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ADOPTION OF A LEUCAENA-BASED CATTLE FATTENING SYSTEM IN THE DOMPU DISTRICT OF NUSA TENGGARA BARAT, INDONESIA

Muktasam A[a] †
Dahlanuddin[b]
Ryan A Putra[c]
Made Sriasih[d]
M. Taufik Fauzi[e]
I G.L. Parta Tanaya[f]
Penny J Back[g]
Rebecca Hickson[h]
William E Pomroy[i]
Janet I Reid[j]
Christopher W N Anderson[k]
Stephen T Morris[l]

[a,e,f]*Faculty of Agriculture, University of Mataram, Mataram, Lombok, Indonesia.*
[b,c,d]*Faculty of Animal Science, University of Mataram, Mataram, Lombok, Indonesia.*
[g,h,j,k,l]*School of Agriculture and Environment, Massey University, Palmerston North, New Zealand.*
[i]*School of Veterinary Sciences, Massey University, Palmerston North, New Zealand.*

† ✉ muktasam03@yahoo.com *(Corresponding author)*

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ABSTRACT
Cattle fattening using Leucaena (*Leucaena leucocephala)* as the source or the main component of the cattle's diets is one of the proven innovations that can provide financial benefit to cattle farmers. The objective of this study is to evaluate the adoption of Leucaena-based cattle fattening and identify the factors contributing to the adoption and diffusion of these improved practices. A mixed method approach was used to understand the adoption of Leucaena and cattle management by local farmers who participated in the early stage (2017) and those who participated in the later stages of the project (2018–2020). The study showed that male Bali cattle (*Bos javanicus*) that were fed Leucaena-based diets grew two times faster than cattle fattened on grasses. This increased live weight gain and, subsequently, faster sales and increased profits. This may account for the rapid adoption and diffusion of Leucaena-based cattle fattening in Dompu through farmer-to-farmer learning, effective facilitation, demonstration trials, and linking farmers to end markets. To sustain the practice change, the project facilitated the development of an agribusiness support center (ASC). Sustaining the ASC requires further efforts that include internalization of the project outcome into the local government program.

Contribution/Originality: This paper contributes strategically to the field of adoption theories, studies, and practices. Moreover, the lessons discussed in this paper may contribute to a better understanding of adoption and diffusion processes that assist in promoting the effective adoption and diffusion of innovations.

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1. INTRODUCTION

Cattle are important for the livelihoods of farmers in Southeast Asian countries as they enable the attainment of multiple necessities and services, such as income, draught power, fertilizer, savings ('walking bank') and social status. In 2018, Indonesia produced 497,000 tons of beef (DGLHS, 2018), which is about 73% of the national beef consumption of 684,000 tons (BPS, 2018). To meet the domestic demand for beef, Indonesia imported live cattle (almost 600,000 heads) from Australia in 2018 (Beef Central, 2020) and 160,000 tons of frozen beef in 2017 also predominately from Australia (BPS, 2018). Indonesia also imported 94,500 tons of buffalo meat from India in 2018 (Agri Xchange, 2019).

Nusa Tenggara Barat (NTB) province in eastern Indonesia has the fourth largest sub-population of the 16.6 million Indonesian cattle population (BPS, 2018). Realizing the significance of NTB's contribution towards the national beef industry, NTB's government launched a program called "Bumi Sejuta Sapi" (land of a million cattle) in 2009. The program is now entering a new phase aiming to improve the efficiency and profitability of beef production along the entire value chain.

Currently, cattle are raised either in a free grazing system (on the native pastures, in native forests, on crop residues or roadsides) or kept in pens and fed using a cut and carry feeding system utilizing native grasses with little technology application.

The Innovative Farming Systems and Capability for Agribusiness (IFSCA) activity, a collaboration between Massey University (New Zealand) and University of Mataram (Indonesia) funded by the Ministry of Foreign Affairs and Trade (New Zealand) aims to increase farm income through improved integration of corn and cattle production in the dry areas of Nusa Tenggara Barat (NTB) province, Indonesia. The innovations in cattle production are based on previous research on cow–calf operations that match the reproduction cycle with available feed resources (Alvarez, Wilson, & Preston, 1977; Dahlanuddin, Supriyadi, Panjaitan, Poppi, & Quigley, 2016), the fattening of bulls using the tree legume Leucaena (*Leucaena leucocephala*) as described in Dahlannudin et al. (2019) and other evidence on the roles of Leucaena for beef production (Buck, Rolfe, Lemin, & English, 2019; Queensland Government – Department of Agriculture and Fisheries, 2015; Radrizzani & Nasca, 2014). Through the IFSCA project, farmers and farmer groups received support, such as Leucaena seeds, pen construction, three-wheel vehicles and technical assistance.

