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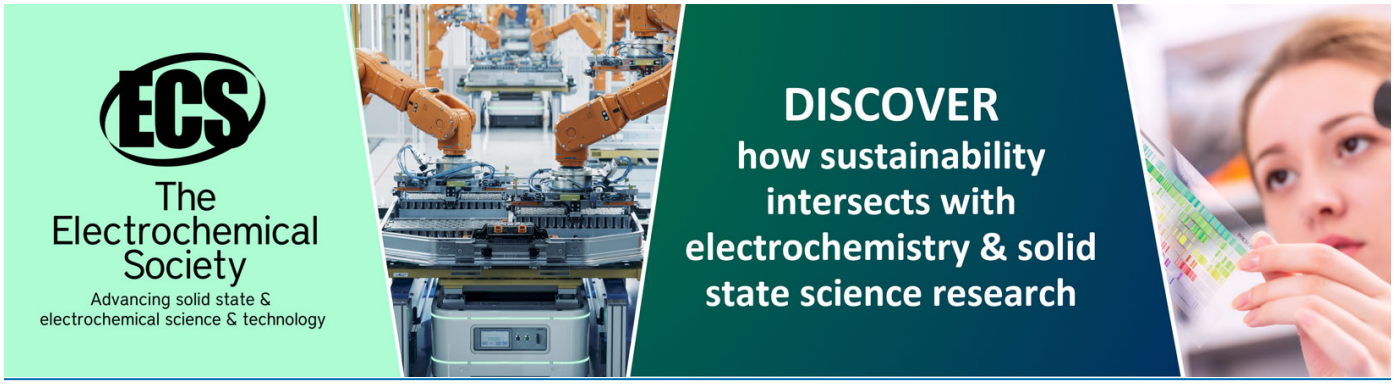

A successful smallholder cattle fattening project based on leucaena diets in eastern Indonesia

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Abstract. This paper describes the outcomes of a five-year (2011-2016) partnership project between the Indonesian Government and the Australian Centre for international Agricultural Research. The objective was to promote the use of *Leucaena leucocephala* for fattening cattle in the Provinces of West Nusa Tenggara (NTB) and East Nusa Tenggara (NTT). Detailed biophysical and socio-economic measurements demonstrated that it was possible to double productivity of smallholder cattle by improving their nutrition based on feeding leucaena, thus improving the livelihoods of farming families. The results highlighted an opportunity to similarly enhance productivity of other smallholder cattle enterprises in Indonesia and in other tropical developing countries.

1. Introduction

From 2011 to 2016, a collaborative initiative was undertaken by the Indonesian Government and the Australian Centre for International Agricultural Research (ACIAR) to conduct research and facilitate the adoption of forage tree legumes for the purpose of enhancing cattle fattening practices. This paper focuses exclusively on the outcomes associated with the utilization of leucaena for the purpose of fattening cattle in the Provinces of West Nusa Tenggara (NTB) and East Nusa Tenggara (NTT).

These Indonesian Provinces, recognized as regions with substantial potential to increase smallholder beef production, have approximately 1.34 and 1.25 million cattle respectively. Enhancing the productivity of fattening operations was identified by provincial agencies as a crucial strategy for augmenting the financial well-being of rural communities, as cattle significantly contributeto generation of household income. At present, smallholder cattle fattening systems exhibit low turn-off rates, as well as subpar carcass quality. These issues mostly derive from the inadequate protein nutrition provided to cattle in traditional feeding practices. Socio-economic restrictions also arise from inadequate understanding of improved forage options, the significance of good animal nutrition, challenges in accessing loans, restricted land availability, and deficiencies in extension services and training [1].

