

Figure 3. A proposed model for smallholder cattle development under an intensive system in Indonesia

With the privilege of confined cattle in an intensive system, one possible alternative income source is processing and selling compost. This system can be simple for some farmers, but for many others can be about a life-changing practice in cattle management. Therefore, facilitation from the institution in charge plays a crucial role in farmer capacity building, enabling them to make the best decision out of their confining limitation. This facilitation will be more effective when farmers are in a functioning group, as farmers' participation in an organization enhances efficiency and ease extension services [110]. Among farmers' capacity strengthening strategies that can be used include raising awareness using video and compare-and-contrast learning visit to a more advanced group, adaptive trials where farmers experience and adjust the introduced innovation according to their local conditions, reflection on results of the adaptive trials and then planning for the next improvement, and thematic trainings based on needs on the field. All these strategies require continuous facilitation by outsider actor either by extension agents or other facilitating actors.

5.2 A model for semi-intensive cattle farming system

Semi-intensive cattle farming is commonly found in rain-fed areas where cropping pattern allows fallow in a year cycle. Crops provide great potency as feed sources in the system. Unfortunately, crops by-products are often underutilized due to a lack of knowledge and seasonal availability, abundant during harvest time but lacking in the rest of the year. A proposed model for cattle development in intensive regions is depicted in Figure 4. Like the intensive system, this model still puts a human capacity element into excellent account as a foundation for cattle development. The addition of this model is feed conservation to ensure availability throughout the year. Feed sources in Western Indonesia rely on oil palm by-products, while in Eastern ones rely on crop by-products.

Semi-intensive cattle farming is a potential source of calves and feeder cattle in a less-cost system. Therefore, this system enables farmers to do cow-calf and fattening enterprises, providing a nearby protein source. Therefore, this model offers tree legumes as a reasonably accessible high-quality protein source. Tree legume like Leucaena has shown impressive performance in dry Nusa Tenggara to support fattening enterprise.

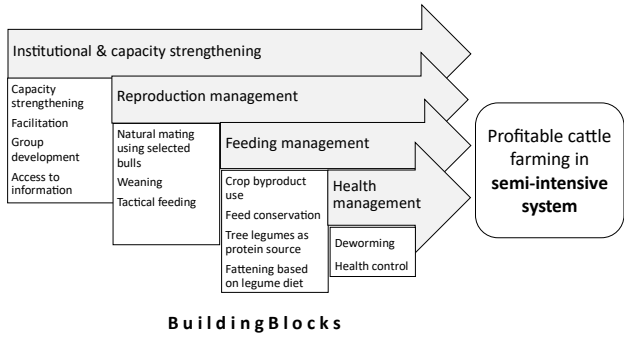

Figure 4. A proposed model for smallholder cattle development under a semi-intensive system in Indonesia

5.3 A model for extensive cattle farming system

An extensive cattle farming system puts the animal in grazing areas yearly. This system produces calves, breeders, and feeders relatively cheaply as farmers use low input. However, this system has been reported to have low productivity and quality as farmers rely greatly on nature as a feed source. Moreover, classical problems of extensive systems are overcarrying capacity and degraded grazing land with low-quality feed. Therefore, a proposed model is shown in Figure 5 to improve productivity.

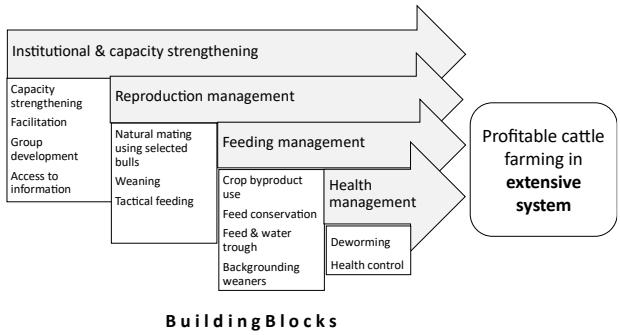

Figure 5. A proposed model for smallholder cattle development under an extensive system in Indonesia

Given that the main aim of extensive farming is to produce more cattle, reproduction management is the core of the model to produce one calve from one cow in one year. Natural mating using selected bulls is highly recommended for its efficacy over AI, although some government programs promote AI across all farming systems. It is recommended to use calendar/seasonal mating to match between calving times that require high-quality feed and feed availability season. This seasonal mating can be achieved by only putting bulls for

mating in the herd and taking out all other male cattle. These male cattle are a potential source of feeders for farmers doing fattening.

