NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY

TIMOR-LESTE

Report of Scientific Research INCT 2023

Designing an Innovative Feed Planning System for
Smallholder Bali Cattle *(Bos javanicus)* Farmers
in Lospalos, Lautem, Timor-Leste

Augusto Barros

December 2023

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Agriculture and Rural Development in Animal Feed Resources Availability

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Scope: Agriculture and Rural Development in Animal Feed Resources Availbility
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DESIGNING AN INNOVATIVE FEED PLANNING SYSTEM FOR SMALLHOLDER BALI CATTLE (*Bos javanicus*) FARMERS IN LOSPALOS, LAUTEM, TIMOR-LESTE

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Abstract

The study was to design an innovative feed planning system for smallholder Bali cattle farmers in Lospalos, Lautem, Timor-Leste. Respondents were interviewed on their Bali cattle farming system and the utilization of natural feed resources either forage grasses, legumes, and agricultural by-products. Proportional random sampling method was used to choose a sample from the number of research subjects that are not the same.

The representative samples of forage grasses, legumes, and agricultural by-products were collected per village in Lospalos. The dry matter (DM) yield of fodder crops and by-product productions per hectare per year was calculated. Carrying capacity and carrying capacity index of forages were estimated according to the DM yields.

The result shows that Bali cattle was reared under semi-intensive 22.3%, semi-extensive 53.5%, extensive 20.4%, and integrated framing (crop-livestock) was 3.8%. Zero-grazing was not found in this study. Around 68.2% were practiced semi grazing with the combination between cut-and-carry systems and grazing by day.

The distribution of agricultural by-product production per year and carrying capacity index shown very critical condition category in all study sites, while, the forage grasses and legumes were in the category of safety in Bauro and Raça. Prone was found in Fuiloro, Souro, and Muapitine, in addition, the critical condition category was found in Home, Leuro, and Cacavei. The major cause of the feed scarcity was drought due to the dry season.

Keywords: Innovative Feed planning system, smallholder farmers

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ABREVIATIONS

ADF	= Acid Detergent Fiber
AFM	= Age at First Mating
AFS	= Age at First Service
AFT	= Age of first calving
ANOVA	= Analysis Variance
AU	= Animal Unit
BH	= Body Height
BL	= Body Length
BWG	= Body Weight Gain
BW	= Birth Weight
CF	= Crude Fiber
CG	= Chest Girth
CI	= Calving Interval
CP	= Crude Protein
CR	= Calving Rate
CV	= Covariance
DDGS	= Distillers Dried Grain Soluble
DGLV	= Directorate of General Livestock and Veterinary
DIP	= Degradable Intake Protein
DM	= Dry Matter
DO	= Days Open
et al	= and others
FAO	= Food and Agriculture Organization
FCR	= Feed Conversion Efficiency
FGD	= Focus Croup Discussion
FGI	= Focus Group Interview
FHG	= Green House Gas
GDS	= General Directorate of Statistics
H	= Hour
Ha	= Hectare
HH	= Household

IU	= International Unit
LFS	= Labor Force Survey
MAF	= Ministry of Agriculture and Fisheries
Mcal	= Mega Calories
ME	= Metabolizable Energy
NDS	= National Directorate of Statistics
NCFS	= Non-Conventional Feed Sources
NDF	= Neutral Detergent Fiber
NGOs	= Non-Governmental Organization
NPN	= Non Protein Nitrogen
NRC	= National Research Council
NTB	= Nusa Tenggara Barat
NTT	= Nusa Tenggara Timor
PHILSAN	= Philippines Society of Animal Nutritionists
PPM	= Post-Partum Mating
PPO	= Post-Partum Oestrus
RDP	= Rumen Degradable Protein
RUP	= Rumen Undegradable Protein
S/C	= Service per Conception
SPSS	= Statistics Package of Social Science
SU	= Standard Unit
TDN	= Total Digestible Nutrient
UIP	= Undegradable Intake Protein
WW	= Weaning Weight
WG	= Weight Gain
YA	= Year Academic
YW	= Year Weight\

I. INTRODUCTION

1.1 Contextualization

Bali cattle *(Bos sondaicus)* farming in Timor-Leste is carried out in a smallholder farming system where cattle are generally reared in small-scale with only 2 – 6 heads of cattle per household. The percentage of household raising Bali cattle was 23% in 2010 and increased to 26%) in 2015 (Timor-Leste Population and Housing Census, 2011-2015), and increased to be 43% in 2019 (Timor-Leste Agriculture Census, 2019).

Although, the production system is done in smallholder, the government is giving attention since demand for export to Indonesia (Waldron, *et al.*, 2015) and for domestic consumption of beef is increasing. In addition, the demand is increasing due to the population growth, changing of the economic status and the people's awareness of the animal protein origin as a dietary constituent. But in fact, the supply beef is not enough because of the low production performance as a result of the poor faming management system and the smallholder farmers depend on natural forages as the main feed throughout the year.

Forage for feed has an important role in animal production, especially animal ruminants. It is very important factor in farming activities in the livestock sector. Therefore, the selection of the right animal feeds will determine the success of livestock farming. The major feed sources are crop residues, native pasture, straws and improved forages harvested from backyard (Demeke *et a*l., 2017). These mixed crop and livestock production systems are characterized as the major farming system in the smallholder farmers in Timor-Leste.

The smallholder Bali cattle farming practices in Timor-Leste, particularly in the study areas of Lospalos, Lautem is considered unproductive as a consequence of low knowledge and skills of the farmers in accessing feed resources and their utilization as animal feeds. Agriculture by-products and other non-conventional feeds are produced in farm level in every cropping time plus another forage crops growing locally can support to develop a feed planning systems.

A feed planning is made to provide guidance of nutrient requirements for cattle to ensure the cattle are fed in the right way that can improve health and prevent negative impacts (Howse, 2013). The same report describes that a feeding plan is given to the

smallholder farmers who raise cattle to ensure the cattle are fed in a suitable manner. It covers all nutritional requirements and some necessary supplements. Therefore, smallholder cattle farmers must provide feed that meets the requirements for the cattle's growth.

Feeding system is required to provide quality and quantity of feeds based on daily requirement of cattle. Feeding system must be well designed to achieve performance of the cattle. Feeds that meet the requirements are feeds that contain protein, carbohydrates, fats, vitamins, minerals, and water. The feed can be provided in the form of forages and concentrates as the materials for ration formulation. The animal feeding plan is needed to develop in smallholder farms particular for those who apply a small-scale Bali cattle farming in Lospalos.

Smallholder farmers are needed to be introduced and guided where cattle are fed with quality and quantity feedstuff that are locally available, such as agriculture by-product, legumes, cassava, grasses and concentrates that are produced annually. Farmer's knowledge and skills about feeding strategy are needed to be improved including feeding plan practices on ration formulation and feeding system must be discussed through community based participatory method using focus group discussion (FGD). FGD is a method used to discuss with stakeholders and farmers in order to give them knowledg1e on feed resources and obtain information on how cattle production system included of agriculture production (by-products) and other feed resources that are potential for cattle feed sources in Lospalos, Lautem, Timor-Leste.

1.2 Problem Statement

Timor-Leste's smallholder Bali cattle farming, farmers are still doing the traditional system. Livestock innovation technologies include housing, breeding, and feeding systems have not been taken in serious attention. Feeding is the most challenging activity in cattle farming. The amounts are given do not meet the requirements because of poor quality. Farmers do not know how to prepare a feeding plan, formulate rations and supplement feeding schedule will cause nutritional deficiencies on cattle. The consequence of inadequate nutrition is a main cause of the young calves becoming weak and stunted.

Adult cattle will experience weight loss or low live weight gains, poor carcass percentage and infertility. In addition, Bali cattle production rate will also decrease due to a decline in reproductive efficiency. Ultimately, this will result in low farmers' income.

1.3 Research Question

From the statement above would be formulated a research question as follows:

1. What are the characteristics of the smallholder farming system on productive and reproductive performance of Bali cattle?
2. What is the feed resource profile in the study areas?
3. Do the forage crops and agriculture by-products meet the needs of cattle reared under smallholder farmers in Lospalos?

1.4 Objective of the Study

a. Main objective

The main objective of this study is to design an innovative feed planning system for smallholder Bali cattle farmers in Lospalos, Lautem, Timor-Leste.

b. Specific objectives

The specific objectives of the study are to:

1. Characterize of production and reproduction systems of Bali cattle under smallholder farms;
2. Determine the feed resources profiles to estimate forge crops and agriculture by-product production in the study area;
3. Design feed calendar to describe the feed availability as a basis for feed planning for Bali cattle.

1.5 Significance of the Study

This study provides information on the availability of feed resources both naturally and locally produced as a feed source to feed Bali cattle under the smallholder farming system. The providence of feed resources can be utilized as the materials in feed formulation (ration) and feed planning that provide proper feeds and their nutritional

requirements to contribute to the improvement of productive and reproductive performance of the Bali cattle under smallholder farms in Lospalos, Lautem, Timor-Leste. Thus, the outcome of the study will provide guidance on both government agencies (extension workers) who will disseminate in integrate extension service programs and the farmers themselves in preparing quality feeds for their cattle so that they can obtain high quality and quantity of production to increase their income.

1.6 Scope and Limitation of the Study

This study focuses on how to design an appropriate feed planning system for the production of small-scale Balinese cattle raised by householder farmers in 8 villages that have been identified as study areas in Lospalos, Lautem, Timor-Leste. The interpretation of the results of the study may not reflect to other regions but it will be specifically reflected in the Lospalos Administrative Post identified as the study area.

The survey study focuses on describing the predominant production systems for the Bali cattle. Characterization of the productive and reproductive performance of Bali cattle on small-scale farms. The productive performance was measured some of the physical appearance subjected to the local breeds of Bali cattle on body length, body height, chest girth, body weight. The reproductive performance was subjected to the information of the mating system, age at first service, age at first calving, and calving interval, and days open. The sample collection and analysis of day matter (DM) yield of feed resources to estimate carrying capacity of forage was done in the study areas and feed calendar was designed as basis for feed planning for Bali cattle in Lospalos, Lautem, Timor-Leste.

1.7 Theoretical Framework

Kuivane *et al.* (2016) described that a farming system is defined as the complex of resources that are arranged and managed according to the totality of production and consumption decisions taken by a farm household, including the choice of crops, livestock, on-farm and off-farm enterprises. The smallholder farming systems are perceived to share certain characteristics which differentiate them from large-scale, profit-driven enterprises. These include: limited access to land, financial capital and inputs, high levels vulnerability and low market participation.

Somda *et al.* (2004) stated that the traditionally farmers own cattle for various purposes including milk, meat, draft animal power, and so forth. Meat and milk products in these systems play an important role in providing food and income.

Livestock farmers provide us with meat, dairy, eggs, wool, leather and other animal products. Livestock farmers in the world face a number of important challenges. Livestock production needs to be more sustainable and productive while at the same time being profitable for farmers. This applies in particular to animal husbandry. Modern and innovative animal equipment and technologies are key components of the solution to these challenges.

Hall *et al.* (2008) revealed that an adequate supply of livestock fodder is crucial to the livelihoods of millions of people across the developing world. Livestock producers meet their fodder requirements through a combination of crop residues and grazing on common lands, private lands, forests, fallow agricultural lands and harvested agricultural lands. Fodder requirements are also met through cultivated forage crops (cultivated mostly by large landholders). Others purchase this fodder. Availability and access to quality fodder resources, however, is emerging as an important constraint in livestock production.

The major approach for addressing feed and fodder scarcity traditionally revolved around evaluating various forage crops (grasses, shrubs, and trees) for their yield, nutritional content and impact on livestock production performance.