Utilization of the tree legume leucaena (*Leucaena leucocephala*) is widely accepted as a viable strategy for enhancing the provision of high-quality protein supplements to cattle, particularly during periods of drought [2]. Demonstration of its value has been observed extensively in tropical regions worldwide. In the state of Queensland, Australia, over 200,000 hectares of leucaena pastures have been

cultivated by graziers seeking a highly efficient and lucrative technique for producing higher quality "grass-fed" cattle [2]. There have been isolated instances documented in the Provonces of Nusa Tenggara Barat and Nusa Tenggara Timur where farmers have employed the use of leucaena for the purpose of livestock fattening [3].

2. Objectives

The primary aim of the project was to enhance rural income by augmenting the rate of turn-off and sales from smallholder cattle fattening in the NTT and NTB Provinces of Indonesia. This objective was pursued by promoting the greater utilization of high-quality leucaena fodder in cow diets. The work comprised study of:

a) Existing planting and feeding practices where farmers and villages had been successfully using leucaena to fatten cattle.
b) Possible occurrence of subclinical toxicity in cattle consuming leucaena to determine if intake and productivity might be hampered. The impact of leucaena feeding on gastrointestinal worm burden was also examined.
c) Obstacles and opportunities to implementing leucaena feeding practices in various cattle fattening systems and locations. It was envisaged that crucial components and tactics necessary to promote thegeneral adoption of these practices could be identified.

3. Methodology

3.1 Field research officers.

The initial task was recruitment of a field research (FR) team consisting of nine young individuals who had recently completed their tertiary education. This team had the responsibility of conducting research, development, and extension activities focused on smallholder agriculture, under the guidance and supervision of project leaders. The field researchers underwent training in the utilization of leucaena as a means to enhance the weight gain of cattle, as well as in the intricacies of group dynamics relevant to their interactions with farmers. The guidance and support from experienced project personnel from Indonesia enhanced their abilities and technical proficiency.

3.2 Establishment of leucaena

A comprehensive evaluation was undertaken to assess the various techniques employed for the establishment of leucaena at multiple project locations in West Timor, where a considerable number of novice farmers had recently initiated leucaena cultivation. The aim of the study was to examine the ways in which farmers modified their planting methods in order to accommodate different climatic and soil conditions, while still achieving good growth of leucaena [4].

3.3 Existing feeding practices

The existing and upgraded feeding practices and growth patterns of Bali bulls in leucaena-based fattening regimens were studied. This investigation was conducted in the rural community of Jatisari, located in the Sumbawa district of Bali. The study collaborated with 21 villagers and obtained data from a sample size of 276 Bali bulls throughout a period spanning from 2011 to 2016 [1]. The parameters monitored encompassed the average daily gain (ADG) of the bulls, the amount of feed supplied to them, and their sale weights.

3.4 Leucaena toxicity and parasite control

This investigation examined the incidence of DHP toxicity and the presence of the rumen bacterium *Synergistes jonesii* in cattle that were ingesting leucaena within the same hamlet. Urine samples were collected, stored, and subjected to high-performance liquid chromatography (HPLC) analysis to determine the presence of dihydroxyphenylalanine (DHP). Rumen fluid was collected, whenever feasible, and analysed at the CSIRO Animal, Food & Health Sciences laboratory in Brisbane, for PCR identification of *S. jonesii*. The investigation encompassed an examination of the genetic variation in *S.*

jonesii in rumen fluid and/or fecal samples obtained from Jatisari cattle. Findings were compared to data from similar analysisof Australian cattle in Queensland, as well as from cattle, sheep, goats, and buffalos in Thailand, Vietnam, China (including yak), and Brazil. The microbial DNA was isolated from the samples and subsequently amplified using a specific set of 16S rDNA nested PCR primers designed for *S. jonesii*. The PCR products that exhibited positive results for *S. jonesii* were further subjected to alignment withthe complete *S. jonesii* 16S rDNA sequence to identify single nucleotide polymorphisms (SNPs) [5].

The present study also aimed to examine the impact of leucaena consumption on the control of gastrointestinal parasites in comparison to alternative control methods. A total of 92 bulls, with an average age of roughly 1.9 years, were subjected to monitoring. Samples of feces were gathered to determine the number of eggs present, and following this, all male cattle were administered with Albendazole at a dosage of 7.5 mg per kilogram of body weight. The frequency of monitoring worm burdens was monthly subsequent to the administration of Albendazole, as documented by [5].

