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Economic analysis of cattle fattening systems based on forage tree legume diets in eastern Indonesia

Análisis económico de sistemas de engorde de ganado basados en árboles leguminosos forrajeros en Indonesia Oriental

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Abstract

Research and government agencies in eastern Indonesia have identified 2 systems with potential to increase productivity and incomes of small-holder cattle producers: improved cattle feeding practices through forage tree legumes (FTL); and the development of more efficient and specialized cattle-fattening systems. Extensive research has been conducted on production and technical aspects of FTL-fattening systems, but there is a gap in research on economic incentives for households to adopt the systems. This paper provides an economic analysis of a leucaena-fattening system in a village in West Timor. It draws on trial data from associated technical research projects and detailed semi-structured interviews with farmers and other stakeholders to populate a bio-economic model built for the research. Under all measures of profitability, leucaena-fattening systems in representative households are profitable in the wet season. Importantly, 'returns to person days' are higher than off-farm incomes. The activity generates cash income, increasingly required to meet cash expenses in modern rural Indonesian society. However, returns vary considerably between households, are considerably lower in the dry season and, as would be expected, are sensitive to relative prices of feeder and finished cattle.

Keywords: Household budgeting, leucaena, profitability, small-holders, West Timor.

Resumen

Instituciones de investigación y desarrollo en Indonesia Oriental han identificado dos sistemas con potencial para aumentar tanto la productividad bovina como los ingresos de pequeños productores de ganado en la región: prácticas de alimentación mejorada de los animales mediante forraje de árboles leguminosos; y el desarrollo de sistemas de engorde de ganado más eficientes y especializados. A pesar de amplias investigaciones sobre aspectos técnicos y de producción de los sistemas de engorde basados en árboles leguminosos forrajeros, aún existe una brecha en la investigación sobre incentivos económicos para que los productores adopten los sistemas. Este trabajo presenta un análisis económico de un sistema de engorde de ganado basado en leucaena en una aldea en Timor Occidental, Indonesia. Basado en datos de experimentos de proyectos de investigación técnica y entrevistas semiestructuradas con agricultores y otras partes interesadas, se desarrolló un modelo bioeconómico específico para esta investigación. Bajo todas las medidas de

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rentabilidad, los sistemas de engorde con leucaena en fincas representativas son rentables en la estación lluviosa. Es importante destacar que los retornos a la mano de obra empleada son más altos que eventuales ingresos provenientes de actividades no agrícolas. El sistema estudiado genera ingresos que son cada vez más requeridos para cubrir los gastos pertinentes a la moderna sociedad rural en Indonesia. Sin embargo, los retornos varían considerablemente entre las fincas, son considerablemente más bajos en la estación seca y, como es de esperar, son sensibles a la relación del precio de compra de animales para engorde y el de venta de los animales para el matadero.

Palabras clave: Leucaena, pequeños productores, presupuesto familiar, rentabilidad, Timor Occidental.

Introduction

The province of Nusa Tenggara Timur (NTT) in eastern Indonesia faces substantial development challenges. The province is one of the least developed in Indonesia, with a per capita GDP one-quarter of the national average. In 2017 incomes of 25% of the rural population of NTT were below the poverty line (Rp 329,136 or AU$ 32 per month), compared with the national average of 13% (BPS 2018). Agriculture is a central economic activity in NTT, and livestock production makes up 16% of agricultural GDP. There are 60,000 livestock producers in NTT, the majority of whom own cattle (DGLAHS 2013), three-quarters of which are small-holders with 1–10 head (Mullik 2012). In particular parts of NTT, cattle sales can represent more than 80% of the family's cash income (Nimmo-Bell and ICASEPS 2007). Cattle also play a social role for ceremonies and as a source of 'savings' that can be cashed-in to meet large cash outlays including housing, school fees, health and transport.