1.8 Conceptual Framework

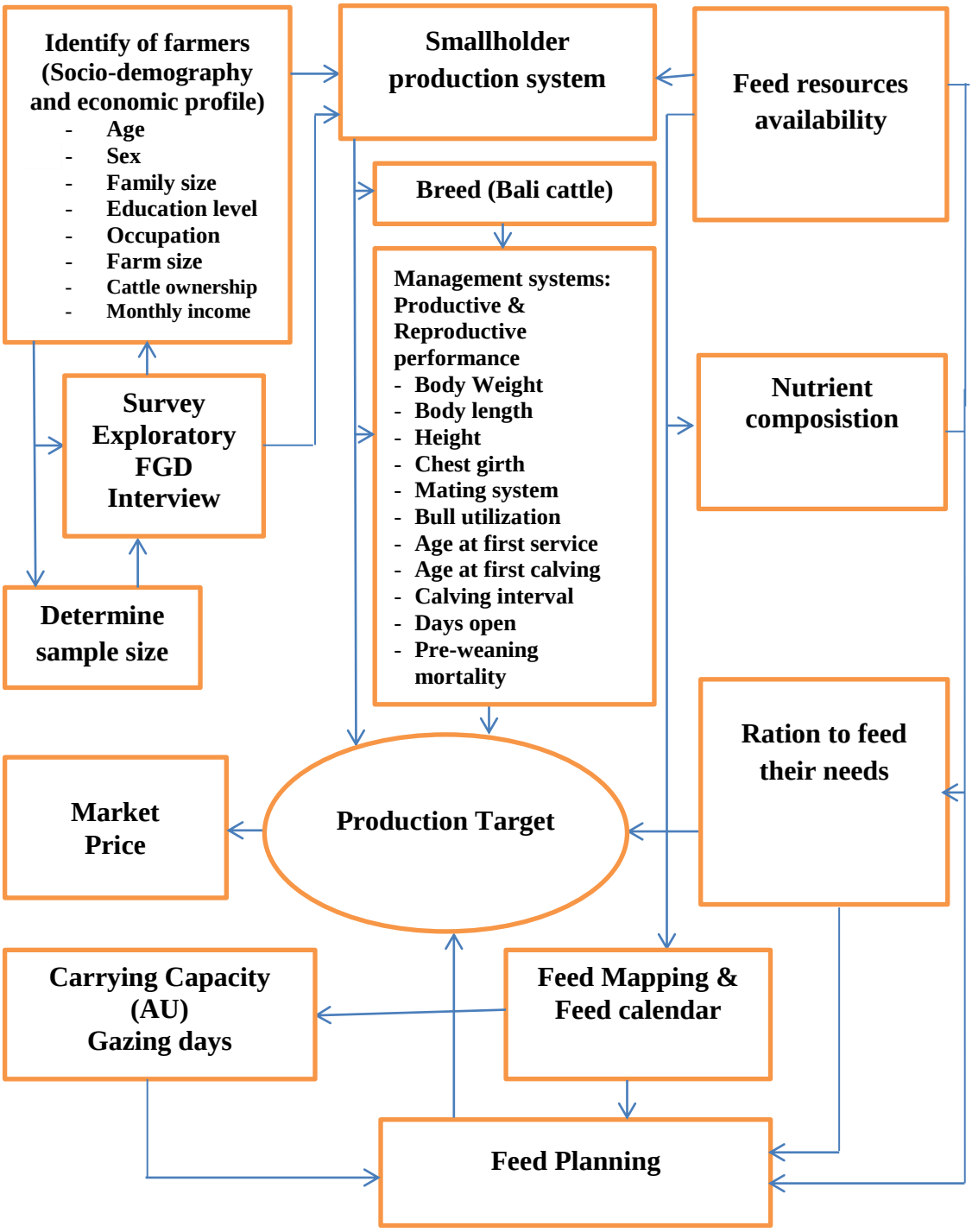


Figure 1. Conceptual Framework

II. LITERATURE REVIEW

2.1 General Description of Lautem Municipality

Lautem municipality is located in the eastern part of the island of Timor. It is around 215 kilometers from the capital, Dili. It is bounded on the north and east sides by the Wetar Sea, in the south by the Timor Sea, in the southeast by the Viqueque municipality and in the northeast by Baucau municipality. As one of thirteen (13) municipalities it occupies about 1,702.33 km2 or almost 1/8 of the land areas of the region, with a population of 1,183,643, where men 601,112 and women 582,531 people. Population density is around 36/km^2 (93/sq mi) and total households are 12,050. The Municipality of Lautem (formerly a district) has 6 Administrative Posts (farmers sub-district) consists of:

- Tutuala Administrative Post 289.07 km^2;
- Lautem Administrative Post 380.17 km^2;
- Iliomar Administrative Post 292.30 km^2;
- Lospalos Administrative Post 592.50 km^2;
- Luro Administrative Post 148.28 km^2;
- Lore Administrative Post (a newly Administrative Post) 179.79 km^2.

Climate Condition in Lautem, commonly the months of May to July have an average of two rainfalls per week and the months of November to January have an average of two hours of heavy rain daily. During August to October is hot and dry with no rainfall. The average temperature is 23.6 - 31.8°C and the highest is 38°C. The annual rainfall ranges from 1,000 mm to 1,500 mm/year and the dry season lasts from 5 to 6 months.

1. Lospalos Administrative Post

Lospalos is an administrative post (former sub-district) in the Lautem municipality (former district) is around 248 kilometers (154 mi) to the east of Dili, the national capital. Lospalos has a population of 31,164 (DNS, 2015) and divided in 8 villages (Sucos) in the Table 1 below:

Table 1. Population distribution by villages in Lospalos administrative post

Name of villages	Population	Area (Km^2)	Population Density
Bauro	2,432	71.5	34.03/km²
Cacavem	974	50.9	19.12/km^2
Fuiloro	16,701	102	48.87/km²
Home	1,933	39.6	34.18/km²
Leuro	812	23.8	19.43/km²
Muapitine	1,763	194	34.42/km²
Raça	1,162	33.8	34.42/km^2
Souro	1,987	38.8	51.18/km²

Source: NDS (2015)

2. Farming in Lospalos, Lautem Municipality

Most of the farmers in this village are raising livestock like cattle, buffalos, goats, pigs and chickens as a side job to obtain extra income.

Cattle rearing are still done in the traditional system where cattle are grazing in the pasture for whole days without any concern on housing, feeding, health care and reproductive management. Some of the households started to raise cattle in semi intensive system, where animals are tied in the special area or private pasture in the day time, feeding on feeds from fodder trees and shrubs as supplement to native pasture. Figure 2 shows the cattle population map in Lautem municipality.

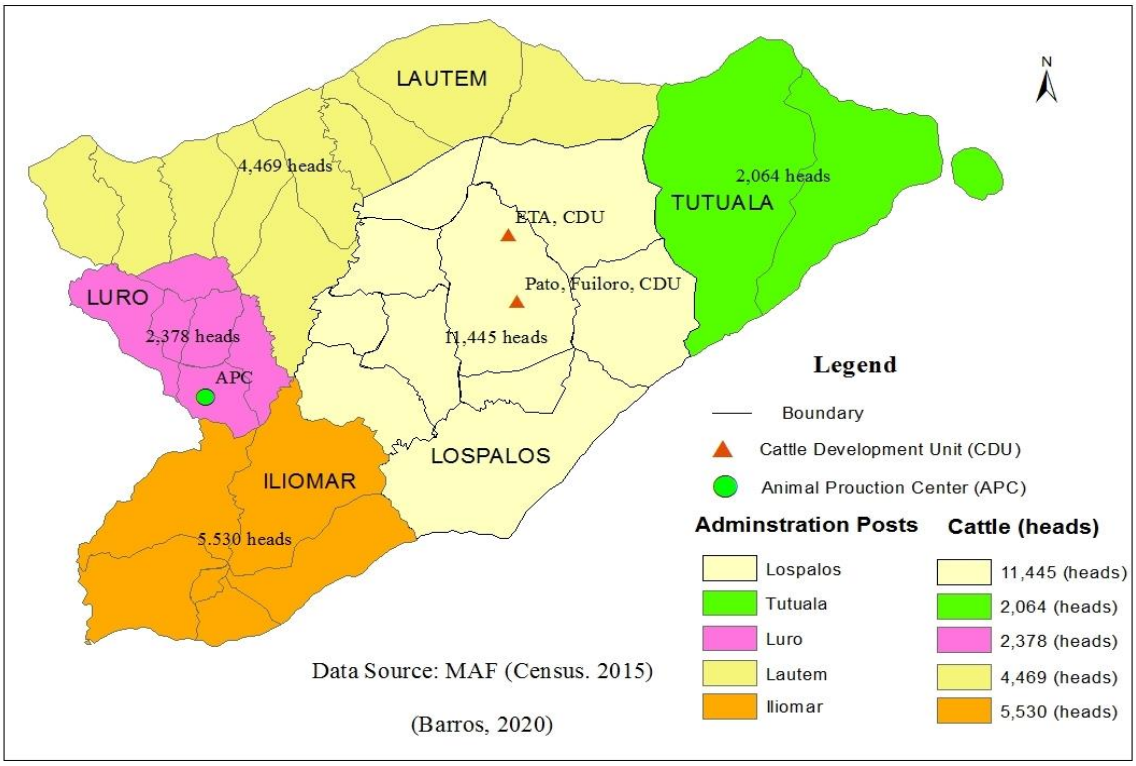


Figure 2. Cattle population distribution mapping by Administrative Post in Lautem Municipality in 2015

The total number of Bali cattle reared in Lautem Municipality is 25,586 heads in 2015 increased to be 43,521 heads in 2019 (Timor-Leste Agriculture Census, 2019) distributed in 6 Administrative Posts namely Tutuala, Lautem, Lospalos, Luro, Iliomar. Lore, and Lospalos. Lospalos Administrative Post consists of 8 villages with totally of heads reared by 1,836 in 2015 and increased to be 1,956 in 2019 (Timor-Leste Agriculture Census, 2019).

2.2 Smallholder Farmer

Smallholders are defined as farmers who own a small land-based plot where they grow subsistence crops and one or two commercial crops that depend almost exclusively on family labor. Smallholder farmers usually live on farms smaller than 2 hectares (Rapsomanikis, 2015).

In livestock sector, the smallholders farmers who raise the small animals, such as pigs, goats, sheep and poultry, and big animals such as cattle and buffalo. Rapsomanikis (2015) smaller animals are easier to raise and produce faster so that they are faster to sell when needed.

Cattle are one of the big animal ruminants that are costly in production inputs if they are reared under intensive system. Feed is one of the production factors which require the largest costs, around 60 to 70% of the total production cost. In smallholder farming, famers are only be able to raise in smaller size, it is around 2 to 6 heads, using traditional farming system where native grasses and by-products as the main feeds. Most of the farmers practice backyard farming where cattle are tied up or penned near the family houses. Cattle farming are more benefited and an important asset that respond to the multiple functions. They can produce meat, milk, manure, and can be used for transportation and plowing farmer's agriculture lands.

2.3 Bali Cattle

Purwantara *et al.* (2012) Bali cattle *(Bos sondaicus, Bos javanicus, Bos/Bibos banteng*), a domesticated descendant of the wild Banteng (*Bibos banteng*). Banteng (Order: Artiodactyla, Family: Bovidae, Subfamily: Bovinae, Genus: Bos, Subgenus: Bibos).

Bali cattle are beef cattle native from Indonesia among others beef cattle, such as Brahman and Ongole. This species had been domesticated in 3,500 BC from wild bull *(Bos-bibos banteng)* (Sari *et al*., 2016). Bali cattle also known as Balinese cattle are an important source of meat as well as for plowing. Among the others beef cattle, Bali cattle are most preferred by smallholder farmers because have well adapted to the tropical environment (Lindell, 2013), even also well adapted to the sub-tropical climate in South-East Asia (Mohamad *et al.* (2012) and a prefect livestock for local condition.

Bali cattle have characteristics in color, where calves are born with reddish-brown coat. The coat color is unchanged in females but its color turn almost black in adult males (Rahayu, 2014). In male, the red covering the body begins to be darken at age of 12 – 18 months (Purwantara *et al.*, 2010).