3.5 Research methods to develop extension strategy.

3.5.1 Selection of farmers. In each of the two Provinces, farmer groups were selected in locations where leucaena feeding already existed and in locations where there was no history of intensive feeding with leucaena. We also worked with successful individual farmers, who became case studies, to understand the reasons for their success.

The selection process for villages and hamlets involved the consideration of many criteria. These criteria encompassed factors such as ownership of land and animals, the prevalence of cattle-related activities, the presence of suitable land for leucaena cultivation, the current utilization of leucaena as cattle feed, the geographical position and accessibility of the village, as well as the functionality of the community group.

During the establishment of the demonstration sites, we worked with about 2,000 farmers in NTT (West Timor and Sumba) and NTB (Lombok and Sumbawa). A comprehensive examination was undertaken to assess the present state of these groups, with the aim of exploring the technical, economic, and socio-cultural dimensions of cattle raising in thedesignated regions. A participatory needs and opportunity assessment was undertaken utilizing focus group discussions and interviews with farmers, extension officers, and community leaders. The main barriers and opportunities were identified and categorised, and a framework for an extension strategy was drafted.

3.5.2 Extension materials. A total of twelve promotional movies, accompanied by illustrative photographic images, was created and employed among farmers, extension workers, and policy officials to promote and facilitate the adoption of fattening methods centered around leucaena. The movies were shown to over 60 government extension employees, and more than 100 farmer leaders. Furthermore, these videos were disseminated to educational institutions located in eastern Indonesia, as well as throughout the nation. These videos can be accessed online on the YouTube platform at the following URL: https://www.youtube.com/channel/UCzJ2nYUlS5No28HaI_2SdnA

A pilot extension strategy was implemented and evaluated. Group visits by farmers to successful farmer groups and individual farmers, permitting farmer to farmer communication, were used to highlight how successful farmers operated.

3.5.3 Engagement with Government and NGO stakeholders. We established robust connections with both governmental and non-governmental organizations. In the context of NTT, we received assistance from governmental bodies operating at the Provincial and Kabupaten (District) Levels. In the Province of NTB, memorandums of understanding (MOUs) were drafted and executed to establish formal connections with the Bupati (regional leader) of West Sumbawa, the Head of Dinas Peternakan (government livestock agency) in Sumbawa District, and the Head of Dinas in Central Lombok.

3.5.4 Communication and dissemination. Extensive communications and information distribution wereemployed to optimize social and technical interaction among team members and with other relevant parties. Additionally, we conducted frequent meetings and conversations with numerous farmer groups and people, as well as with governmental and non-governmental entities.

3.5.5 Training. The prioritization of ongoing training for young field researchers was a consistent and enduring focus. Most participants exhibited positive responses and displayed significant enhancements in their abilities. During the later stages of the project, training courses were developed and conducted for extensionpersonnel from the Livestock and Extension Departments. The courses were enhanced with supplementary resources, including of a set of 12 training videos focused on different facets of cattle fattening using leucaena.

4. Results and discussion

We developed a comprehensive understanding of the various techniques necessary to:- successfully establish leucaena; enhance management practices to improve housing and hygiene of bulls; and the impact of these practices on cattle productivity. Additionally, there was a recognition of the obstacles that hindered the widespread adoption of these approaches. The aforementioned research was recorded and published by [1] and [7].

4.1 Where can leucaena be grown?

The utilization of agro-ecological zoning (AEZ) was employed as a methodology to systematically assess the biophysical appropriateness of various geographical areas for leucaena production. This assessment considered factors such as soil characteristics, climatic conditions, altitude, and other relevant parameters. The AEZ approach relied on the expertise and knowledge of qualified professionals in the field. The task of conducting this work for NTT was previously undertaken in a different ACIAR project (specifically AS2/2000/157). Based on the GIS mapping analysis, it can be inferred that a significant portion of NTT Province possesses favourable conditions for cultivating leucaena. These conditions include a tropical climate and soils with a pH level ranging from neutral to alkaline. Currently, there is a lack of GIS suitability maps for the Province of NTB. Table 1 displays the soil and climatic conditions that are conducive to the growth of leucaena.