Feed is still an essential part of the model, yet provision needs to be modified as extensive systems usually reside in communal areas. In this regard, organizing farmers in the same grazing area often determines the success of any management intervention. Communal areas are seen as common property that everybody can access. Others can spoil management improvement by part of the grazers. For example, planting forage in the overloaded Doro Ncanga grazing land in West Nusa Tenggara has failed as other roaming cattle destroyed it. Hence, the facilitation of farmers' organizations is vital here.

6. CONCLUSIONS

This paper aims to review and recommend a model for smallholder cattle development in Indonesia by considering varying bio-physical potency and social and institutional conditions to achieve sustainable outcomes. This paper found three main cattle farming systems closely related to crops farming systems, land availability, and agroecological conditions in the respective regions. The intensive cut-and-carry feeding system is usually practiced in densely populated regions with irrigated land where farmers count on crops by-products as a feed source. Meanwhile, a semi-intensive system is usually practiced where cattle are needed to graze crops residue after harvest in upland areas or graze underneath estate crop plantations. Farmers still still take controll by putting cattle in pen for a certain period. Finally, the extensive system is found where grazing land is still available sufficiently to graze cattle throughout the year with minor intervention from farmers. Across all the cattle farming systems, feed scarcity especially during dry season, reproduction and health problems, and socio-human resistance for innovation uptake to improve cattle productivity are still the main hinderance for cattle development in Indonesia. At the same time, feed source from crops byproducts like rice and maize are availbale abundanty during harvest season. The main challenge in utilising these by products include labour availability to harvest, process and store it. Hence, simple mechanisation for these processes would be significant to ensure feed availability througout the year.

A number of cattle development programs has been launched by the Indonesia Government to boost cattle population and productivity. This oaoer asseses their achievements and pitfalls. The claimed achivements were reportedly unsutainabke and unclear in other studies. Meanwhile this paper identifies their drawbacks including unclear operational guidelines leading to varying operational implementation; top-down approach of one-size-fits-all overlooking diverse bio-physical and socio-economic conditions across the nation which leads to uneffective program due to insuitabilty, and weak monitoring and evaluation systems that leave program implementation without feedback loop mechanism to improve any weaknesses.

Therefore, this paper proposed models for smallholder cattle development under an intensive system in Indonesia with four main pillars: individual and institutional capacity development that put farmers' development as a foundation, then feeding, reproduction, and health management as another equally important pilars. Operationalization of this model is flexible for the respected system to suit existing local conditions. Meanwhile, its implemnetation lies on the farmers' capacity strengthening as the underpinning foundation to identify problems and opportunity which then lead to practice changes related to the other three pilars. Hence, future cattle development programs by the Government of Indonesia and other development agents are expected to consider those four pillars strengthening. Beef cattle development programs need to be targeted for specific regions that provide a greater possibility of success. The three cattle farming systems cannot negate one to each other for their respective advantage that one system can support the other one. An extensive system, for example, can produce breeder and feeder cattle for intensive ones. Therefore, developing all types of cattle farming systems must be done simultaneously. Special efforts are needed in feed quality and improvement of grazing areas, innovation interventions for bio-physical and socio-economic aspects, fostering local regulations to support cattle development programs, and strengthening animal health and extension services.

While this paper insights on achievementts and pitfalls of cattle developement in Indonesia that can be a reference for future similar programs, we also acknowledge some limitations of this study. As this desk study rely on documents, reports and previous studys as main source of data, the proposed recommenadations are not tested and piloted yet under field conditions. Therefore, it provides avenue for future research. Reserach questions such as how can cattle production and reproduction, and the livelihoods of smallholder farmerss, be improved within the constraints and opportunities of crop-based farming systems? How can efficient cattle production systems be scaled out in different settings? How can government programs be improved to support cattle and smallholder farmers develeopment across the nation? Are among reaserch questions that need to be asnwered in the future reserach.

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