2.4 Bali Cattle Development and distribution

Bali cattle (*Bos javanicus*) are one of local beef cattle breeds contributing to the livestock development industries in Indonesia specially Bali island. Apart from the Bali Island itself, Bali cattle are also dominant species in most of the eastern islands. This cattle are spread over in some regions in Indonesia such as Bali, Nusa Tenggara Barat (NTB),

Nusa Tenggara Timur (NTT), South Sulawesi, Lampung, Bengkulu, Central Kalimantan (Purwantara *et al.*, 2012) including Timor-Leste.

2.5 Bali Cattle Development in Timor-Leste

The evolution of the number of Balinese cattle over the last century shows three moments where Bali cattle were existed from Portuguese colonization, the beginning of Indonesian occupation and developed after the independence of Timor-Leste. During the Indonesia occupation until Timor-Leste became independent country, the cattle were developed from year to year and currently the number of Bali cattle in Timor-Leste according to census 2015 of 221,767 heads reared by 26% households (DNS, 2015) and Timor-Leste Agricultural Census (2019) indicated that the population becomes of 285,701 heads (22.38% increased). The percentage of households rearing Bali cattle was increased around 43% (Timor-Leste Agriculture Census, 2019). The number of Bali cattle reared by household can be seen in the Table 2 below.

Table 2. The numbers of Bali cattle reared by household from 1983 to 2019

Year	Cattle (heads)	Number increased (heads)	% Increased	Cattle SU per capita
1983	39,705			0.10
1997	146,557	106,852	72.91	0.20
2010	161,654	15,097	9.34	0.15
2015	221,767	60,113	27.11	0.20
2019	285,701	63,934	22.38	0.22

Source: Timor-Leste Population and Housing Census, 2011 & 2015; Timor-Leste Agriculture Census (2019)

These numbers of the Bali cattle are distributed in 13 Municipalities in the territory of Timor-Leste with using total pastures of 206,227 ha.

The table 4 below indicates Bali cattle distribution by municipalities and the utilization of pasture areas.

Table 3. Bali cattle distribution by regions in 2019 and native pasture utilization areas (ha)

Municipalities	Cattle population (heads)	Cattle population (AU)	Native Pasture (ha)	Stocking rate (AU/ ha)
Aileu	8,420	5,894.00	501	11.76
Ainaro	12,467	8,726.90	6,845	1.27
Baucau	13,944	9,760.80	17,585	0.56
Bobonaro	42,259	29,581.30	18,061	1.64
Covalima	40,444	28,310.80	34,339	0.82
Dili	3,156	2,209.20	388	5.69
Ermera	19,969	13,978.30	3,396	4.12
Lautem	34,521	24,164.70	39,994	0.60
Liquiça	13,525	9,467.50	6,575	1.44
Manatuto	12,462	8,723.40	13,040	0.67
Manufahi	15,899	11,129.30	25,454	0.44
Oecusse	26,012	18,208.40	14,626	1.24
Viqueque	42,623	29,836.10	25,422	1.17
Total	285,701	199,990.70	206,227	0.97

Data Source: Da Cruz (2003); Timor-Leste Agriculture Census (2019)

Animal Unit (AU) = Cattle population multiplied by the conversion factor 0.7.
To represent cattle population which consists of males, females and calves with various levels of age, therefore, the total cattle population is multiplied by 0.7 (Ashari *et al*., 1995).

2.6 Bali Cattle Farming System in Timor-Leste

Marawali and Ratnawaty (2015) reported the livestock farming applied in Timor-Leste is traditional farming system. The characteristics of the traditional farming systems are rely on native grasses as feed, cheaper production costs, less labors, cattle productivity varies with season. In the rainy season, abundant forage production helps increase the body weight gain (BWG) of cattle. On the other hand, in the dry season, forage production decreases so that the BWG decreases which causes increased calf mortality.

Farmers in Timor-Leste are using Bali cattle in their farm. These cattle are Indonesian native cattle. It has already spread over across Indonesia regions including

Timor-Leste because of it has high adaptability and become the highest population among other native cattle.

Bali cattle production in Timor-Leste is done under household farming system. Purwantara *et at.* (2012) reported the Bali cattle production system is generally quite small scale (small farming) with only 2 to 6 cattle per household can be tied close to their houses and applied cut-and-carry system. The male calves are usually reared for fattening. They are needed to supply the local markets and to be exported to Indonesia. The female calves are for breeding purposes to maintain the balance of cattle production.

2.7 Feeding System

Feeding system is using natural pasture, crops, agricultural by-products. Native pastures available occupied an area approximately 10% of the country. The area is around 206,227 hectares produced 82,491 tons per year per pasture available. The average number of cattle per ha of native pasture is around 1.3 AU (Soares *et al.*, 2018). In addition, Soares stated the feeding system is done using native pastures, crop residues, agricultural by-products and waste materials around houses and villages. No grazing management rules of natural pastures leads many times to overgrazing and unsustainable animal production due to loss of the cover vegetation and enhanced soil erosion.

Feeding on Natural Pasture

Dahlanudin *et al*. (2012) estimated the annual biomass production was 400 to 500 kg DM per ha per year in high land native pasture, and 300 to 400 kg per ha per year in low land native pastures. The condition of pasture at the time of observation indicates the biomass production from native pastures may be double in the peak of wet season.

Sontakke *et al.* (2014) reported the natural pasture is estimated 80 to 90% of livestock feeds and its quality and quantity are seasonal.

1. **Feeding on crop residues**

Residue of maize, sugarcane, sorghum grains, soybean, vegetables and other non-conventional feed resources are involved in animal feeding (Sontakke *et al*., 2014).

Rice straws and corn stovers are very common feedstuffs for cattle after been harvested rice and corn. However, it is low in nutritive value needs to improve its quality in feeding strategy.

Grazing crop residues can only commence after the grain has been harvested, especially during a wet season. It contributes up to 50% of the feed supply in mixed farming system (Sontakke *et al.* 2014).

In feeding with non-conventional feed source (NCFS), Sontakke *et al.* (2014) revealed there is serious shortage in animal feeds in the conventional types. The insufficiency of conventional feeds can be met with NCFS. NCFS refers to those feeds that have not been traditionally used in animal feeding and are not normally used in commercially produced rations for livestock. NCFS commonly includes a variety of feeds from perennial crops and feeds of animal and industrial origin. It describes a new source of feedstuffs as pellet oil mill effluent and palm press fiber (oil palm by-products), single cell protein, and feed materials derived from agro-industrial by-products of plant and animal origin.

2. Cut-and-carry systems

Palmer (1998) stated that the feeding system of the animals using cut-and-carry is not a new concept for the Asian farmers. The animals are penned and enough space is given for animals to move, but not so much that they do not waste too much energy in exercising. The feeds, primarily green forages are then brought to the animal in appropriate amounts and intervals to effect maximum growth. Generally, freshly cut forage can be given to an animal equivalent to around 10% of the body weight per day.

FAO (n.d) reported the cut-and-carry is feeding method that widely practiced by smallholders in many countries and is well suited to small scale dairy production where access to grazing land is short. It is used to provide the complete requirement of cattle kept in zero grazing.

In Timor-Leste, cut-and-system is done specially for legume trees and shrubs in the dry season when the cattle are penned. Feeding a 100% Leucaena to cattle has started to be the common practice. However, feeding 100% Leucaena for fattening may not be economically, therefore it should be combined with crop residues such as maize stovers, the most commonly available energy source in Timor-Leste (Soares *et al*., 2018).

2.8 Ruminant Animal Feedstuffs

Tisch (2005) said that feedstuff is an ingredient in a ration. Ration is a combination of feed ingredients that are formulated to meet the daily nutritional needs of the animal. The ration is part of the diet, where diet refers to all the feeds consumed by animals from time to time. Diet plays an important role in increasing production efficiency in all animals (Wilkanowska and Kokoszyński, 2015). In an intensely managed animal operation, the composition of feed is depicted by rations.

Various types of feedstuffs or feed ingredients are available to supply the nutritional needs of livestock. These feedstuffs are raw materials that are converted into animal cells, tissues, organs and products (Tisch, 2005). A familiarity with the chemical and nutritional composition of the various classes of feedstuffs is essential in order to formulate the most economical and profitable rations. It is also important to be familiar with the various feedstuff types to plan for planting, harvesting, and storage of homegrown feedstuffs.

1. Fresh forages

Forages are given in fresh, including fresh grasses, young corn stalks, and legumes. The amount of forage given to cattle in Indonesia is 30 - 40 kg (Astuti, 2019). It really depends on the weight of the cow in question. Generally, it can be given 10% of body weight. Green feed functions as a source of minerals, carbohydrates, vitamins, and protein (especially those from nuts). Fresh green from superior species of grass, such as elephant grass, the nutritional value is guaranteed, and the volume is more than that of weeds (Astuti, 2019).

2. Dry Forages

Astuti (2019) stated that the feeds derived from dried forage, such as straws from the agricultural by-products such as rice straws, peanuts, soybeans, corn stovers and others. Those straws are feedstuffs with low quality protein, high cellulose, and lignin that can be utilized by ruminant animals, however, it is difficult to digest. Cows that eat 10 kg of straw are only about 3 kg or 3% digested (Astuti, 2019).

The utilization of straws is only recommended a maximum of 2% of cow body weight. In addition, if the straws are given separately it can cause a decrease in body weight of cows.

3. Concentrates

Feed concentrate is a feed ingredient with high nutritional concentration and low in crude fiber content which is relatively easy to digest. These materials are in the form of bran, coconut cake, peanut cake, cassava and others. In general, farmers in serving this booster feed are still very simple. They only make feed compositions or mixtures that consist of only 2 (two) kinds of ingredients, and some even have only one type of material (Astuti, 2019). Moreover, Astuti reported the concentrate is a mixture of feed ingredients that contain more than 12 to 16% protein.

2.9 Ruminant Feed Resources

Dandessa (2015) reported that inadequate of feed supply, both of quality and quantity is the major constraint affecting livestock production. Feed shortage is indicated as a factor resulting for the lower productive and reproductive performance of the animal during the dry season. Inadequate of the grazing resources in dry season resulting of the animals are not be able to meet their body maintenance and lose of weight. Animal feeds are classified as native pasture, crop residues, improved grasses and agro-industrial by-products in which there are the major contribution in livestock production.

1. Native Pastures

Sontakke *et al*. (2014) described the contribution of native pasture to the ruminant is estimated around 80 to 90% of livestock feeds and whose quantities are seasonally variable and it is the main source of feed in arid and semi-arid pastoral areas. Crop residue contributes up to 50% of the feed supply in mixed-farming system. Grazing lands are steady shrinking by conversion of arable lands, and natural pastures are also restricted to areas that are marginal and have little farming potential.

Blackwood *et al*. (2006) stated the most native pastures have complex plant communities that contain a large number of species with varying drought tolerance, feed values and persistence when grazed. It is estimated up to 100 different plant species often exist in a single paddock. However, 5 to 20 common grazes usually dominate and determine the overall productive potential. In the same report, Blackwood (2006) also stated the dominant species within native pasture can change from season to season even from year to year depending on the rainfall, temperature, fertilizer application, and grazing management.

2. Fodder Trees and Shrubs

Fodder trees and shrubs are always played a significant role in feeding livestock ruminants. In fact, trees and shrubs are increasingly recognized as important components of animal feeding, especially as suppliers of protein and particularly in harsh environmental conditions (FAO, 1991). Dicko (n.d) stated fodder trees and shrubs are constituting of the main protein, mineral and vitamin and become an integral part of the animal diets during the dry season.

Tol (2004) said the fodder trees' deals with trees and shrubs mainly or partially grown to provide fodder for livestock. The information in this brochure helps extension workers in the tropics to advice farmers about feeding fodder tree leaves to cattle, goats and sheep. It describes in short how farmers can benefit from fodder trees and which type of tree, how many and where they should be planted. It also deals with harvesting, feeding rations and the harmful side effects, when tree leaves are fed in excess to the animals.