In response to high beef prices over a sustained period, cattle numbers have almost doubled in the past decade from 555,000 in 2007 to more than one million in 2017 (BPS 2018). However, productivity is low as indicated by annual turnoff rates of just 13%, due to low weaning rates and long periods of slow growth to reach sale weight, for either slaughter or live cattle export (Waldron et al. 2012). Cow-calf production is conducted mainly in extensive grazing systems in NTT and various measures have been taken to improve reproduction and reduce calf mortality (Copland et al. 2011). The emergence of a cattle-fattening sector has potential to increase growth rates to reach sale weights at an earlier age and to create demand for feeder cattle (from the cow-calf sector). Of particular interest in relation to this paper, cattle-fattening has the potential to generate positive cash flows that are increasingly required in a society transitioning from a subsistence to a cash economy.

Forage tree legumes, particularly leucaena, have been identified as a central feed source for the development of the small-holder cattle-fattening sector. This has given rise to a body of literature on the impacts on cattle growth of feeding tree legume forage (e.g. Dahlanuddin et al. 2014, 2019; Shelton and the Project Team 2017). However, there has been a dearth of studies to verify the economic incentives for households to take up and sustain the systems, which is the focus of this paper.

Methods

Sites

The economic analysis on which this paper draws was conducted across 3 sites in the provinces of NTT and NTB, which have differing characteristics. This paper focuses on the West Timor village site of Oebola, where Bali bulls are fattened in pens on a leucaena-based diet. Leucaena is strip-planted with corn. The system is widely applicable to other areas of West Timor including Kupang and Amarasi, which are the largest cattle-producing areas in NTT. Results for the Sumbawa site of Jati Sari are reported in this issue (Dahlanuddin et al. 2019), including cattle systems, history, adoption, productivity, economics and meat output from the village.

The model

To assess household structures and incentives for FTL-based fattening, a bio-economic model was developed for a representative cattle-fattening household in Oebola. It is a partial budget, insofar as it focuses on the activity of leucaena production and cattle fattening. It is also a steady-state budget, with production and returns assessed over a specified fattening period, which is almost always less than 365 days. The focus on leucaena-fattening means that the model accounts for virtually all direct cost and revenue items. However, the budget does not account for environmental externalities including soil enrichment and reduction in over-grazing.

It is problematic to conduct a 'with and without' economic analysis of leucaena-fattening systems. Small-holders did not fatten cattle as a specialized activity prior to the extension of the systems. As elaborated in the 'scenarios' section of the paper, it is economically unviable to fatten cattle on a diet of crop residues and grasses, and grain is prohibitively expensive. Thus this analysis begins with a detailed discussion of a single

scenario of fattening with leucaena, namely a representative (typical) household in Oebola fattening 4 cattle in the wet season, with average prices over the period. Alternative scenarios – based on season, weight gains and prices – are then examined to test production and income effects. The model reports on various measures of profitability, the most relevant being 'returns to labor'. All budget items and formulae are explicitly stated in Excel spreadsheets that are publically available on request. All values are expressed in Rupiah and the exchange rate adopted is Rp 10,000 to AU$ 1 in 2014 when the research and fieldwork was conducted.

Data

Production data for the research were drawn from ACIAR project LPS/2008/054, which monitored 8 households in Oebola during 2013 and 2014 with a total of 30 head of cattle between them (Pakereng 2015). Price data collected from the monitored households were cross-referenced with meetings with traders and butchers and with weekly beef price data (MoA, various years). Costs and sales data were collected through focus groups and semi-structured interviews with 5 farmers. Village-level data were used to place the farmers in context and to establish a 'representative' or 'typical' fattening household, which is reported in this paper. Fieldwork was undertaken in August 2012, May 2014 and July 2015.

Results

Background on Oebola village

The budgeting for NTT focuses on Oebola village, Fatuleu Sub-District, Kupang District, West Timor. The system is based on corn cropping with strip-planting of leucaena and the fattening of Bali bulls in pens owned by individual households, all of which immigrated from other parts of Indonesia. In 2015 village statistics reported 276 households with an average of 4.2 household members. Household cropland sizes were 0.5–1 ha per household but some households had up to 2 ha split into parcels. Cattle were grazed collectively on village land and sometimes government forest land. Ninety-five percent of households earned a living from agriculture for both own consumption and sales. The main crops were corn (a single crop in the wet season), pumpkins and beans. Livestock included cattle, pigs and chickens. There were 1,453 cattle in the village, i.e. an average of 5.3 head per household. Cow-calf production in grazing systems predominated and calves were usually taken through to slaughter age. Many households bought-in feeder cattle to use in specialized feeding operations and most households fattened only 1 or 2 head at a time, with a maximum of 8.