In the IFSCA project areas, Leucaena is planted on marginal land, some of which is on slopes (5° or greater) that is currently planted with maize. Advantages of using marginal land include its nitrogen-fixing ability, long-term survival (up to 25 years), land stability (to avoid erosion), carbon sequestration ability and provision of firewood. The project supported farmer groups through the provision of funds (40%–50% of total costs) for the construction of drylots, and seeds for establishing Leucaena nurseries.

After three years of the project implementation, there is a need to understand and evaluate how farmers respond to the introduction of Leucaena-based cattle fattening, identifying factors contributing to the adoption and diffusion of these improved practices. An important secondary aim is to collate and analyze production metrics that allow the comparison and evaluation of improvements, which will be important for future benchmarking. This information can be used to inform local governments what is needed to sustain the adoption of this practice that has led to the improvement of smallholders' livelihoods. This paper discusses the adoption of the improved Leucaena-based cattle fattening system in the dryland in Nusa Tenggara Barat, Indonesia.

2. MATERIALS AND METHODS

A mixed method approach was used, combining both quantitative and qualitative research methods (Creswell, 2009). The quantitative research methods used involved measuring the weight gains of cattle and the use of Leucaena for cattle fattening. This was integrated with survey methodology to understand the degree of use of Leucaena and cattle management by local farmers who participated in the early stage of the project (2017) and those who participated in the later stages (2018–2020). Qualitative methods were applied to understand the adoption and diffusion of improved innovations introduced through the project and the reasons for the adoption and non-adoption of all or part of the innovations.

The Dompu district in Nusa Tenggara Barat was selected as the research location and consists of five regions where the project promoted and facilitated farmer groups and farmer learnings. These regions are Woja Subdistrict (Region 1), Pajo Subdistrict (Region 2), Manggelewa – southern areas (Region 3), Manggelewa – northern areas (Region 4), and Kempo Subdistrict (Region 5). A detailed description of the regions is presented in the results section.

Data collection was conducted during the project from 2017 to 2020. Various appropriate data collection instruments for quantitative and qualitative research, such as questionnaires, interviews and observation guides, were used. Purposive and snowball sampling techniques were used to understand the adoption and diffusion pathways and factors associated with the adoption rate. By the end of the project period (end of 2020), there were 25 farmer groups and more than 400 farmers who participated in the project.

Quantitative and qualitative data was analyzed using descriptive statistics, qualitative data transcriptions and trend/patterns analysis of responses.

3. RESULTS AND DISCUSSION

3.1. Description of Participating Farmers and Districts

The IFSCA project started in 2016 with five initial farmer groups representing five different farming systems that can be found in the Dompu region of Sumbawa. The rainfall pattern in this district provides a suitable environment for cattle production, and the cattle population in the last 10 years has met local consumption requirements with surplus for export to other Indonesian islands. A farmer group in Indonesia is defined as a number of farmers who gather together to address their problems and achieve common goals. The farmer groups were selected based on the following criteria: (i) The cattle population is mostly based on the indigenous Bali (*Bos javanicus*) cattle that have a high reproductive rate and have adapted to the local feed resources and climatic conditions; (ii) Dompu has a large area of grazing land which generates cattle for fattening, and (iii) Dompu has been declared an area for corn cattle integration, indicating that cattle are one of the priority commodities for development.

The five initial farmer groups (see Figure 1) represent five specific regions and farming systems within the Dompu region. Region 1 is the Woja Subdistrict, which consists of dry, flat land and hence farmers are reluctant to plant Leucaena along with corn, with all land utilized to plant corn in the wet season resulting in cattle not having sufficient feed or access to a grazing area during this time. Farmers are mainly from local Dompu ethnic groups. The Mada Lemba farmer group is located in this region. Region 2 is the Pajo Subdistrict, which consists of a mix of rice paddy and forest area, with some horticulture and tobacco farming. Farmers are a mix of the local Dompu community and transmigrants from Lombok. The Kampus Tani farmer group is located in this region. Region 3 is the Manggelewa south region, which consists of a mix of rice paddy and flat, dry, grazeable land. Farmers in this region are a mix of local Dompu and Balinese ethnic groups and it is the location of the Salaja Mbaru farmer group. Region 4 is the Manggelewa north region, which consists of drylands and the predominant land use is for corn cropping together with some rice and often a second corn crop in the rice fields during the dry season. The farmers here are transmigrants from Lombok. The Tekad Makmur farmer group is located here. Region 5 is the Kempo Subdistrict, which is characterized by drylands with slopes ranging from 5° to more than 30° that are used for corn production. Farmers involved in this area are mainly Balinese farmers who have a history of extensive cattle farming systems. This is the location of Bersama Sambi Maci farmer group.