Chen (n.d) the use of fodder shrubs such as Leucaena have become a phenomenon recently and much needs to be done to encourage small farmers to exploit this valuable source of feed. Many potentially useful shrub species such as Gliricidia, Flemingia, Tephrosia and Albizia are planted on cocoa plantations as protective trees. Franzel (2013) stated the fodder trees are easy to grow, require little land, labor or capital, have numerous by-products and often supply feed within a year after planting.

3. Crop Residues

Animal production is integrated with crop production in the smallholder farming systems. The animals provide draught power, manure and produce meat and milk for human consumption. However, the crop land expansion increases, the availability of grazing land decreases, thus, limiting the scope for increased livestock production. In such circumstances crop residues play an important role in supplying feed to ruminant animals (Tesfaye and Chairatanayuth, 2007). Rasby (2014) said although corn crop residue grazing is effective in reducing feed costs, some producers are concerned that grazing and, therefore, residue removal and compaction will have a negative effect on subsequent grain yields.

Khajarern and Khajaren (n.d) explained that the livestock production in a tropical Southeast Asian farm is of secondary importance after crop production. Ruminants are raised for draught purposes and/or as the growing farm assets, while pigs and poultry are raised for cash needs and for family consumption. Khajarern and Khajaren also stated the Southeast Asian agriculture as a whole has placed more emphasis on crop rather than livestock production. Ruminants are expected to graze on marginal land about the cultivated plots to obtain barely enough green forage during the rainy season. The green feed supply is generally inadequate during the dry period. During these dry months, crop residues represent the important source of feedstuffs to feed them.

The varieties of crop residues and agro-industry by-products that commonly produced and utilized in Southeast Asia regions as follows.

Table 4. List of agro-industrial by-products and crop residues produced and utilized in Southeast Asian regions

Agro-industrial by-products	Crop Residues
Rice bran	Rice straw
Broken rice	Maize stover
Maize bran	Maize husk
Maize germ meal	Sorghum stover
Cassava wastes	Sorghum head w/o grain
Sugar-cane molasses	Sweet potato vine
Soya bean meal	Cassava leaves
Ground nut meal	Banana stem and leaves
Cotton seed meal	Banana fruit wastes

Table 4. Continued…

Agro-Industrial by-products	Crop Residues
Copra meal	Pineapple wastes
Roughages	Sugar-cane tops and leaves
Rice hulls	Soya bean stover and pods
Maize cob	Groundnut vine
Pineapple bran	
Sugarcane bagasse	

Source: Khajarern and Khajaren (n.d)

4. Agro-Industrial By-Products

Agro-industrial by-products have special value in feeding animals in urban and peri-urban livestock production system where the productive of the potential animals is relatively require high nutrient supply (Dandessa, 2015). The major agro-industry by-products that commonly used are rice bran, corn bran, wheat bran, edible oil extraction palm such as cottonseed cake, peanut cake, sunflower cake, breweries, copra meal, and molasses are given to the livestock through supplementation where the amount offered is limited.

5. Improved Grass Development

Forages are the major feed for ruminants in the form of grasses and leaves (Rukmana, 2005). The improved grasses are cultivated. They are grouped into various species utilize as the main feed for ruminants.

The types of improved grasses which are developed for ruminant feedstuffs are napier grass *(Pennisetum purpureum),* Setaria *(setaria sphacelata,*, Brachiaria *(Bhachria brizantha),* Guinea grass *(Panicum maximum),* Paragrass *(Brachiaria mutica)* King grass *(Pennisetum purpudoides),etc.* King grass has a high production rate which has been developed by many breeders.

Vierman (2017) stated that King grass is easy to cultivate and has high production potential. Compared to elephant grass, the King grass production is twice than Elephant grass, which can reach 40 tons of fresh grass per hectare at a time or the equivalent of 200-

250 tons of fresh grass per hectare per year. The high productivity of the King grass makes this King grass widely used as feed in the fattening of ruminants (cows, goats, sheep, and buffaloes) wherein forage is usually given about 10% of the animal's body weight.

2.10 Feed Planning

Howse (2013) stated a feed planning is made to provide guidance on the nutrient requirements of cattle to ensure the cattle are fed in right way that can promote good health and prevent negative impacts. A feeding plan can be given to someone who is rearing for the cattle to ensure that they feed the cattle in the right way. A feeding plan must include all nutritional requirements and any supplements needed. In the same report, Howse (2013) stated the factors that needed to be considered in designing feeding plan are animal age, species, life stage (pregnant, lactating), health (sickness), level of activity, and individual breed.

PNMG (2013) informs the cattle must be fed a well-balanced diet for energy, protein, minerals and vitamins. This will be ensured their nutritional requirements are met and not exceeded which would lead to waste and inefficiency. Feed planning is starting by the calculation of the amount of the nutrients that animals need to perform expected level, calculating what can be grown on-farm, provides an opportunity for farmers and industry to enhance profitability while protecting our environment. In the same report described the category of nutrients required for all animals to grow, thrive and produce milk and meat are energy, protein, minerals, and vitamins.

a. Energy

The energy requirements obtained from feeds for the dairy cows (Metabolizable energy (ME) are based on the consideration of the factors such as body weight, milk production, milk fats, efficient use energy, pregnancy status and energy density from the feed. PNMG (2013) stated that the animals' response to energy depends upon the carbohydrates and fats are contented in the diets. Carbohydrate such as starches, simple sugar and more complex cellulose and hemicellulose are fermented in the rumen and broken down to volatile fatty acids to provide the energy required.

b. Protein

Parish and Rhinehart (2008) protein in beef cattle diets is commonly expressed as crude protein. To determine the crude protein content of a forage or feedstuff, first measure the nitrogen content of the feed. Then multiply the nitrogen value by 6.25, because proteins typically contain 16 percent nitrogen (1/.16 = 6.25).

Crude protein is comprised of both true protein and non-protein nitrogen (NPN). Not all nitrogen-containing compounds are true proteins. Urea is an example of NPN source. Many NPN compounds can supply nitrogen to the rumen microbes that then build microbial protein in the rumen using this nitrogen.

True protein is sometimes called natural protein. It is either degradable (can be broken down) or undegradable (cannot be broken down) in the rumen. Ruminally degradable protein (RDP) is broken down in the rumen and is also referred to as degradable intake protein (DIP). Ruminally undegradable protein (RUP) is protein not broken down in the rumen but is potentially degradable in the small intestine. It is sometimes called undegradable intake protein (UIP) or rumen bypass protein. A minimum amount of DIP is needed in the diet to support microbial growth. Otherwise the intake and digestibility of the diet will be limited. Crude protein is the sum of UIP and DIP.

c. Minerals

Minerals are essential components of animal feed ingredients. They are very important in ensuring normal functioning of the body as well as in maintaining good health (Infonet-biovision, 2011).

Cattle require some form of mineral supplementation during all times of the year (Troxel, 2015). The available minerals needed are macro and micro mineral. The macro minerals including sodium (Na), phosphorus (P), calcium (Ca), potassium (K), magnesium (Mg), and sulfur (S) are the most important used by animals for many physiological functions to boost animal production.

The micro minerals or called trace minerals such as zinc (Zn), copper (Cu), selenium (Se), cobalt (Co), and ion (F) are no less important than the major ones, they are just needed in smaller quantities. However, they are essential to animal for maintaining growth and health (PNMG, 2013).

d. Vitamins

All vitamins are very important for all animals, in most cases only vitamin A needs to be considered in ruminants feeds. Vitamin A can be stored in the liver and body tissues during periods of high intake and is used during periods of low intake. Vitamin B is usually synthesized in ruminant rumen. For other animals, it is useful to include a small amount of feed from animal origin to supply vitamin B_{12}.

Vitamin C most of the time can be taken from green fodder eaten by ruminants. Vitamin D is produced when animals are exposed to direct sunlight, for this reason it is always recommended to give livestock the opportunity to spend time in the sun (Infonet, n.d).

2.11 Nutrient Composition of Feed Ingredients

The information on the nutrient composition of feed ingredients is very important for formulating feeds and diets to meet the nutrient requirements of animals. Various nutritional composition of certain feed ingredients is a function of several factors, including conditions of growth and harvest, the effect of processing and storage and nutritional status of organisms (NRC, 1998). Nutrient composition of common roughages dry matter basis) according to NRC (2001) as cited by PHILSAN (2010) listed in the Table below.

Table 5. Nutrient composition of roughages (dry matter basis)

A. Forage	Scientific Name	DM (%)	ME (Mcal)	TDN (%)	CP (%)	Ca (%)	P (%)
Cogon grass	*Imperata cylindrical*	32.4	1.4	39.2	4.9	0.06	0.06
Corn silage	*Zea mays*	30-35	2.4-2.5	65-70	7.5-8.5	0.30	0.30
Corn stover	*Zea mays*	89.0	1.7	47.0	3.6	0.62	0.90
Corn stover silage	*Zea mays*	33-45	1.8-2.0	50-56	5-7	0.30	0.30
Guinea grass	*Panicum maximum*						
21 days		22.7	2.1	58.1	11.0	-	-
42 days		24.0	2.1	57.9	7.9	-	-
45 days		24.67	-	-	10.78	-	-
56 days		24.6	2.0	54.1	6.1	-	-
		25.0	1.9	52.0	10.3	0.74	-
Napier grass	*Pennisetum*						
21 days	*purpureum*	16.6	2.2	61.4	15.1	-	-
42 days		20.3	2.1	58.6	9.8	-	-
45 days (local variety)		17.5	-	-	9.6	-	-
						-	-
45 days (hybrid, Florida)		17.1	-	-	10.9	-	-
56 days		20.5	2.1	57.6	7.8	-	-
		22.0	2.0	55.0	9.5	0.42	0.39

Table 5. Continued…

A. Forage	Scientific Name	DM (%)	ME (Mcal)	TDN (%)	CP (%)	Ca (%)	P (%)
Paragrass	*Brachiaria mutica*	26.0	2.0	56.3	10.6	-	-
Rice straw	*Oryza sativa*	90.0	1.7	47.0	3.8	0.32	0.10
Sugarcane	*Saccharum officinarum*	31.0	1.9	52.0	6.4	0.20	1.17
B. Legumes							
Acacia leaves	*Samanea saman*	-	-	-	22.8	-	-
Centro	*Centrocema pubescens*						
42 days		18.5	2.3	64.0	27.6	-	-
63 days		20.2	2.2	62.4	25.7	-	-
48 days		22.3	2.2	60.5	22.4	-	-
Cowpea hay	*Vigna sinensis*	88.0	2.1	57.0	20.4	1.15	0.69
Kakawate	*Gliricidia sepium*	-	-	-	26.4	-	-
		20.8	-	-	21.4	-	-
Ipil-ipil leaves	*Leucaena*	29.2	2.1	59.2	27.4	-	-
Tops	*leucocephala*	27.8	2.6	71.2	21.9	-	-
		-	-	-	26.9	-	-
		-	-	-	24.4	-	-
Moringa	*Moringa olifira*	-	-	-	29.3	-	-
Peanut hay	*Arachis hypogea*	85.0	2.0	55.0	17.3	1.23	0.15
Sesbania	*Sesbania grandiflora*	-	-	-	31.0	-	-
Stylosanthes	*Stylosanthes guianensis*	-	-	-	16.7	-	-

Data Source: NRC (2001) as cited by PHILSAN (2010).
DM = dry matter, ME = metabolizable energy, TDN = total digestible nutrients, CP = crude protein, Ca = calcium, P = phosphorous

Table 6. Nutrient composition of common feed ingredients (as fed basis)