Cattle fattening in Oebola

The budget results are summarized in Table 1 and detailed throughout the rest of the paper. Based on average results of monitored households (Pakereng 2015) the representative household sourced 4 bulls from its own herd or bought them in, with a starting live weight of 189 kg. Feeding periods were variable but averaged 170 days. There was a large difference in feed regimes and weight gains between seasons. In the wet season, bulls were fed a diet amounting to 2.5% of their body weight, comprised of 80% FTL (60% leucaena, 20% gliricidia), 17.5% native grasses and leaves and 2.5% corn silage. Average daily weight gain (ADWG) was 0.4 kg/d and bulls were sold at 257 kg live weight. In the dry season bulls were fed only 40% FTL (30% leucaena, 10% gliricidia) plus 60% native grasses and leaves and ADWG was only 0.2 kg/d, with bulls sold at 223 kg live weight.

Revenues

Cattle sales accounted for 98% of all cattle revenues for the household. Prices for both feeder and finished cattle were Rp 29,000/kg live weight in July 2015 (with price variations discussed in scenarios below). The model also accounted for revenue from manure and timber. While these were only 2% of total revenues, they were significant as a percentage of value added from fattening (finished cattle cost minus feeder cattle cost) at 7 and 12%, respectively. Of the manure produced (35% of DM intake), 10% was sold (Rp 250/kg dry), 20% was used for fertilizer (valued based on the substitution of urea and NPK fertilizers) and 50% was unused (which can have negative environmental impacts). The remainder (20%) was used for biogas which was valued based on reduction in household labor spent collecting firewood (1 hour per day) and kerosene usage for cooking and light in the household. The branches of leucaena trees were used for firewood. If 2 branches were used per cut (every 120 days) then 3,600 branches were collected over the fattening period with a value of Rp 100,000.

Capital investments

The representative household made capital investments in items used for multiple household activities over extended periods. The cost (both cash and labor) was amortized over the economic life of the asset and attributed to cattle fattening over the fattening period.

Table 1. Revenues, costs and returns (in Indonesian rupiah; 1 AU$ = 10,000 Rp) on leucaena-based cattle fattening for a representative household in Oebola village, West Timor, and weight gain and price scenarios. Highlighted cells refer to the scenarios analyzed in the paper and the key indicator of 'returns to labor'. Source: Author calculations; all values are expressed for a fattening period for the number of cattle specified, except 'returns to labor', which are expressed on a per day basis.