Baseline data collected for the project highlighted that farmers traditionally let their cattle roam free (free range) over available grazing areas, while some farmers, especially the Bali and Lombok ethnic groups, have been used to keeping their cattle in stalls and feeding them with grass and fodder such as gamal *(Gliricidia sepium)* and wild Leucaena. Prior to the IFSCA project, farmers did not measure their cattle weight regularly to understand the importance of weight gain and to use this information to assist in making decisions to market cattle.

A further 20 farmer groups were added to the project in 2017 and 2018 resulting in a total of 464 farmers that were directly monitored and evaluated. Variables, such as cattle ownership, number of farmers involved in Leucaena planting, stall establishment, feeding practices, and socioeconomic impacts, were measured regularly. Collected data were tabulated and analyzed descriptively.

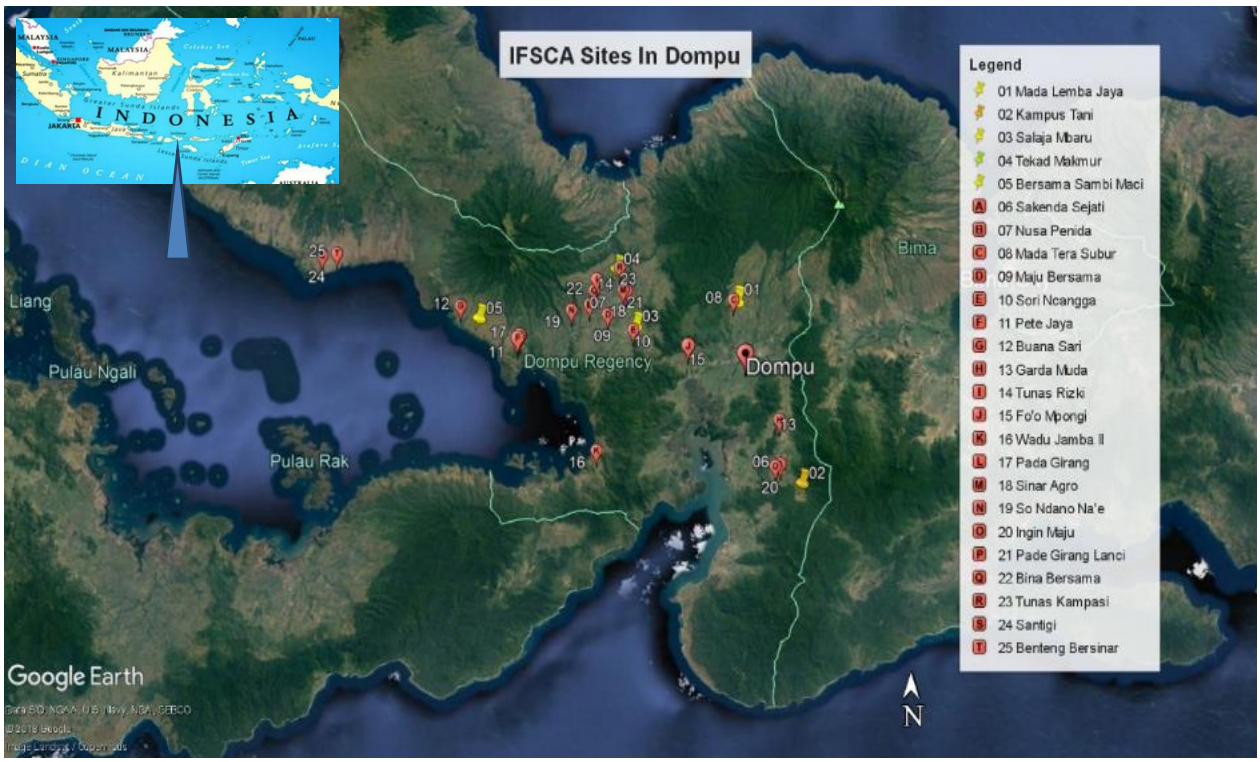

Figure 1. Locations of the five initial farmer groups (1–5; yellow pins) and the subsequent 20 new groups (red balloons).