4.2 Establishment of leucaena

Farmers in West Timor implemented diverse planting strategies in order to establish leucaena [4]. Some prepared seedlings in poly-bags, with the intention of planting them during the early stages of the rainy season, typically the months of December to February. Some used direct seeding techniques into maize cultivation at the onset of the wet season. Another alternative was to utilize bare-root seedlings acquired from beneath well-established tree rows. Observations in NTB showed that famers also achieved excellent success using bare root seedlings obtained from high density plantings in small nursery gardens.

4.3 Tarramba leucaena

The leucaena cultivar Tarramba was initially introduced to Indonesia in 2001/2003 as part of the ACIAR Project AS2/2000/157 [7]. The cultivar was identified as favoured by cattle, less susceptible to psyllids, possessing more foliage, exhibiting prolonged durability during the dry season, and offering greater pole quality. There is a general consensus that it is superior in comparison to local or Cunningham variants. The Provincial and Livestock agencies provided significant support for the development and utilization of Tarramba.

This interest created a significant need for seeds. Seed orchards of this cultivar were produced in collaboration with smallholders and government entities, namely the National Research an Innovation Agency (BRIN) and the Livestock Agency. BRIN-NTT emerged as the primary provider of Tarramba seed for Indonesia, under the coordination of Ms. Debbie Kana Hau. Throughout the duration of the

project, a total of over 2,000 kg of seed were allocated to multiple areas both within and beyond the regions of NTT and NTB.

Table 1. Biophysical requirements for growth of leucaena

Characteristic	Non-limiting	Minor limitation	Moderate limitation	Severe limitation	Unsuitable
Toxicities					
pH	>5.5	5.2-5.5	4.8-5.1	4.5-4.8	<4.5
Al saturation (%)	<5	5-20	20-40	40-60	>60
EC (dS/m)	<2	2-4	4-8	8-15	>15
ESP (%)	<6	6-10	10-15	15-40	>40
Fertility					
P conc (ppm)	>20	15-20	10-15	5-10	<5
S conc (ppm)	>5	4-5	3-4	<3	
K conc (Meq/100g)	>0.2	0.15-0.2	0.1 -0.15	0.05-0.1	<0.05
CEC (Meq/100g)	>10	8-10	5-8	3-5	<3
Rooting conditions					
Soil depth (m)	>2	1.5-2.0	1.0-1.5	0.5-1.0	<0.5
Soil moisture					
Annual rainfall (mm)	>1500	1000-1500	600-1000	400-600	<400
Dry season (months)	<3	3-5	5-7	7-9	>9
Flooding (weeks/year)	None	<1	1-3	3-8	>8
Drainage	WD	MWD	ED	P	VP
Temperature					
Mean maximum (^{o}C)	28-33	25-28, >33	22-25	19-22	<22
Mean minimum (^{o}C)	>22	18-22	14-18	10-14	<10

Drainage: WD - well drained; MWD - moderately well drained; ED - excessively drained; P - poor drainage; VP - very poor drainage

4.4 Survey and feeding trials

Results of the survey were reported in [1] and revealed that:

a) The average landholding size among farmers was 2.8 hectares, with a range of 0.1 to 5.0 hectares for planted leucaena. According to [7], the researchers acquired bulls with an average live weight of 191 ±41 kg when they were around 18 ± 7 months old. These bulls were then fattened for an average durationof 127 ± 58 days.

b) The mean percentage of leucaena in the dietary composition was found to be 80%, accompanied by 13% maize stover and 7% natural grass. The highest proportions of leucaena, reaching 100%, were observed during the wet season, while the lowest proportions, roughly 50%, were recorded in October.This decline in proportions can be attributed to the limited availability of leucaena, leading farmers to supplement diets with agricultural leftovers.