BUDGET SUMMARY - over fattening period	Wet season - representative household	% of category	Dry season - representative household	Wet - best performing	Wet - worst performing	Wet - price increase 15%	Wet - price decrease 15%	Grass-corn stover diet
Main parameters								
Cattle								
ADWG (kg/day)	0.4		0.2	0.8	-0.2	0.4	0.4	0.15
Weight exit of household (kg)	257		223	325	155	257	257	214.5
Feed								
DM intake (kg/head/day)	5.6		4.1	6.4	4.3	5.6	5.6	5
Proportion FTL in diet	80%		40%	80%	80%	80%	80%	0%
Prices								
Cattle purchase price (Rp/kg LW)	29,000		29,000	29,000	29,000	29,000	29,000	29,000
Cattle sales price (Rp/kg LW)	29,000		29,000	29,000	29,000	33,350	24,650	29,000
Revenues	**30,468,838**		**26,512,614**	**38,363,979**	**18,626,126**	**34,940,638**	**25,997,038**	**25,534,375**
Cattle sales	29,812,000	98%	25,868,000	37,700,000	17,980,000	34,283,800	25,340,200	24,882,000
Manure	556,838	2%	544,614	563,979	546,126	556,838	556,838	552,375
Leucaena branches	100,000	0%	100,000	100,000	100,000	100,000	100,000	100,000
Costs (excl labor and capital)	**23,274,655**		**23,308,655**	**23,274,655**	**23,274,655**	**23,274,655**	**23,274,655**	**23,152,777**
Capital investments								
Depreciation of leucaena, pens, water, motorbike, biogas	185,778	1%	185,778	185,778	185,778	185,778	185,778	182,900
Production costs								
Cattle purchase	21,924,000	94%	21,924,000	21,924,000	21,924,000	21,924,000	21,924,000	21,924,000
Fuel and water	237,534	1%	271,534	237,534	237,534	237,534	237,534	118,534
Veterinary and additives	364,000	2%	364,000	364,000	364,000	364,000	364,000	364,000
Cattle marketing	228,000	1%	228,000	228,000	228,000	228,000	228,000	228,000
Crop shading and moisture	335,342	1%	335,342	335,342	335,342	335,342	335,342	335,342
Gross profit	**7,194,183**		**3,203,959**	**15,089,324**	**-4,648,529**	**11,665,983**	**2,722,383**	**2,381,598**
Less capital costs (feeder cattle and infrastructure)	1,938,169		1,938,169	1,938,169	1,938,169	1,938,169	1,938,169	1,938,169
Net profit (excl own labor)	**5,256,013**		**1,265,789**	**13,151,155**	**-6,586,698**	**9,727,813**	**784,213**	**452,638**
Divided by family labor, of which	86		105	86	86	86	86	94
Capital investments	0.8	1%	0.8	0.8	0.8	0.8	0.8	0.6
Cattle purchase and sales	8	9%	8	8	8	8	8	8
Feeding costs	56	65%	75	56	56	56	56	64
Kandang work	21	25%	21	21	21	21	21	21
Hours per day on cattle fattening	**4.0**		**4.9**	**4.0**	**4.0**	**4.0**	**4.0**	**4.4**
Returns to labor (person days)	**61,463**		**12,097**	**153,788**	**-77,024**	**113,756**	**9,170**	**4,821**

To meet dietary requirements of the 4 bulls, the household required a total of 1,200 trees with a 120-day interval between harvests, strip-planted on the land of the household. Planting costs included fencing, purchase of seeds, nursery (poly bags, bedding, shade cloth) and transplanting (labor and transport). The modest up-front costs (Rp 308,000 in cash and 13 person days labor) were negligible when depreciated over 40 years.

The costs of constructing a pen (nails, wire, timber, cement, sand, gravel, reinforcing, troughs, roof and other items) were higher than for trees (Rp 1.35 million) but also low when depreciated, given a lifespan of over 20 years and fattening 160 cattle. The 'design capacity' of the pen was 5 head. Given the actual number (4 head) and time not on feed (26 days) capacity utilization was 72%, which increased overhead costs per head.

The cost of a motorbike (used to transport feed and marketing of cattle) was high but the machine was used for fattening for only 20% of the time and was depreciated over a life-span of 15 years. Most households had a well that lasts 15 years at a cost of Rp 1,500,000 plus the costs of meals for workers that dig it. Biogas facilities (pits and converters) are commonly installed in West Timor to use effluent from the pens. Equipment is free (as part of a government program) but costs are incurred for meals for installers and household labor, especially to dig the pit and for maintenance (cleaning out pits and lines).

When costs of all capital items were amortized, depreciation costs totaled Rp 186,000 per fattening period. Together, these made up <1% of total costs and were eclipsed by other costs, so appear to be small. However, it is important to note that these are up-front costs (in land, labor and capital) that can be significant for households when first investing and can be a barrier to adoption. While loans are available through formal and informal channels including banks with subsidized loans, traders and profit-sharing arrangements with other households (Waldron et al. 2012), households usually use their own limited savings for these infrastructure items.