3.2. Adoption of Leucaena-based Cattle Fattening by the First Five Farmer Groups

Data collected from monitoring the first five farmer groups showed that three farmer groups adopted Leucaena-based cattle fattening, namely the Bersama Sambi Maci, Mada Lemba, and Tekad Makmur farmer groups, while the other two groups failed to adopt the drylot system, not only in planting Leucaena, but also in fattening cattle. Sociometric studies on the adoption and diffusion of Leucaena-based cattle fattening highlighted that farmers around the three farmer groups that adopted the drylot system were interested in the innovation and started to follow by planting Leucaena on their farms and constructing their own feeding pens. This type of farmer-to-farmer learning has been used by the project to facilitate other farmers and farmer groups that has led to a total of 25 farmer groups within the IFSCA project. In addition to farmer-to-farmer learning, the diffusion of Leucaena-based fattening has been significantly promoted through cross visits and demonstration trials. After three years in the project from a zero base (defined by no cattle fattening or use of cultivated Leucaena), the number of farmers involved was 397 who were farming a total of 272 ha of Leucaena (see Table 2) and fattening 547 male cattle (see Figure 6).

3.3. Cattle Population, Ownership, and Breeds

The total cattle population in the five initial farmer groups by sex at start of the project (December 2016) is presented in Figure 2. The greatest number of cattle was found in the Bersama Sambi Maci farmer group, while the lowest was in the Mada Lemba farmer group. The lowest number of male cattle was found in the Kampus Tani farmer group. Farmers living in areas close to the Doro Ncanga communal grazing area in Dompu from the Salaja Mbaru and Bersama Sambi Maci farmer groups owned more cattle—mostly female cattle—because their cattle has access to free grazing during the wet season and also, for some, their animals could stay at the grazing area all year round. These groups also owned more of the Hissar cattle breed compared to the other farmer groups (see Figure 5).

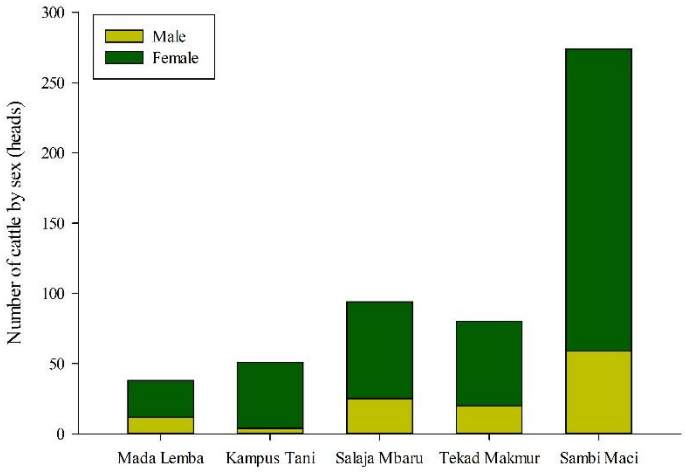

Figure 2. Cattle population in the initial five farmer groups.

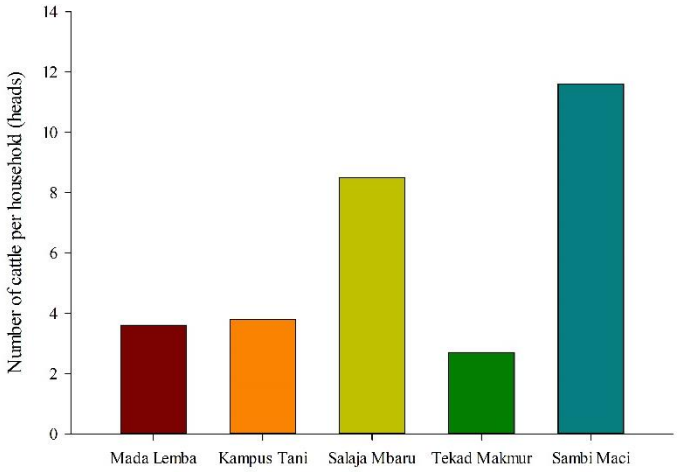

Figure 3. Cattle number per household in the five initial farmer groups.

Cattle ownership in the five initial farmer groups range between two to 12 cattle per household (Figure 3). Consistent with the total cattle population, farmers belonging to the Salaja Mbaru, and Bersama Sambi Maci farmer groups have more cattle compared to the Tekad Makmur, Mada Lemba and Kampus Tani farmer groups. These three farmer groups are far (70–80 km) from the Doro Ncanga communal grazing land and hence had little access to grazing land.