According to the study conducted by [7], the daily liveweight gains (ADGs) of Bali bulls fed leucaena varied between 0.4 and 0.6 kg/d, based on a monitoring period of over three years. The ADG of Bali bulls in the traditional rearing technique without leucaena was 0.2 kg/d, which was at least doubled in the current system. The ADGs reached their highest values (0.56-0.61 kg/d) during the months of May, June, and January, coinciding with the periods of maximum feed supply and the highest proportion of leucaena in the diets (about 100%). The highest performing individual farmers were able to attain monthly weight gains of at least 0.8 kg per day, which is near to the genetic potential of Bali bulls.

4.5 Leucaena toxicity and parasite control

There were important findings regarding the perceived need to inoculate with the bacterium *Synergistes jonesii* which has been regarded as the primary pathway in the breakdown of the leucaena toxins mimosine and dihydroxy pyridine (DHP) to non-toxic products. Our findings suggested that this was not the case in eastern Indonesia. Results can be summarised as follows:

a) *S. jonesii* was observed to be present in all animals that were subjected to testing [5]. However, it

was observed to be ineffective in the degradation of DHP in animals fed high leucaena diets. Instead,animals exhibited a mechanism of hepatic conjugation to mitigate the detrimental effects of elevatedlevels of DHP in their bloodstream, so rendering it non-toxic.

b) It appeared that by gradually introducing cattle onto a high leucaena diet, inoculation with *S. jonesii* was unnecessary as animals were healthy and had high ADGs on diets up to 100% leucaena.

c) The implications of these discoveries will significantly impact the management strategies for animals worldwide that consume leucaena, hence revolutionizing our current understanding in thisfield. As an illustration, it can be stated that Indonesian Bali bulls do not require inoculation; nonetheless, they do need to be slowly introduced to leucaena in order to acclimate to mimosine andpromote conjugation pathways that mitigate the effects of DHP. Comprehensive information regarding this study can be found in the publication authored by [8].

According to [6], the investigation into the influence of leucaena on the management of gastrointestinal parasites in NTB indicated that the administration of leucaena was efficacious. The study observed that the levels of faecal nematode egg counts in Bali bulls, which were provided with adiet consisting of 70% leucaena, declined to nil within a period of 60 days after the treatment. Furthermore, these counts were consistently low until the last measurement taken at 120 days.

4.6 Barriers to and Opportunities for adoption of leucaena

The initial documentation of the obstacles and prospects pertaining to the adoption of leucaena in Indonesia was presented in the article authored by [9]. An updated more detailed inventory of obstacles and prospects for implementation occurred during the fifth year of the project and was described in the final report to ACIAR [10] and is summarised below against key categories.

(a) Nature of the innovation. The innovation was able to meet the needs of farmers, was not outside their experience and addressed a principal limitation, namely shortage of high-quality forage.

(b) Technical constraints. Research and associated demonstrations allayed farmer concerns about the palatability of leucaena and its possible toxicity to cattle. Knowledge gaps were addressed by adequate demonstration sites, ample planting materials, and relevant training available on establishment techniques, management and feeding, as well as animal nutrition.

(c) Project leadership, staffing and engagement with farmers. There was effective overall leadership ensuring enthusiasm and well-trained field staff which in turn led to the respect and appreciation of farmers. Differences due to diverse ethnic backgrounds of farmers were overcome as all groups appreciated that the principal elements of the innovation were common to all groups.

(d) Socio-economic and agribusiness issues. The many potential socio-economic barriers were addressed, namely: Limited land for leucaena planting, unrealistic expectations of cooperating farmers, lack of agronomic and animal nutrition expertise, lack of access to finance or credit facilities, power imbalance with traders who purchased fattened bulls, potential conflict and opportunity cost comparisons with other traditional on-farm enterprises, theft of valuable cattle,and the variable price signals for sale cattle.