Production costs

Production costs are incurred specifically for cattle fattening on a daily basis or within the fattening cycle and are directly linked to production volumes. Feeder cattle purchase costs accounted for 94% of total costs. Self-produced bulls were valued as an opportunity cost (that could otherwise be sold) or as a cash cost when bought in. Costs of cattle purchases, mainly from a nearby live cattle market, included search costs (telephone, fuel and household labor), trucking and broker fees. Cattle were sold to traders at the farm gate and so incurred negligible sale costs.

After leucaena has been established there are no additional cash costs but there are significant labor costs for collection and transport. In the wet season all members of the household traveled an average of 1 km (range of 0.5–5 km) to collect forage twice per day, taking 1.5 hours. Motorbike fuel was Rp 700 per day. The collection of native grasses and leaves in the wet season was less time-consuming because it comprised the smaller part of the diet but was more labor-intensive to collect from scattered trees and bending over to cut grass. Labor costs to collect native grasses and leaves in the dry season were high (2 hours per day). Corn stalks were fed after harvest (at the end of the wet season), which required labor for cutting, transport and storage over a few days but little after that.

Several households in the group paid Rp 240,000 per year for access to group water supplies (access, pipe maintenance, fuel for pump) of which about 30% was used for cattle fattening. The household spent 30 minutes per day collecting and distributing water to the troughs in the pen. The household spent another hour per day in cleaning pens and cattle management.

Veterinary costs included vaccination (for anthrax and haemorrhagic septicaemia to allow for live export), one medical check (from local vet), a vitamin supplement and a small amount of salt. The total veterinary treatment costs (Rp 364,000 over a fattening period) were the second highest cash outlay.

Crop shading and moisture competition were included as additional costs of production. When 1 ha of corn is planted in the wet season and strip-cropped with leucaena, it is assumed that the grain yield (2,400 kg/ha) is reduced by 10%. Valued at Rp 3,000/kg, the forgone revenue is Rp 720,000 or Rp 335,000, when allocated over a fattening period.

Returns to cattle fattening

The returns (or profits) were estimated in different ways to provide different measures of profitability. Subtraction of costs from revenues provided 'Gross profit', which was positive in the wet season (at more than Rp 7 million over the fattening period) but declined to less than half of this in the dry season. Capital costs were deducted from gross profits to give 'Net profit'. Few households took out loans, but an opportunity cost was applied to the money invested in cattle that could otherwise be invested. The interest rate on a deposit in a savings account was used to value the opportunity cost of capital (8%). For large and expensive inputs like feeder cattle, the opportunity costs of capital were significant.

The next section on family labor reports the labor inputs into cattle fattening. The majority of labor was used on feed collection and watering, followed by work in pens, then by cattle marketing. Labor input into infrastructure was allocated over the fattening period and was small. The total labor inputs were converted into hours per day in cattle fattening (i.e. 4 hours for 4 cattle in the wet season), then converted into an 8-hour working day (i.e. half a day).

'Net returns' were divided by total labor input to derive 'Returns to labor', which provided the most useful indicator of profitability. This provided an indication of the profits from cattle production that a household was making from their own labor and management, and allowed comparison with other farm and off-farm work. Results for the representative household suggested that returns to cattle fattening in the wet season were positive (Rp 61,463), which compared favorably with average off-farm work (Rp 45,000). Comparisons were not so favorable in the dry season. At Rp 12,097 per day, income was at or below the poverty line. However, it must be considered that cattle can be produced all-year-round compared with off-farm work, which can be seasonal or inconsistent. Farmers may also be attracted to the customs and pride of running their own enterprise.

Budget results from 1 ha of corn in Oebola using (low) yields from 2015 and 2016 suggested that returns to person days were comparable with cattle fattening in the wet season. Because of its central role in household consumption and cash sales and its agro-climatic suitability, farmers in Oebola continue to grow corn. While strip planting of leucaena reduces corn yields (by 10%), it is integrated into the corn cropping, and not a substitute activity.

Scenarios

While the discussion above examined an average household in 2 seasons, there is large variation between households and natural and market conditions. A range of scenarios are reported in Waldron et al. (2015) including changes to rations, weight gains, fattening period, price, capital investment, labor cost and sales channels. This paper examines just the major variables – weight gain and price.