Within all the farmer groups, a large proportion of the cattle were owned by the farmers themselves (Figure 4), but farmers within Tekad Makmur and Kampus Tani also reared other peoples' cattle through a 50:50 profit-sharing agreement.

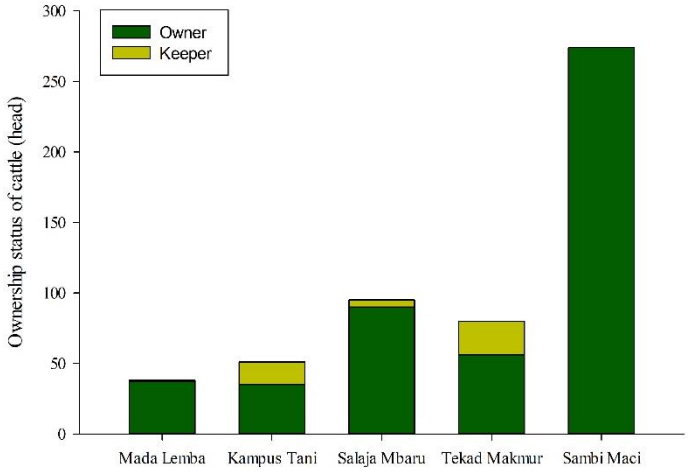

Figure 4. Ownership status of cattle in the five initial farmer groups.

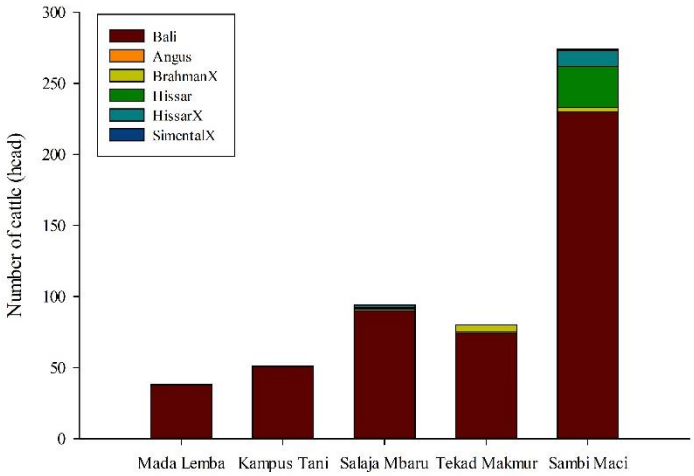

Figure 5. Cattle breeds in the five initial farmer groups.

Data on the cattle breeds of the five initial farmer groups indicated that most of the cattle are Bali cattle, while the rest consist of Hissar and Hissar x Bali cross, Brahman, Angus, and Simmental (see Figure 5).

3.4. Adoption of Leucaena-based Cattle Fattening by All Farmer Groups Across the Regions

Table 1 reveals that 37.1% of farmers across the 25 farmer groups have adopted the Leucaena-based fattening systems. Regions 3, 4 and 5 are characterized by a higher rate of adoption of fattening activities. Farmers in these regions own more land compared to the farmers in Regions 1 and 2. The primary data collected for this project found that average land ownership of farmers in these three regions was approximately 1.81 ha compared to the remaining two regions that had fewer Leucaena plantings and where average land ownership was 1.13 ha.

Table 1. Number of farmers involved in Leucaena-based cattle fattening (up to June 2020). The recently planted Leucaena in categories 1 & 2 was in its first year and not ready for harvest.

Category	Region 1	Region 2	Region 3	Region 4	Region 5	Total	
						n	%
(1) Recently planted Leucaena on own land but no fattening	36.0	36.0	19.0	7.00	5.00	103.0	22.2
(2) Fattening using wild Leucaena	12.0	12.0	15.0	14.0	13.0	66.0	14.2
(3) Fattening using wild Leucaena and recently planted Leucaena on own land	10.0	18.0	37.0	18.0	40.0	123.0	26.5
(4) Fattening using farmers' own Leucaena	19.0	12.0	29.0	56.0	56.0	172.0	37.1
Total number of farmers who have adopted recommended practices	77.0	78.0	100	95.0	114	464	100

Table 1 also indicates that 40.7% of farmers (189 out of 464 farmers) across the regions have fattened their cattle using wild and recently planted Leucaena, which indicates that they were familiar with the benefits of using Leucaena as a feed in a cattle fattening system. Again, a larger number of farmers in groups within Regions 3, 4, and 5 have adopted Leucaena-based fattening. Data presented in Table 2 indicates that the average number of Leucaena trees planted per household in Regions 3, 4 and 5 was between 391 and 984, which is enough to keep one to three cattle per household. Based on the calculation of cattle's dry matter intake requirement of 2.5% of live weight and estimated dry matter production of a Leucaena tree of 1–1.5 kg per tree, with a harvest interval of 2–3 months, a male Bali cattle weighing 250 kg will require around 300 Leucaena trees if it is to be fed 100% Leucaena.