(e) Government policy and involvement. Potential barriers from government policy were addressed including financial support and commitment, and time available for staff to participate.

4.7 Adoption

A substantial level of adoption was observed during the project, surpassing the initially established targets. The measurement of adoption encompassed various indicators, such as the quantity of leucaena seedlings planted, the number of bulls successfully fattened, and the extent of farmer engagement in the adoption process. More than 2000 kg of Tarramba leucaena seed was disseminated over all provinces within the Indonesia. The Livestock Department emerged as the primary procurer of seed, while numerous other entities, including NGOs, and private farmers made smaller-scale acquisitions. A total of almost one million seedlings of leucaena were also cultivated and distributed.

The Livestock Department implemented a scheme aimed at providing farmers with feeder cattle to initiate the fattening process, contingent upon their prior cultivation of Tarramba leucaena. This policy generated a substantial motivation to cultivate leucaena.

4.8 Project impacts

The impacts of the project are now summarised.

4.8.1 Economic impacts. Waldron conducted an analysis of our key leucaena sites and reported that: "Under all measures of profitability, representative (cattle fattening) households at all sites were profitable in the wet season. As expected, 'return to person days' in the dry season were lower than average off-farm wages" due to reduced leucaena biomass productivity and hence the number of cattle raised per household [11].

According to findings reported in [12], the economic consequences of the project were evident. Farmers participating in the initiative successfully sold over 2,300 bulls, weighing an average of 250 kg, at an average price of IDR25,000 per kg live weight. This resulted in a gross sale value of approximately AUD1.5 million, which accounted for approximately 85% of the project's total cost.
Farmers observed a three-fold increase in the rate at which they sold fattened bulls. This can be attributed to the accelerated growth and improved availability of feed derived from leucaena. Many farmers transformed their traditional cattle fattening enterprise into a more business-oriented endeavour.They transitioned from merely tending cattle and occasionally selling lower-quality animals for immediate cash, or during periods of limited feed availability, to actively producing fattened cattle in superior condition and increased body weights. The growing demand for Tarramba seed was evidence of the desire to boost leucaena production. The sale of seed within the initial year of planting presented an appealing opportunity for farmers to generatesupplementary income.

4.8.2 The social ramifications. According to [12]. The sale of a larger quantity and higher value of cattle resulted in societal advantages, namely:

a) The living conditions of households were enhanced as the revenues generated from cattle fatteningwere allocated towards the upgrading of housing and other vital family necessities.
b) The capacity of villagers to acquire assets increased such as purchase of motorcycles, thereby fulfilling additional transportation requirements for the household, was increased.
c) Enhanced education, health, and labour productivity was observed as a result of augmented cashincome received on a more consistent basis, specifically during the dry season.
d) The utilization of biogas systems by farmers engaged in cattle fattening resulted in positive socialand economic consequences, primarily in terms of the availability of lighting and heating facilities.
e) The tree trunks of Tarramba leucaena served as a valuable source of firewood and construction polesfor building purposes.

4.8.3 Positive environmental impacts. Positive environmental impacts occurred from the adoption and expansion of leucaena plantings at the farm, catchment and global levels. Farm level benefits occurred as leucaena buffered the effect of extended dry periods, improved water use efficiency, enhanced soil fertility and controlled weed ingress [12]. The benefits obtained at the catchment level arose from the enhancement of hydrological balance, whereas the benefits at the global level arose from the improvement of greenhouse gas balance throughcarbon sequestration and the reduction of methane emissions.

4.8.4 Capacity-building impacts. Capacity-building impacts were observed at multiple levels, specifically in the form of enhanced abilities among senior project leaders, junior field researchers and other stakeholders including District Livestock Department and Extension workers.