Weight gain. Profitability of feeding in the wet season was far greater than in the dry season for the representative household. By far the most important determinant was the difference in ADWG (0.4 vs. 0.2 kg/d) due to diet and compensatory weight gain early in the wet season. The labor cost in collecting native grasses and leaves in the dry season was also slightly higher than collecting FTL leaves in the wet season. The differences in ADWGs lead to returns to labor of Rp 61,463 in the wet season more than 5 times the returns in the dry season (Rp 12,097).

Households in the group with highest gains in the wet season (0.8 kg/d) recorded very high returns (Rp 153,788), while those with lowest weight changes (-0.2 kg/d) operated at a heavy loss (Rp -77,024).

Prices. Profitability is also sensitive to market trends and especially the relative prices of feeder and finished cattle, which are a function of market conditions, weather, household conditions, the skills of buyers and sellers in appraising cattle (visually) and timing (ceremonies, the issue of export permits or when school fees are due). If finished cattle prices are 15% higher than feeder cattle prices, returns increase strongly by 86%, but if they are 15% lower than feeder prices, cattle fattening is barely a break-even activity (Rp 9,170).

Returns without FTL. It is also useful to examine returns to fattening without leucaena. This is done in the modelling by assuming a diet of improved grasses (80%) and corn stover (20%). However, this would not be possible throughout the wet season because corn is harvested at the end of the wet season, unless corn stover was carried over from the previous season or was purchased in. While the stover could be stored and used in the dry season, quantities of grass available would be insufficient or very time-consuming to collect. Weight gains are reduced to 0.15 kg/d, which is a generous assumption given comparisons in various feed systems and locations (Quigley et al. 2009; Panjaitan 2012; Dahlanuddin et al. 2014). Time to chop stover increases from 0.1 to 0.5 hours, and to collect grass and leaves from 1 to 2.5 hours. In this case, 'Returns to person days' are very low at Rp 4,821, indicating that cattle fattening is not biologically or commercially viable without leucaena.

Conclusions

Analyses reported in this paper confirm the intuitive understanding that cattle fattening on a leucaena-based diet is biologically and economically viable for most small-holders in West Timor under most conditions. Leucaena is a low-cost input, provides feed through the dry season (albeit at a lower yield) and generates reasonable weight gains. Cattle fattening is capital-intensive, but allows for rapid turnover of both cattle and capital. Cattle fattening is not land-intensive, can be done under various ownership (owner-keeper) arrangements, and is relevant for a wide range of households. These factors explain the growth of leucaena-fattening systems in NTT.

Growth in the sector could be disrupted if circum-stances differed. Beef prices were buoyant for most of the

2010s and market fundamentals remained strong, but prices have fluctuated in recent years (for policy reasons, including trade policy and domestic support), which may affect incentives. Cattle fattening with leucaena is relatively labor-intensive. In countries and regions where there are good alternative opportunities for work and wages, small-holders can be drawn out of cattle production (Waldron et al. 2018). While cattle fattening may provide reasonable returns for small-scale farmers (such as the representative household in this study), profits of AU$ 6 per day will not make them rich. Future growth in the sector may see the emergence of more large, skilled and entrepreneurial fattening-trading households, which could utilize leucaena sometimes through land and cattle-/land and labor-sharing arrangements.

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References

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BPS (Biro Pusat Statistik). 2018. Statistical Yearbook of Indonesia. BPS, Jakarta, Indonesia. bit.ly/2ZcbPKf

Copland R; Jelantik G; Mullik M; Belli HLL; Soigen J; Nalley A; Benu F. 2011. Evaluating strategies to improve calf survival in West Timor villages. Final project. Australian Centre for International Agricultural Research (ACIAR), Canberra, ACT, Australia. bit.ly/30w1u9v

DGLAHS (Directorate General for Livestock and Animal Health Statistics). 2013. Statistik Peternakan dan Kesehatan Hewan (Livestock and Animal Health Statistics). Direktorat Jenderal Peternakan dan Kesehatan Hewan, Jakarta, Indonesia.