Table 2. Number of farmers planting Leucaena and the area planted (up to June 2020).

Variables	Region 1	Region 2	Region 3	Region 4	Region 5	All
Number of farmers	64.0	74.0	113	85.0	61.0	397
Total land area (Ha)	102	140	182	258	207	889
Total Leucaena area (Ha)	29.6	52.9	107.1	33.6	48.4	271.6
Number of Leucaena trees	35,252	16,850	44,200	83,605	44,289	224,196
Average land ownership (Ha/HH)	0.97	1.28	1.52	2.00	1.91	1.54
Average Leucaena area (Ha/HH)	0.29	1.36	0.95	0.39	0.79	0.76
Average number of trees (trees/HH)	551	228	391	984	726	576

As a result of having Leucaena trees on their own land, the number of farmers using Leucaena to fatten their cattle is increasing. Figure 6 shows the number of cattle fattened and the average daily weight gain (ADG) of male Bali cattle in the five regions, which is very different compared to the baseline data in 2016 where no farmers fattened using Leucaena. During the project, farmers monitored their cattle's daily weight gain and understood the effect of Leucaena feeding. Consequently, the farmers' bargaining position has now increased as they use cattle's body weight to determine their cattle's selling price. The growth rates of 0.4 kg/day are similar to that achieved in Bali cattle fed Leucaena reported previously (Dahlanuddin, Yanuarianto, Poppi, McLennan, & Quigley, 2014) and about twice that of what is reported for Bali cattle fattened on grass alone (Dahlanuddin, Yulianto, Priyanti, Poppi, & Quigley, 2012).

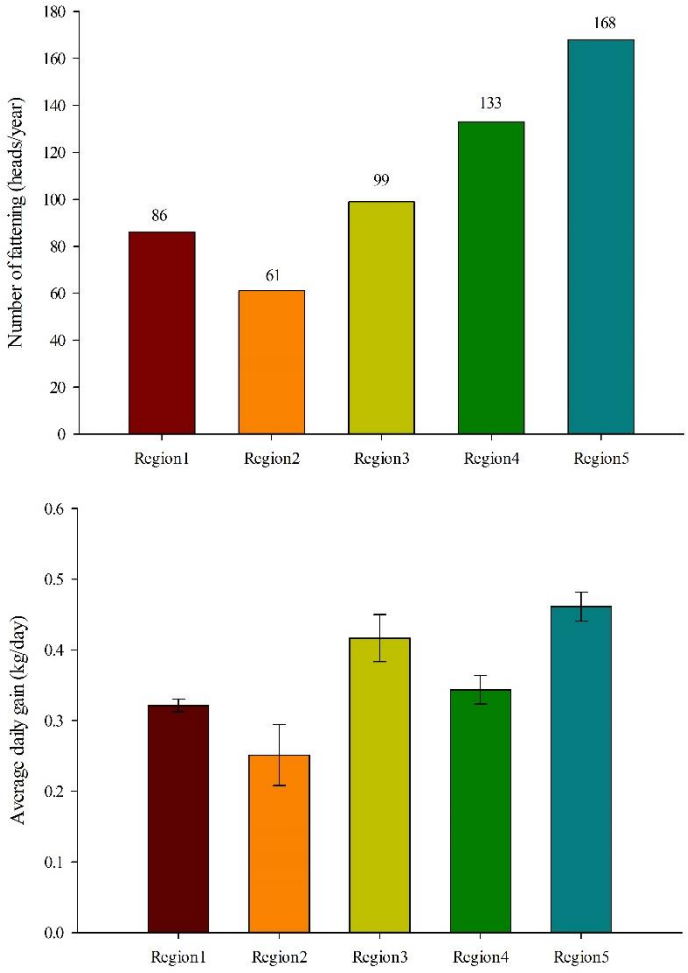

Figure 6. Number of cattle fattening regions and average daily weight gain by region in 2018.