Feed ingredients	Dry matter (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	Starch (%)	TDN (%)
A. Energy source							
Banana meal, peeled	90.00	5.40	1.10	3.50	5.20	70.00	60.20
Barley	89.65	9.23	3.14	6.52	1.74	56.80	70.00
Cassava, residue	86.60	2.20	0.90	12.30	5.30	56.00	70.94
Cassava meal	90.00	3.80	0.40	1.10	1.20	59.00	74.53
Corn, cooked	91.59	6.85	0.76	0.73	0.49	83.00	81.40
Corn, yellow (imported)	90.00	8.60	3.40	1.60	1.20	62.00	80.68
Corn, yellow (local)	89.29	8.05	3.94	2.44	1.42	71.00	80.00
Rice, broken	88.00	7.50	0.90	3.80	0.70	58.00	77.50
Rice, broken (imported)	90.00	9.00	4.00	1.00	3.00	70.00	-
Rice, paddy	89.00	7.30	1.20	9.00	4.90	50.00	71.20
Sorghum	88.00	9.00	2.70	2.20	1.80	62.00	77.40
B. Protein Source							
Blood meal, drum dried	90.00	80.00	1.00	0.50	5.00	-	63.47
Blood meal, spray dried	93.50	90.00	2.00	0.50	4.50	-	69.71
Fish meal, local sardines (50%)	87.70	49.40	4.60	1.00	20.70	-	-
Fish meal, local tuna (55%)	96.60	54.60	17.60	0.35	18.49	-	-
Fish meal, local tuna (60%)	92.69	59.15	13.28	0.57	17.98	-	-
Fish meal, prime	93.9	68.00	7.90	0.10	14.30	-	-
Meat and bone meal (50%)	94.00	50.00	10.00	1.70	27.60	-	65.00

Table 6. Continued…

Feed ingredients	Dry matter (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	Starch (%)	TDN (%)
C. Plant source protein							
Black beans	90.30	39.50	1.50	11.60	6.00	-	-
Feed peas	89.80	22.30	1.30	5.20	3.20	46.00	-
Cow pea	88.00	21.50	1.20	3.20	3.20	-	-
Green peas	92.70	21.40	1.21	1.79	2.61	70.11	60.30
Ipil-ipil leaf meal	90.00	20.00	4.40	10.30	7.00	-	-
Mung bean	88.56	24.77	1.13	4.32	3.70	-	-
Pigeon pea	88.00	22.50	1.00	8.00	4.70	-	-
Rice bean (tapilan)	89.10	18.60	1.20	6.50	3.90	-	-
Soybean meal, Argentine	91.52	47.00	1.60	3.10	6.40	-	-
Soybean meal US high protein , 1	90.72	47.65	1.23	3.43	6.60	4.00	75.00
Soybean meal US high protein, 2	91.92	46.74	1.29	3.50	6.74	4.00	74.76
Soybean meal US low protein	90.00	43.10	1.80	5.00	6.40	5.50	70.16
Soybean full fat	90.27	35.72	1.93	6.26	4.69	4.00	-
Sunflower seeds	93.92	18.10	31.58	24.49	3.50	-	-
D. Non protein nitrogen							
Urea	98.00	281.75	-	-	-	-	-
E. Milling and factory by-product							
Copra meal, expeller	96.20	21.00	10.51	8.76	6.13	-	82.10
Corn bran	88.60	9.00	8.50	7.00	3.20	40.00	74.80
Corn gluten feed	94.75	18.28	2.73	10.48	5.61	21.00	82.10
Corn gluten meal	90.50	60.00	2.00	2.50	1.80	13.00	59.30
Distillers dried grain soluble (DDGS)	90.18	26.00	10.02	8.73	4.38	-	-
Molasses	75.00	2.90	-	-	-	-	54.84
Rice bran, D1	91.40	12.14	13.79	5.27	6.89	28.00	77.16
Rice bran, D2	89.00	10.00	9.90	10.20	7.20	20.00	73.14
Soy hulls	92.00	8.00	0.70	36.40	4.30	-	48.20

Data Source: NRC (2001) as cited by PHILSAN (2010).

2.12 Carrying Capacity of Forages

Carrying capacity is a measurement (actual or estimated) of how much forage unit or piece of ground is able to produce on an average year (Meehan *et al.*, 2018). In the same report Meehan stated that the carrying capacity is the maximum stocking rate possible that is consistent with maintaining or improving forage and other vegetation and related

resources. It can vary from year to year on the same area due to changes in forage production. Carrying capacity is expressed as the number of animal units that can be grazed for a specific time period in amount of forage available for grazing animals which expressed in animal unit months (AUMs), or number of animal units grazed for one month. An animal unit month (AUM) is based on the age, class and size of livestock, and the amount of forage they will consume in one month. An AUM also is a common way of expressing stocking rates.

In calculating of the carrying capacity of forage, Matitaputty and Kuntoro (2010) stated that there are several assumptions on the requirement of feeds to the ruminants. The assumption is that one animal unit (AU) required an average of dry matter (DM) is 6.25 kg/ (NRC, 1984). The results of the calculation of dry matter are used to obtain the carrying capacity (CC) of forage, carrying capacity index (CCI), and determine the grazing days in the paddocks of pasture. Ashari *et al*. (1995) reported that the level of feed safety in an area is measured with the CCI of livestock. The CCI values indicate the standard criteria for the carrying capacity of forage in a region to sustain the livestock's productivity. The criteria such as: safety (CCI > 2), prone (CCI < 1.5 – 2), critical (CCI < 1 – 1.5), and very critical value (CCI < 1) (Ashari *et al*., 1995).

2.13 Bali Cattle Productive and Reproductive Performance

1. Productive Performance

Larson (2015) beef cattle production is carried out in a system that includes grazing on a large amount of land per cow, being fed a high-calorie diet for several months in large populations immediately before slaughtering. Sari *et al*. (2016) said that there are three different Balinese cattle farming systems including intensive, semi-intensive, and extensive. In intensive farming systems, farmers carry and provide water and chopped or cut grass for their cattle in the paddock. In the semi-intensive system the cattle get their own feed from the cowherd land in the morning and are penned up in the afternoon. Bali cattle from extensive farming move freely around the grazing land, do not require additional feed. These different farming systems will affect the ability of Bali cattle production which can be indicated by birth weight (BW), weaning weight (WW), weight

gain (WG), and year weight (YW). It is important to study the effect of the farming system on Bali cattle production.

2. Reproductive Performance

Rastosari (2018) one effort to increase the population is to improve the reproductive performance of cattle. Population increase and livestock production depend on reproductive success, if reproduction is not regulated as well as possible, the production level will be low. Reproduction performance observed included the age of first mating (AFM), the age of first calving (AFC), service per conception (S/C), postpartum oestrus (PPO), and postpartum mating (PPM). Reproduction performance can be used to calculate the estimated livestock population in the future.

Wathes *et al*. (2016) bull reproductive performance is influenced by several factors including testicular development, semen quality, libido, mating ability, and physical soundness. Pribadi *et al.* (2008) reported the productive efficiency includes as follows:

- Age at First Service (AFS) is a period of age in which a heifer has the first mating. The age recommended for first mating is around 18 months.
- Age at First Calving (AFC) is a period of age in which a heifer has the first parturition. The acceptable and optimum performance of age at first calving under improved small holder system in the tropics is less than 30 and 36 months, respectively;
- The first calving makes the beginning of a cow productive life and influences both the production and reproduction life of the female, directly through its effect on her life time calf crop and milk production and indirectly it is influence on the cost invested for up-bringing (Mukasa-Mugerwa, 1989).
- Days open (DO) is the interval (days) from calving to conception. Cows showing long DO have low reproductive efficiency;
- Calving interval (CI) is the period of time between two successive calving. It is the sum of the gestation period and days open period;
- Calving rate (CR) is the percentage of cows served, which calve at term and have optimal chances of producing a living calf. This value might be lower than the conception rate determined during early pregnancy period because an average of 3% of abortions has to be occurred during pregnancy period;
- Pre-weaning mortality is the percentage of animal's dead between birth and weaning,

Krishnan (2014) said nutrition plays a significant role in animal reproduction and there is always a positive correlation between the two. The influence of nutrition in animal reproduction begins early in the animal's life as the influence of nutrition in young animals affect the age at which they reach puberty. In mature animals poor nutrition can reduce production of ova and spermatozoa, so that a female either fails to conceive or produce fewer offspring than normal. During pregnancy females have specific nutrient requirements for the maintenance and growth of fetus.

III. MATERIALS AND METHODS

3.1 Study Site

The survey study was conducted in Lautem Municipality, Administrative Post of Lospalos which cover 8 villages selected as study areas due to the highest population of Bali cattle and have permanent potential natural pastures or grassland for cattle development. Figure 3 below shows the location of the study in Lospalos Administrative Post, Lautem Municipality.

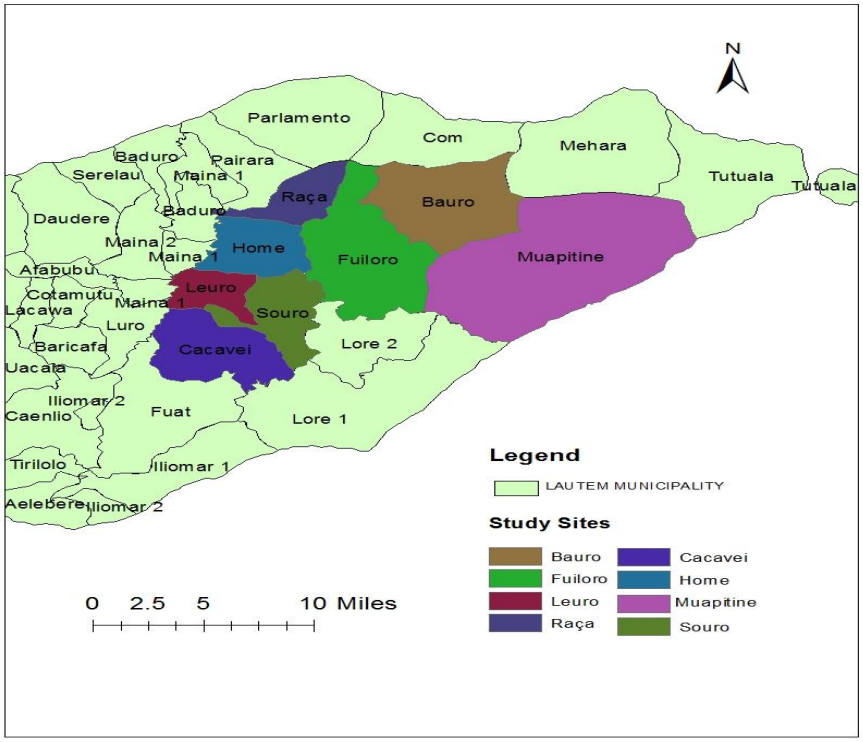


Figure 3. Location of the study research in Lospalos, Lautem Municipality.

Lospalos with the total area of 248 km2, total Bali cattle are 11,443 heads reared by 1,836 private households.

3.2 Sampling

The research target in study survey was the smallholder Bali cattle farmers in Lospalos Administrative Post which cover 8 villages like Fuiloro, Home, Bauro, Raça, Muapitine, Souro, Leuro, Cacavei, inside the Lautem Municipality, Timor-Leste.

Fraenkel *et al.* (2013) one of the most important steps in research process is the selection of samples of individuals who will be observed or questioned. Samples refer to the process of selection of individuals from a population. The population in this study is the smallholder household rearing Bali cattle in the study areas.

Sample in this study is selected by using **Proportional Random Sampling** techniques. Proportional Random Sampling is used to choose a sample from the number of research subjects that are not the same. Therefore, to obtain a representative sample, take the subjects of each region is determined as balanced or proportional to many subjects in each region (Arikunto, 2006). Moreover, Arikunto (2006) explained that 10% - 25% of the population is selected as sample. Therefore, in this study about 10% households were selected as respondents.

3.3 Data Collection

Data was obtained according to the data collection method in each study. In generally, there were collected the primary and secondary data. The primary data was collected by using questionnaire through direct interviews, focus group discussion (FGD), direct observations, measurements of research objects and experimental trials. The secondary data was obtained from the government institution, such as the Ministry of Agriculture and Fisheries (MAF), administrative offices of municipality, and NGO's both local and international.