Dahlanuddin; Yanuarianto O; Poppi DP; McLennan SR; Quigley SP. 2014. Liveweight gain and feed intake of weaned Bali cattle fed grass and tree legumes in West Nusa Tenggara, Indonesia. Animal Production Science 54:915–921. doi: 10.1071/AN13276

Dahlanuddin; Panjaitan T; Waldron S; Halliday M; Ash A; Morris S; Shelton HM. 2019. Adoption of leucaena-based feeding systems in Sumbawa, eastern Indonesia and its impact on cattle productivity and farm profitability. Tropical Grasslands-Forrajes Tropicales 7:428–436. doi: 10.17138/TGFT(7)428-436

MoA (Ministry of Agriculture). Various years. Buletin Analisis Perkembangan Harga Komoditas Pertanian. Kementerian Pertanian Republik Indonesia, Jakarta, Indonesia. bit.ly/2z9vGet

Mullik M. 2012. Pembangunan Pertanian Yang Selaras Wilayah Lahan Kering Iklim Kering di Indonesia: Potensi, tantangan, dan strategi pengembangan. Presentation for Pertemuan Alumni SMKPPN, Kupang, Indonesia, 27 October 2012.

Nimmo-Bell and Company Ltd; ICASEPS (Indonesian Center for Agriculture Socio-Economic and Policy Studies). 2007. Value chain analysis for SADI agri sectors: The NTT beef industry. IFC SADI Agri Sectors, Jakarta, Indonesia. bit.ly/2zdszCk

Pakereng C. 2015. Progress in adoption of bull fattening with FTL in new (and existing) locations and the keys to success. Villages: Oebola Dalam, Naunu, Camplong I, Nunsaen, Ekateta, Uel, and Raknamo, West Timor, Kupang District. Presentation at project workshop LPS/2008/054, Carnarvon Gorge, QLD, Australia, December 8–9, 2015.

Panjaitan T. 2012. Performance of male Bali cattle in village system of Lombok. In: Koonawootrittriron S; Suwanasopee T; Jattawa D; Boonyanuwat K; Skunmun P, eds. Improving smallholder and industrial livestock production for enhancing food security, environment and human welfare. Proceedings of the 15th AAAP Animal Science Congress, Bangkok, Thailand, 26−30 November 2012. p. 956−959. bit.ly/2KJOrvj

Quigley SP; Poppi DP; Budisantoso E; Dahlanuddin; Marsetyo; McLennan SR; Pamungkas D; Panjaitan T; Priyanti A. 2009. Strategies to increase growth of weaned Bali calves. Final Report LPS/2004/023. Australian Centre for International Agricultural Research (ACIAR), Canberra, ACT, Australia. goo.gl/yMDCnB

Shelton HM and the Project Team. 2017. Improving smallholder cattle fattening systems based on forage tree legume diets in eastern Indonesia and northern Australia. Final report. Australian Centre for International Agricultural Research (ACIAR), Canberra, ACT, Australia. goo.gl/b9RX5N

Waldron S; Dahlanuddin; Mayberry D; Mulik M; Quigley S; Poppi D. 2012. Eastern Indonesia agribusiness development opportunities - analysis of beef value chains. Final report. Australian Centre for International Agricultural Research (ACIAR), Canberra, ACT, Australia. espace.library.uq.edu.au/view/UQ:326414

Waldron S; Halliday M; Shelton HM; Ngongo J; Nulik J; Nulik D; Kusuma Putri Utami S; Panjaitan T; Baiq Tutik Y; Dahlanuddin. 2015. Economic analysis of cattle fattening systems based on forage tree legume diets in eastern Indonesia.

Final Report. Australian Centre for International Agricultural Research (ACIAR), Canberra, ACT, Australia. bit.ly/33JxicJ

Waldron S; Pham L; Smith D; Hieu PS; Dong XX; Brown C. 2018. Macro developments in the China and Southeast Asia beef sector. Animal Production Science 59:1001–1015. doi: 10.1071/AN17434

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