4.8.5 Scientific impacts. Scientific impacts encompassed a wide range of areas ranging across plant and animal research, molecular research, through to field research aimed at development impacts. More than 30 publications, comprising peer-reviewed journal articles, conference papers, and many other written and oral modes of communication, were accomplished. Numerous scholarly articles were published including on leucaena toxicity, the agronomy and feeding of leucaena to cattle, and the adoption of leucaena systems. The project placed significant emphasis on active engagement inconferences with approximately19 talks or poster papers conducted.

4.9 Reasons for success of project.

The reasons for success of the project were reported by [10] and [12]and are listed below:

a) The project leaders in Australia and Indonesia effectively and enthusiastically managed the project, with the help of a highly capable field research team in NTT and NTB. Regular communication among project leaders and the field researchers was integral to success.
b) The project's aims and objectives were effectively designed and implemented, encompassing both socio-economic and technological aspects. The technical concerns were addressed in a definitive manner and supported by robust scientific evidence.
c) During the implementation phase, the primary focus was firstly on the establishment of leucaena rather than on expansion of the cattle population. Therefore, when extra cattle were introduced, a reliable source of high-quality feed was ensured. In the past, there has been a historical focus on theintroduction of better grasses, predominantly elephant grass, and not on forage legumes, which meantthat cattle production was limited by absence of high-quality fodder especially during the dry season.
d) The emphasis on leucaena was not novel among farmers. The species was widely recognized, and aproportion of farmers had already adopted its use. Hence, the project concept was characterized by its simplicity, cultural suitability, and manageable level of effort. Leucaena also offered other ancillary advantages, including the provision of timber, fuelwood, and weed control.
e) A basic design for a fattening shed (kandang) was created, intended for easy replication by individual farmers or farmer collectives. This design could be replicated in single or multiple units, either adhering strictly to the prescribed specifications or adapted to accommodate locally available building materials.
f) The management of constraints that hindered implementation of the extension strategy was successfully addressed. The implementation of demonstration sites played a pivotal role in this endeavor, serving as platforms for reciprocal visits aimed at fostering the adoption of effective management techniques.
g) There existed a favourable alignment of interests between the professional personnel from Australia and Indonesia, along with robust connections with government agencies. This was primarily attributed to the congruence of policy objectives at both the Provincial and National levels, as well as the presence of pertinent knowledge from Australia.
h) The interest of farmers in planted forages experienced a surge during the mid to late 1990s as a result of shifting historical circumstances. This may be attributed to several factors, including the growing value and demand for high-quality cattle, the diminishing availability of land for free grazing, and the escalating labour demands associated with herding free-range animals.
i) A key factor was the success of the cultivar Tarramba [13] which gained significant recognition among both governmental authorities and farmers because of its favourable characteristics. It was favoured by cattle, exhibited reduced susceptibility to psyllid infestations, possessed a high leaf density, exhibited prolonged persistence throughout the dry season, and yielded superior poles.

5. Conclusions and recommendations

Project outcomes demonstrated that it was possible to double productivity of smallholder cattle in Indonesia by improving their nutrition based on feeding leucaena, thus improving the livelihoods of farming families. The results highlighted an opportunity to enhance productivity of other smallholder

cattle enterprises in Indonesia and in other tropical developing countries using similar methodology. Several recommendations can be made, namely:

a) It is imperative to develop comprehensive instructional manuals that outline optimal strategies for the establishment, administration, and nourishment of leucaena.
b) Due to the strong demand for Tarramba seeds, it is advisable to incentivize private investors to engage in seed production. This would guarantee a consistent and sustainable market supply to meetthe escalating demand.

Continuing research priorities encompass various areas, including: (a) The exploration of opportunities to enhance cattle productivity through energy supplementation; (b) the potential for establishing a high-quality high-end beef supply to cater to the needs of tourists; (c) the underlying factors contributing to the observed anthelmintic properties of leucaena; (d) the introduction and assessment of the novel psyllidresistant leucaena cultivar 'Redlands'; and (e) the ongoing investigation into the capacity of cattle on high leucaena diets to counteract DHP toxicity without the necessity of inoculation with *S. jonesii*.

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