3.4 Study 1. Characterization of Farming System, Production and Reproduction Performance of Bali Cattle under Smallholder Farms

Materials and Methods

A survey study was conducted to find out the information of Bali cattle farming system and reproduction efficiency in Lospalos, Lautem, using questionnaire. Farmers and

the other stakeholders were the main targets, hence, the sample was selected with proportional random sampling method.

Focus group discussion (FGD) was done to gather information on the Bali cattle production system in Lospalos. The FGD participants was selected purposively based on their knowledge of the cattle production system being practiced in the study areas. An FGD in each village was conducted to collect information on Bali cattle production systems including agriculture production that used its by-products as the feed sources and other feed resources through discussion (asking questions) using a prepared set of guide questions.

Purposive sampling by the herd was conducted and randomly selected around 18 heads of Bali cattle from different growing stages samples. The measurements of body dimensions were conducted on each animal. The measuring instruments were tape and measuring stick. The tape was used to measure the chest girth (CG) and body length (BL), the measuring stick was used to measure the body height (BH), The measurements of the body dimension are as follows:

A-B: Body length (BL) was measured form distance between the site of shoulder to pin bone;

C-D: Chest girth (CG) was measured as body circumference at behind the foreleg; and

E-F: Body height (BH) was measured from ground level parallel to the foreleg until it withers.

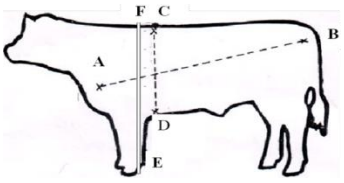


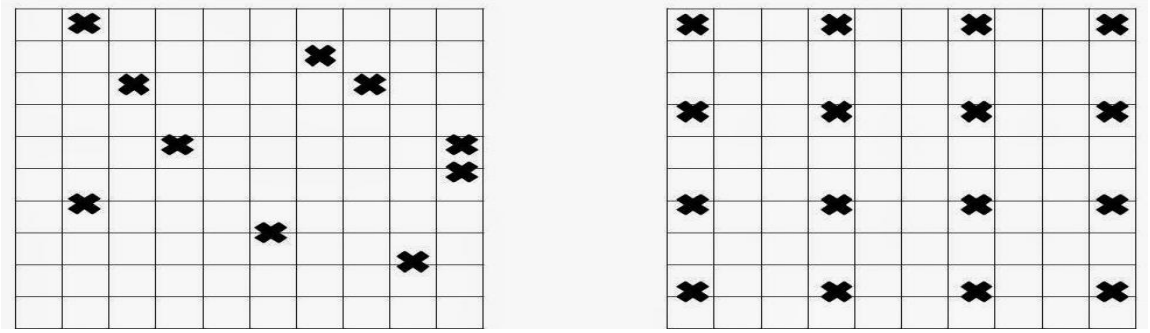
Figure 4: Measurement of cattle body dimensions

3.5 Study 2. Profiling of Feed Resources in Lospalos, Lautem, Timor-Leste

Materials and Methods

Purposive sampling techniques was used to determine the sample size (representative areas) based on the requirements (households who have minimal 2 heads of cattle, crop fields and private paddock or pasture).

Figure below indicates the layout of forages crop's areas (100 m2) using randomized and systematics sampling.



Area A: Randomized sampling Area B: Systematics sampling

Figure 5. Layout of forage crop's areas for sampling, X: Cage quadrates (Sized 1 x 1 m)

The representative sample was collected per village (8 villages) in Lospalos Administrative Post at least 5,000 to 10,000 m^2 of the areas.

The procedure of measurement:

a. Find the representative area for taking sample;
b. Sample was taken with a 1 m x 1 m (1 m^2) sized square quadrat (plate mater) made from PCV pipe 1/2 inch;
c. Quadrat was placed in that representative area of the amounts of grasses and by-products in the fields;
d. Cut any forage to 2 cm above ground level and put it into a paper bag;
e. Cut 10 – 12 cage quadrats at each site; and
f. Each site (100 m^2) was placed 5 – 10 cage quadrates (500 – 10,000 cage quadrates per hectare);
f. Weigh the fresh weight of the sample;
g. Air or sun drying during 3 days and weigh and write the weight (g);
h. Take sample at least 200 to 300 g for oven dying (105^{o}C for 2 h or 70^{o}C for 24 h);

i. Weighing the wt of sample (g) using analytical scale;

j. Calculate the DM with using this formula:

Note: For the legume trees can take 5 trees per m^2. Cut about 1.5 m above ground level. Put in the paper bag and weigh for the fresh weight.

The dry matter (DM) yield of fodder crops and by-product productions per hectare and per year was calculated. Carrying capacity (CC), carrying capacity index (CCI) of forages and grazing days was estimated according to the DM yields.

Formula for calculating according to Ashari *et al*., 1995 is as follows:

- Production per ha = $\frac{\text{Area (ha)}}{\text{Size of quadrat } (m^2)}$ x Quadrat production (kg)
- Production per year = Production/ ha x Area (ha) x Number of harvest a year
- Carrying capacity of forage (AU) = $\frac{\text{DM yields (kg/year)}}{\text{DMC of cattle (kg/ year)}}$
- Carrying capacity Index of forage = $\frac{\text{Total DM yields (kg)}}{\text{Total cattle (AU) x DMC of cattle (kg/AU)}}$

or, carrying capacity index of forage = $\frac{\text{Carrying Capacity of forage (AU)}}{\text{Total cattle (AU)}}$

3.6 Study 3. Designing a feed calendar as basis for feeding plan for Bali cattle

Materials and Methods

A survey study was carried out to obtain the data on feed resources availability in the study areas. Data was collected through in-depth interviews using questionnaire and direct observation in the field (taking photos, videos and measurements in the paddocks and the crops fields). Secondary data was obtained from related institutions (pictures, photos, and videos and documents).

3.7 Data Analysis

The data obtained from interview were analyzed in descriptive and statistical analysis by using Microsoft Excel and Statistics Package of Social Science (SPSS). In descriptive analysis, the data were processed through establishment of the category or classification of the data, coding, and tabulation and qualitative data was described and interpreted into narrative form.

The result of the FGD was analyzed qualitatively to describe the production systems in the study areas using SPSS. Data of the mating system, male utilization, age at first service, age at first calving, calving interval, calving rate, pre-weaning mortality, and days open organized in the Excel spreadsheet and then will be analyzed using SPSS Statistical Software to describe the frequency and percentage. The data on the body length, height, chest girth, body was subjected to the regression linear model to evaluate the significant of source of variation affecting measurement of each animal. The interrelationship between body weight and body measurements were estimated using simple correlation and regression (Steel and Torrie, 1980; Byrkit, 1987). The fixed effect considered was age. The model used was:

$Yij = \mu + \alpha i + sj + eij$

Where: Yij = records of body measurements of each animal and other farming characteristics; μ = overall mean; αi = the fixed effect of *i*th age of the animal, *j*th sex, and eij = random error associated with the record of each animal and other characteristics. a: age group, s: sex.

To predict live weight from body measure, simple regression analysis was used (Microsoft Office Excel, 2011). A simple regression model for predicting live weight from chest girth and body length in each age group of the animals was using as follows:

$$\mathbf{Y = a + bX}$$

Where Y = dependent variable of the animal live weight;

a = intercept; b = coefficient of regression, and X = independent variable of the animal body measurements either body length and chest girth.

Data from the feed resources were organized in the excel spreadsheet and then analyzed using descriptive statistics and SPSS to describe and interpret the situation of the feed resources availability in all the study areas.

IV. RESULTS AND DISCUSION

4.1 Household Characteristics

The survey resulted on 157 of household in 8 villages with their characteristics such of age of household, education, occupation, farm size, Bali cattle ownership, and farming period of time or experience in rearing Bali cattle. The household characteristics in the study areas are shown in the Table 7.

Table 7. Household characteristics of the smallholder in 8 were selected as respondents

No	Household characteristics	Freq.	Percent
1.	Farmers age		
	a. ≤36 years old	23	14.65
	b. > 36 – 57.3 years old	84	53.50
	c. > 57.3 years old	50	31.85
2	Educational attainment		
	a. Illiterate	24	15.29
	b. Elementary school	43	27.39
	c. Junior high school	18	11.46
	d. Senior high school	47	29.94
	e. University	25	15.92
3.	Experience in keeping Bali cattle		
	a. ≤14.7 years	94	59.87
	b. >14.7 – 27.4 years	47	29.94
	c. > 27.4 years	16	10.19
4.	Occupation		
	a. Farmer (crops – livestock)	133	84.71
	b. Civil servant	15	9.55
	c. Retirement	1	0.64
	d. Small business	4	2.55
	e. Private sector	4	2.55
5.	Farm size		
	a. Small (≤2.13)	152	96.82
	b. Medium (>2.13 – 4.1)	4	2.55
	c. Big (> 4.1)	1	0.64
6.	Cattle ownership		
	a. Very small (≤35.6)	147	93.63
	a. Small (>35.6 - 69.2)	8	5.1
	b. Medium (>69.2 - 102.8)	0	0
	c. Big (>102.8 - 136.4)	1	0.64
	d. Very big (> 136.4)	1	0.64

1. Age of Household

The age of the respondent can be grouped in 3 aging groups where the minimum age of respondents was 15 years old and the maximum age was 79. The data indicates that the respondents with the age below 36 years old were 14.65%, age between 36 – 57.3 years old were 53.50%, and the age above 57.3 were 31.85% respectively.

The majority of household reared Bali cattle in 8 study area was 53.50%. The result shows that the farmers with the old age were involved in the smallholder Bali cattle in the study areas. Age was one of the independents variables that can affect to the farmer's activity in rearing cattle. They have been experienced in keeping cattle but their level of acceptance to the innovation take time and required a lot of consideration.

2. Education Attainment

The education attainment of household (HH) reared Bali cattle under smallholder in the study areas. Of the 157 respondents, 15.29% illiterate, 27.39% elementary school, 11.46% junior high school, 29.94% senior high school, and 15.92% graduated from the university.

The data indicated that the majority of respondents were not much educated. It was from the compilation of the percentage of the illiterate, elementary school, and junior high school with the 54.14% compared to the senior high school and university with the total of 45.86%.

3. Occupation

Most of the HH are cropping as their primary jobs, while the cattle are reared as side work. Table indicates that around 88.4% they relied on agriculture and livestock for their livelihoods. 9.55% of the farmers were from the civil servants, retirement was 0.64%, small business and private sector were 2.55%.

The data indicated that the majority of household occupations were the combination of both crops and livestock where the crop production as the main occupation and the livestock as a side work. This is why they were not focused on the livestock rearing but they were focused on their main crops productions. Another reason is the livestock is

reared for selling as well as for the culture activities. The study resulted that 86.4 respondents said that the purpose of rearing cattle was for selling and for culture activities.

4. Experience in Keeping Bali Cattle

The data shown that the farmers who have experience in keeping Bali cattle below 14.7 years was 59.87%, farmer's experience between 14.7 – 27.4 years was 29.94, and 10.19% of farmers who have experience above 27.4 years.

5. Farm size and Cattle ownership

Farm size was considered as the unit of land provided to the crops and vegetables productions. The result of the study indicates that the minimum farm size was 0.2 ha and the maximum was 6 ha. The small size of the farm below 2.13 ha owned by the household was 96.82%. Medium size between 2.13- 4.1 ha was 2.55%, and the big size above 4.1 ha was 0.64%.

Bali cattle ownership with the very small size below 36 heads was 93.63%, following 36 – 69 heads was 5.1%, between 103 – 136 heads, and above was 0.64% each.