3.5. Changes of Socioeconomic Conditions Due to Adoption of Leucaena-based Cattle Fattening

Data from focus group discussions conducted within the five regions confirmed changes in social and economic behavior. Farmers are now moving from subsistent types of cattle production to commercialization. Farmers are no longer keeping cattle just to fulfill their household needs for consumption and savings but are farming and keeping cattle because it is profitable. Once they perceive that they can make sufficient profit from selling, they sell their cattle and then buy replacement cattle. The increasing roles of female farmers in feeding and looking after cattle is another change in communities' social and economic behavior. Previously, male farmers used to go out to gather Leucaena or other feeds, but since planting Leucaena on their own land, cutting and collecting feed and feeding the cattle are now tasks performed by female farmers. Male farmers have more time to do other jobs, such as look after their crops or female cattle.

Leucaena-based cattle fattening has increased the number of cattle fattened and sold and hence farmers' income. Almost all groups in all regions claimed that their selling trend has increased, and household income has also increased.

4. DISCUSSION

This study found steady adoption and diffusion of Leucaena-based cattle fattening in the Dompu region from 2016 to 2020. The project has facilitated learnings from the first five farmer groups to other groups as evidenced by the increasing number of farmers involved in the project. Leucaena-based cattle fattening resulted in a higher cattle growth rate and promoted social and economic impacts on farming families and communities. Factors contributing to the rapid adoption and diffusion in Regions 4 and 5, for example, were that (1) the demonstration effects of Leucaena farms where other farmers observed Leucaena farms belonging to the Bersama Sambi Maci farmer group led to the involvement of the Pete Jaya farmer group and other surrounding groups, such as the Wadu Jamba farmer group; (2) farmers have experience in fattening cattle, and certain ethic groups in particular, such as the Balinese and those originating from Lombok, have a long history of fattening cattle compared to the local Dompu farmers. Farmers in these regions are also not as busy with crops as those in rice producing areas (Regions 1 and 2) and have a sufficient area of suitable land (mostly dry land on the slopes) for Leucaena planting; (3) effective learning facilitated and supported by the project's Agribusiness Support Centre and the field officers followed the concepts of Dale (1969), where people tend to learn more when they observe and then do it themselves. Cross visits and trials facilitated during the project also followed this concept. A recent extension project following this principle has been reported where farmers learned more through observation and doing it themselves, and from other farmers who have more experience rather than field agents with limited or no experience (Muktasam, Reid, Race, & Perdana, 2019a; Muktasam et al., 2019b; Race, Muktasam, & Reid, 2019). These factors contributing to the rapid adoption and diffusion of Leucaena-based cattle fattening are consistent with the concept of "Innovation Characteristics" where farmers tend to adopt innovations that have relative advantages, are compatible with local conditions and practices, are not complicated, and could be observed and tried (Rogers, 1995). The "Transformation of smallholder beef cattle production in Vietnam" provides more supporting evidence that the rapid adoption of farm-grown forages and stall-feeding was due to (i) a convincing innovation – the use of farm-grown fodder – that provided immediate benefits to farmers and provided a vision for local stakeholders; (ii) a participatory, systems-oriented innovation process that emphasized capacity strengthening; (iii) a value chain approach that linked farmers and local traders to markets; (iv) the formation of a loosely structured coalition of local stakeholders that facilitated and managed the innovation process; and (v) technical support over a sufficiently long time period to allow innovation processes to become sustainable (Werner, Khanh, & Duncan, 2013).

Moreover, the slow adoption and diffusion rates in Regions 1 and 2 have been attributed to factors, such farmers being busy with corn and rice cropping activities; farmers are not experienced in fattening cattle; farmers do not want to use cropping land to plant Leucaena; farmers see cattle as a way to save money rather than as a business venture; and farmers' land area, topography and ownership structure result in reluctance to plant Leucaena. Findings reported by Fujisaka (1994) and Long, Blok, & Coninx (2016) support these findings, especially the social and socioeconomic factors, and stated: "six overlapping reasons why farmers do not adopt are that farmers do not face the problem targeted by the innovation, farmer practice is equal to or better than the innovation, the innovation does not work, extension fails, the innovation costs too much, and 'social' factors" (Fujisaka, 1994).

Within the IFSCA project, roles within the Agribusiness Support Center (ASC) were created and this was a substantial factor which influenced the fast adoption and diffusion of Leucaena-based cattle fattening. The field officers employed by the ASC possess extensive knowledge on the innovations and local communities and have a commitment to work with farmers. The establishment of every new farmer group beyond the first initial five groups has been, to some extent, due to the "demonstration effects" of the first five groups facilitated by the roles of the ASC and their field officers.