4.2 Study 1. Characterization of Bali cattle farming system, Production and Reproduction performance Under Smallholder Farms

1. Cattle Farming System and Farming Experience

The average of cattle been reared was of 13.02 ± 18.40. This can be categorized as a smallholder farm conducted by household in the study areas. The amount of cattle owned by the farmers ranged from 2 to 170 heads. Those household who have minimum amount of cattle were those who have less experience compared to those who have the bigger amounts of cattle. The average of farming period is 12.90 ± 9.32 with the ranged from 2 to 30 years. This indicates that some of the farmers were just want to start their farming with the small scale. For those farmers who have the bigger numbers of cattle, mostly they reared under the extensive and semi-extensive system. It means that the cattle were lush in the pasture for long time period and some were penned in the night time. The utilization of feed resources comes from the open areas, private pastures and the small farm size. Farm size was small minimum 0.2 and maximum 6 ha with an average of 1 ± 0.91 ha due to the

land shortage for extending farmer's agricultural land area. With the small area they utilize for many varieties of crops and the by-products then some of them are utilized as animal feeds.

2. Rearing Practice

Farmers in 8 study areas reared Bali cattle in semi-intensive, semi-extensive, extensive system. While some of the household were kept their cattle in the private ranch.

Table 8. Household rearing practice of the Bali cattle in the study areas

Rearing practice	Freq.	Percent
Intensive	0	0
Semi Intensive	35	22.3
Semi Extensive	84	53.5
Extensive	32	20.4
Private Ranch	6	3.8
Total	157	100

Table above indicates there was no intensive system on Bali cattle by household in the study areas. However, semi extensive was practiced by the household around 53.5% from the total of respondents, followed by semi-intensive system with of 22%, extensive was of 20%, and HH keeping their cattle in private ranch was of 3.8%.

3. Grazing System

Table below is the results of the grazing system applied by household in the study areas in Lospalos, Lautem Municipality.

Table 9. Grazing system of Bali cattle under smallholder farm in the study areas

Grazing System	Frequency	Percent
Zero grazing	0	0
Semi-grazing	107	68.2
Free grazing	39	24.8
Integrated (crop-livestock)	11	7.0
Total	157	100

Table above indicates that the zero-grazing was not found in the study areas. This indicates that there was no stall feeding practice. Around 68.2% from 157 responds were practiced semi grazing, means the combination between cut-and-carry system and grazing by day. Those farmers were tied their cattle for long day behind their houses or at their backyards. Grazing was in deal with the rearing system where the cut-and-carry system was done when the cattle were reared in semi intensive systems. Free grazing was done when the cattle were in extensive system. It means that the cattle were grazing in the pasture for long time of period.

Most of the Bali cattle were penned in the open stables either traditional or permanent. The integrated farming (livestock-crops) mostly done by the farmers who have private ranch. Of the 157 respondents, only about 11% farmers were done crops-livestock farming practice. It means that the utilization of agricultural by-products for animal feeds was done when the farmers were harvested their crops, such as corn stovers, rice straws, potato leaves, cassava, beans, and so on. These by-products were seasonally produced by farmers in their small farms with an average farm size was 1 ha.

Mostly cattle are feed only twice a day morning and afternoon for those who tied their cattle on their backyard farms or near their house. Drinking water was offered only once a day about 5 – 10 liters a day. This was practiced when in the summer season, while in the rainy season the farmers were rarely offer the drinking water to their cattle.

4. Production Performance of Bali cattle under smallholder farms

The cattle production performance resulted under the smallholder farms that only rely on natural grasses and legumes which have low quality and quantity for the cattle. The table below is the data of the cattle's body measured in the study area.

Table 10. Data of cattle body dimension measurement

No.	Cattle herd	Teeth	Age (mon)	BL (cm)	BH (cm)	CG (cm)	BW (kg)
1	F	Full	60	96	120	155	212.77
2	F	8	48	86	114	149	176.13
3	F	8	48	91	109	143	171.67
4	M	6	36	86	116	146	169.11
5	M	6	36	96	114	141	176.07
6	M	6	32	94	111	137	162.76
7	F	4	18	87	100	125	125.40
8	F	4	20	68	99	128	102.78
9	F	4	24	87	111	155	192.82
10	F	4	24	68	95	110	75.90
11	M	4	24	88	100	126	128.88
12	M	4	24	80	100	125	115.31
13	M	4	24	86	106	105	87.47
14	M	4	18	87	97	121	117.51
15	F	8 milk teeth	7	68	88	97	59.02
16	F	8 milk teeth	10	86	99	103	84,17
17	M	8 milk teeth	10	87	98	102	83.50
18	M	8 milk teeth	9	85	87	100	78.41

Mon = month, BL = body length, BH = body height, CG = chest girth, BW = body weight

Estimated the body weight with Scheifer's Formula: BW = $(CG\ (cm)^2 * BL)/10840$

Table below is the comparison of mean, SD, and CV on morphometric of Bali cattle male and female from the age groups.

Table 11. The mean, SD, and CV on morphometric of Bali cattle (male & female)

Parameters	Age group	Mean ± SD		CV, %	
		M	F	M	F
Age (Month)	Adult	34.6±2.3	52±6.9	6.7	13.3
	Young	22.5±3	21.5±3	13.3	14
	Calf	9.5±0.7	8.5±0.1	6.7	0.2

Table 11. Continued…

Parameters	Age group	Mean ± SD		CV, %	
		M	F	M	F
BL (Inch)	Adult	92±5.3	91±5	5.8	5.5
	Young	85.3±3.6	77.5±11	4.2	14.2
	Calf	86±1.4	77±12.7	1.6	0.17
BH (Inch)	Adult	113.7±2.5	114.3±5.5	2.2	4.8
	Young	100.8±7.8	101.3±3.8	3.7	6.8
	Calf	92,5±7.8	93.5±7.8	8.4	0.1
CG (Inch)	Adult	141.3±4.5	149±6.0	3.2	4.0
	Young	119,3±9,7	129.5±18,7	8.2	14.5
	Calf	101±1.4	100±4.2	1.4	0.04
BW (kg)	Adult	169.3± 6.7	186.86±18.4	3.9	9.9
	Young	112.3± 17.6	124.23± 50.0	15.7	40,3
	Calf	80.9± 3.6	71.6± 17.8	4.44	24.8

SD = Standard deviation, CV = Covariance, BL = Body length, BH = Body height, CG = Chest girth, BW = Body weight

Morphometric characteristics of Balinese cattle in the form of body weight (BW), body length (BL), body height (BH), and chest girth (CG) were measured to describe the characteristics of local Balinese cattle reared under smallholder farming systems.

Table 11 shows the difference in average body size of male and female cattle according to age group (adult, young and calf). The average age of cows was 52±6.9 months and bulls were 34.6±2.3months, respectively.

Practically, the body length of bulls was 92±5.3 cm slightly higher to 91±5 cm for cows. The body height of cows was found to be 114.3±5.5 cm slightly to bulls, which was 113.7±2.5 cm. The chest girth of cows was 149±6.0 cm compared to bulls, which was 141.3±4.5 cm, respectively.

The body weight of cows was 186.86±18,4 kg higher compared to 169.3± 6.7 kg for bulls. This was in line with the findings of Saputra *et al.* (2019), said that the body weight of cows was higher than that of bulls.

The average age of steers was 22.5±3 months slightly to heifers with of 21.5±3 months. The body length of steers was 85.3±3.6 cm higher than that of heifers 77.5±11 cm, respectively. The average body height of heifers was 101.3±3.8 cm slightly higher to steers, 100.8±7.8 cm.

The chest girth of heifers was 129.5±18.7 cm higher than that of steers at 119.3±9.7 cm. The body weight of heifers was 124.23±50.0 kg higher than that of steers at 112.3±17.6 kg.

In addition, the age of male calves was 9.5±0.7 months compared to female calves with of 8.5±0.1 months. The body length of male calves was 86±1.4 cm slightly higher to female calves, 77±12.7 cm. Body height female calves was found at 93.5±7.8 cm slightly higher compared to male calves at 92,5±7.8 cm.

The chest girth of male calves was 101±1.4 cm slightly higher to female calves was 100±4.2 cm. In addition, the body weight of male calves was higher at 80,9± 3,6 kg compared to female calves at 71.6±17.8 kg. This was in accordance with the findings of Saputra *et al*. (2019), stated that the average body weight of bulls, heifers, and calves was higher than the female cattle. Chest girth was found to be higher in cows and heifers than in male. However, female calves were lower than male calves. Chest girth of calves and bulls was in line to the results of research conducted by Saputra *et al*. (2019). It was reported that the comparison of the chest girth of male and female showed that male calves were larger than female calves. Meanwhile, cows have higher chest girth than bulls.

Simple regression model for predicting the body weight from body length, body height, and chest girth of Bali cattle reared under smallholder farms.

Table 12. Simple regression model for predicting body weight

Age (mon)	Y	X	Regression Equation	R^2
>30	BW	BL	y = 1.5997x + 31.711	0.2
		BH	y = 3.6247x – 235.13	0.6
		CG	y = 2.3581x – 164.23	0.7
12 – 24	BW	BL	y = 2,4101x - 75,816	0.3
		BH	y = 4.7008x – 356.52	0.5
		CG	y = 2.2322x – 159.37	0.9
≤10	BW	BL	y = 1.8464x – 67.991	0.5
		BH	y = 1.2862x – 43.337	0.5
		CG	y = 4.2801x – 353.87	0.9

Mon = month, y = dependent variable, x = independent variable, R^2 = coefficient determination, BW = body weight, BL = body length, Body height, CG = chest girth

The results of the simple regression model with using Microsoft Excel 2010 show that chest girth is a perfect parameter to use in prediction the body weight. This was indicated that coefficient determinant in all age groups ranged of 0.7 to 0.9. This means that every 1 kg of body weight changed, about 70% to 90% influenced by the chest girth. Ozkaya and Bozkurt (2009) sated that chest girth was the best parameter of all prediction

the body weight, where the coefficient determination of variable independent of chest girth was higher and more consistent.

The correlation of the variable age, body length, body height, and chest girth on the body weight can be seen in the table below using Statistix 8.1.

Table 13. The correlation between variable age, body length, body height, and chest girth on the body weight of cattle

	Wt	Age	BL	BH
Age	0,84	1		
P-v	0.00			
BL	0.67	0.50	1	
P-v	0.00`	0.04		
BH	0.90	0.86	0.64	1
P-v	0.00	0.00	0.004	
CG	0.97	0.83	0.49	0.86
P-v	0.00	0.00	0.04	0.00

Wt = weight, BL = body length, BH = body height, CH = chest girth

The data indicate that the correlation between age, body height, and chest girth with the body weight were strong positive correlation with the coefficient of 0.84, 0.80, 0.97, respectively, with highly significant (Pv = 0.00). The correlation of the body chest girth and body length, and body height with the body weight was in line with the finding of Ozkaya and Bozkurt (2009), however, there were different breeds (Holstein breeds vs Baliness breeds). In addition, the correlation between the variable chest girth and the body height was also have strong positive correlation with age with the coefficient correlation was 0.86 and 0.83, with highly significant (Pv = 0.00). Chest girth with body height has also strong positive correlation with the coefficient of 0.86, highly significant correlation (r = 0.00).

While, the moderate correlation was body length with the body weight (r = 0,67), body height with body length (r = 0.64), and body length with age (r = 0.50). In addition, the weak correlation was chest girth with body length (r = 0.48)

The animal age was found strongly influence the live weight, body hight, and chest girth. This was in accordance with the finding of Maputungan *et al.* (2018).

Live body weight has been reported to be positively associated with the growth dimension of linear body dimension in ruminants, in which an increase in body weight is accompanied by an increase in body measurements (Lukuyu *et al*., 2016). The result of the correlation was also associated with the finding of Azis *et al*. (2023). Said that the body

weight had a positively high significant correlation ($P < 0.01$) with BL ($r = 0.754$), and CG ($r = 0.877$).

5. Reproduction Systems of the Bali cattle under smallholder farms

a. Mating System and Bull Utilization

The study survey was conducted to interview about 157 households who keep the Bali cattle. Figure below shows the mating system on Bali cattle distributed in 8 villages in Lospalos Administrative Post, Lautem Municipality.