There are at least three strategies conducted to sustain the adoption and diffusion of this improved cattle fattening practice. The first is to continue to promote farmer-to-farmer learning through cross study visits as it was done at the initial stage of the IFSCA project where farmers visited Leucaena sites in the Sumbawa district (Dahlannudin et al., 2019). Another way to promote farmer-to-farmer learning is to invite successful farmers to share their knowledge, skills and experiences through demonstrations. Sharing the experiences and benefits from cattle fattening practices will not only create awareness among other farmers, it will also create interest and the intention to apply or continue applying good agricultural practices (Tinh, Hung, Dzung, & Trinh, 2019). Facilitating field days is another option to promote effective farmer-to-farmer learning (Muktasam et al., 2019b). These strategies have been carried out through the IFSCA project. The formation of farmer groups and the use of the group approach in the project are the strategies taken to sustain learning among farmers that may lead to the adoption and diffusion of the innovations, even when the project has finished. This is in line with Williams, Wensveen, Grünbühel, & Puspadi (2022), who concluded that "a

focus on measures to build capacity and empower farmers with information to adapt and respond to change, regardless of project activities, is a much more important goal and indicator of impact than measuring adoption".

The second strategy involves the inclusion of the outcomes of this project into government policies and programs. Activities conducted through the project have influenced local government to adopt Leucaena-based cattle fattening. Examples include a government-funded project in Dompu for a 200 ha Leucaena plantation to be used for cattle fattening and a provincial government plan to plant 5000 ha of Leucaena to improve beef production. Further capacity-building activities for the local government's technical and extension staff are also needed in both cattle management and Leucaena plantation management (Nulik & Hau, 2019).

The third strategy to sustain the adoption of this practice is to promote public–private partnerships. Farmers can meet with people in the meat processing industry, hotels and restaurants, and can establish partnerships. By linking farmers with markets, they then have a clear market for their products. Farmers may also then have clear ideas about requirements regarding production quantity, quality, time and price well in advance that help to make good production and marketing decisions. Farmers claim that Leucaena-fed cattle have an attractive appearance (hence easy to sell) and the meat has a distinctive taste. There is a challenge here, however, to upgrade existing meat processing practices from selling hot beef in wet markets to producing high-quality beef that can be sold in high-end markets. The IFSCA has been facilitating a beef processor to improve the processing system (pre-slaughter, chilling, aging, packaging) and then links this abattoir to hotels and steak houses and sells direct to medium- to high-end household consumers.

Challenges to sustaining the project impact have been discussed by Ash, Dahlanuddin, & Sutaryono (2017). Some of the challenges are the subsistence farming practices where farmers only rear cattle for savings and emergency use and are therefore not business-oriented. The lack of consumer appreciation of meat quality means no significant price incentive for the high-quality cattle fattened with Leucaena, and this may discourage further expansion of the Leucaena-based cattle fattening system. The project has therefore started to promote the high-quality beef produced by this system to create a niche market and develop a premium local beef supply chain. The findings presented in this paper may address the question "*Why haven't silvopastoral systems expanded in Brazil?*" (Márquez, Ovani, & Abdalla, 2021).

5. CONCLUSIONS

Leucaena-based cattle fattening has been adopted widely in the five regions of Dompu, West Nusa Tenggara Province, since it was introduced in 2016. Almost all farmers participating in the IFSCA project have adopted some or all of the innovations introduced by the project. The high rate of adoption has been due to the immediate benefits of feeding cattle with Leucaena, which include significant improvements in cattle conditions and cattle growth rates. This has resulted in increased cattle prices and farm incomes. Sustaining the adoption of existing Leucaena-based cattle fattening can be encouraged through local government pathways, utilizing farmer-to-farmer learning and policy advocacy. Keeping and extending the existing critical roles of the Agribusiness Support Centre developed by the current project will lead to further developments in the cattle value chain and agribusiness sector.

The size of the areas selected for the project and time required for the development and collection of data on adoption is a limitation of the study. Further research needs to include economic analysis, including the benefit–cost ratio and environmental impacts of land use options, comparing maize monoculture, Leucaena monoculture for cattle fattening, and maize–Leucaena integration for cattle fattening. Additionally, provision of more detailed production and financial metrics will provide the means to reach greater numbers of farmers who may consider adopting these practices.

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