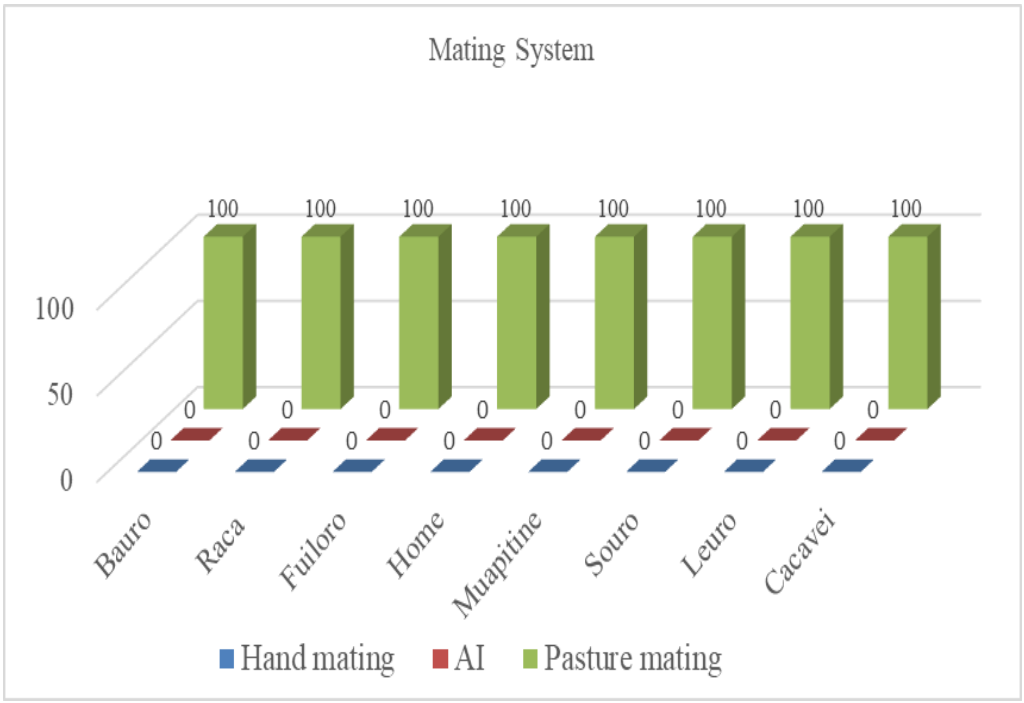


Figure 6: Mating system of Bali Cattle in the study areas

Of the respondents interviewed said that there was no control in mating the cows (hand mating). Artificial Insemination (AI) was not applied in their cows. Thus, 100% all productive cows are naturally mated in the pasture. From this mating system can be said that inbreeding depression cannot be avoided in cows herd. This can effect to the Bali cattle's production traits and reproduction efficiency.

b. Adult and Pre-Weaning Mortality

Graph below describes the adult and pre-weaning mortality of Bali cattle during the study survey conducted in 8 study sites.

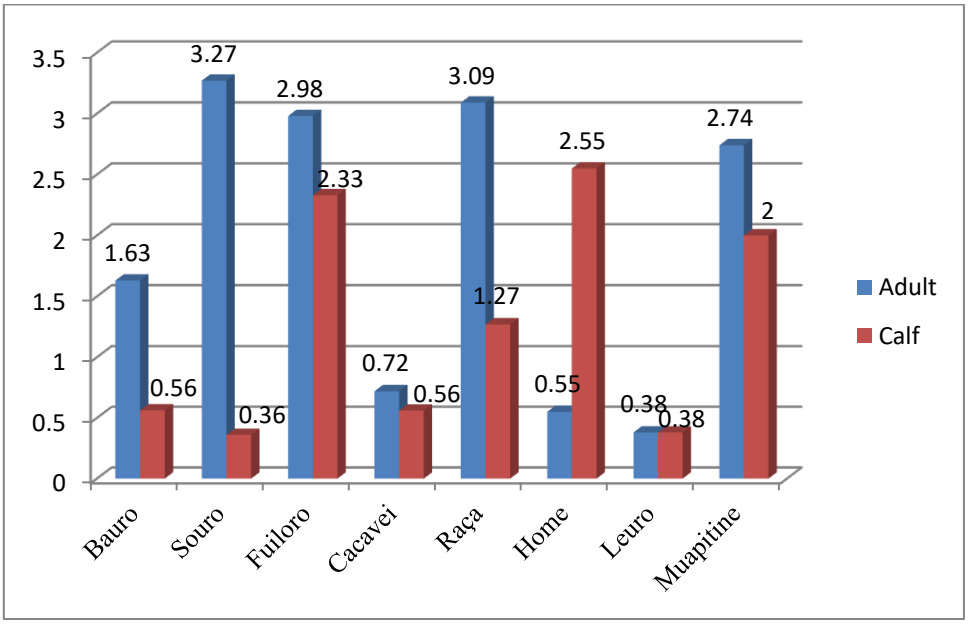


Figure 7. Graph of adult and pre-weaning mortality of Bali cattle

The study survey found that the mortality rate for adults was higher than for calves. Bauro was found higher adult mortality rates with of 1.63±2.65 compared to calves was 0.56±1.36, Souro was found higher with of 3.27±4.05 and 0.36±1.05 for calves, Fuiloro was 2.98±3.27 for adult and 2.33±2. 71 for calves, Cacavei was found 0.72±1.27 for adult, slightly with of 0.56 ±1.34 for calves, Raça was found higher in adult with of 3.09 ± 6.17 than calves with of 1.27±1.90, Home was 0.56 ± 0.95 for adult and 2.55±2.27 for calves, Leuro was found 0.38±0.96 for adult same as with calves at 0.38 ± 0.87. Muapitine was 2.74±4.01 for adult and 2±2.16 for calves, Overall, the adult mortality rate was higher than the pre-weaning mortality.

Of the 159 respondents interviewed in this study, 52.23% of respondents stated that the cause of death was disease, then 7.64% stated that it was because of killed, 1.72% of respondents stated that it was due to reproductive disorders and cold during the rainy season with of 1.72%. However, respondents were not provided information on the causes of death were 44%

c. Reproduction Efficiency

The observation of the reproduction efficiency on Bali cattle reared of household in 8 study areas on 837 heads of Bali cattle productive cows. The variables observed were age at first mating, age at first calving, days open, caving interval, and calving rate.

Table 14. The mean and SD of the reproduction efficiency of the balines cows reared under smallholder in the study areas

Parameters	N	Mean±SD
Age at first mating, mon	837	21.36 ± 2.4
Age at first calving, mon	837	33.4 ± 2.4
Days open, d	837	257.3 ± 52
Caving interval, mon	837	20.6 ± 2.4
Calving rate, %	837	42.3 ± 27.7

N = Sample, Sd = Standard deviation, mon = month, d = day,

Table above describes that the mean of age at first mating of the baliness cows was found were 21.36±2.4. Age at first calving was found 33.4±2.4, less than 3 years. This was inline with the finding of Halimah *et al.* (2022), who reported that the age at first calving on baliness cows was 37.3±6.35. The days open was 257.3±52 bigger than the finding of Halimah *et al*. (2022). Calving interval and calving rate were 20.6±2.4 months and 42.3±27.7 percent respectively. Calving interval was found bigger than the finding of Halimah *et al*. (2022), who reported that of 339.83±10.36 days or less than one year.

The results of this study illustrates that there was a slightly difference in numbers of the calving interval with the finding of Halimah *et al*. (2022). However, it closed to the report of Talib (2002) that calving for the Bali cattle is 15 – 18 month.

4.3 Study 2. Profiling of Feed Resources in Lospalos, Lautem, Tim or-Leste

Feed resources profiles on DM basis of forage, legumes, and agricultural by-products in the research areas.

Table 15. Composition of forage and agricultural by-products production per year per ha

Forage types	Production/ha/yr (kg)	DM production/ ha/yr (kg)	Fresh based, %
Grasses	4,393.76	1,657.42	100
- Bermuda grass	3,026.76	891.72	68.9
- Imperata	153.6	120	3.5
- King grass	1,213.4	645.7	27.6
Legumes	4,949.03	2,268.74	100
- Ipil-ipil	1,734	971.1	35.04
- Kakawate	1,189.29	275.74	24.03
- Waru	850.8	494.4	17.19
- Jack fruit leaves	639	298	12.9
- Siratro	535.94	229.5	10.82
Agricultural by-products	1,283.03	372.09	100
- Corn stovers	794.8	215.72	61.9
- Cassava leaves	252.9	83.7	19.7
- Batato leaves	235.33	72.67	18.34
- Banana leaves	378	91	29.5

Of the amount of forage grass, legumes and agricultural by-products, fresh forage production and DM are calculated to estimate forage production per ha per year, calculate forage carrying capacity (AU) and carrying capacity index. (CCI) to determine the condition of forage available in the research areas. The formula for calculating according to Ashari *et al*. (1995) is as follows:

- Production per ha = $\frac{\text{Area (ha)}}{\text{Size of quadrat (m}^2\text{)}}$ x Quadrat production (kg)
- Production per year = Production/ ha x Area (ha) x Number of harvest a year
- Carrying capacity of forage (AU) = $\frac{\text{DM yields (kg/year)}}{\text{DMC of cattle (kg/ year)}}$
- Carrying capacity Index of forage = $\frac{\text{Total DM yields (kg)}}{\text{Total cattle (AU) x DMC of cattle (kg/AU)}}$

or, carrying capacity index = $\frac{\text{Carrying Capacity of forage (AU)}}{\text{Total cattle (AU)}}$

The criteria such as: safety (CCI > 2), prone (CCI < 1.5 – 2), critical (CCI < 1 – 1.5), and very critical value (CCI < 1) (Ashari *et al.*, 1995).

Table 16. Distribution of agricultural by-products production and carrying capacity index in the study areas

Study Sites	Cattle (AU)	Total DM Prod kg/yr	CC (AU)	CCI	Category
Bauro	74	122,960	53.90	0.73	Very critical
Raça	121.	41,918.8	18.38	0.15	Very critical
Fuiloro	447	842,160	369.17	0.83	Very critical
Home	53.2	25,520	11.19	0.21	Very critical
Muapitine	242.2	81,200	35.59	0.15	Very critical
Souro	214.2	175,160	67.78	0.32	Very critical
Leuro	84.7	46,400	20.34	0.24	Very critical
Cacavei	223.3	114,260	50.09	0.22	Very critical

AU= animal unit, Cattle population multiplied by the conversion factor 0.7, DM = dry matter, CC = Carrying capacity, CCI = Carrying capacity index, Prod = production, yr = year, dry matter consumption per cattle per year = 2,281.25 kg

Table 17. Distribution of forage grass and legumes productions and carrying capacity Index in the study areas

Study Sites	Cattle (AU)	Total DM Prod. kg/year	CC (AU)	CCI	Category
Bauro	74	367,284.8	161.00	2.56	Safety
Raça	121.	747,079.5	327.49	2.71	Safety
Fuiloro	447	1,246,559	546.44	1.63	Prone
Home	53.2	1,388,607	608.70	1.14	Critical
Muapitine	242.2	8,148,12.2	357.18	1.84	Prone
Souro	214.2	973,166	426.59	2	Prone
Leuro	84.7	252,451.7	110.66	1.31	Critical
Cacavei	223.3	729,334.7	322.54	1.44	Critical

Animal Unit (AU) = Cattle population multiplied by the conversion factor 0.7, DM = dry matter, CC = Carrying capacity, CCI = Carrying capacity index

Table 16 shows crop residues or agricultural by-products produced from agricultural farm units are in very critical category. However, crop residues are not the main daily feed for the cattle. It is another major source of feed for the cattle in the dry season. When farmers are harvesting their crops can be used for supplementing grasses and legumes. Table 17 shows the types of grasses, legumes and shrubs available vary in condition based

on the potential of pasture in the study areas. The research results show that Bauro and Raça were in the safe category with CCI > 2. Fuiloro, Souro, and Muapitine were in the prone category with CCI < 1.5 – 2. Home, Leuro, and Cacavei were in the category of critical with CCI < 1 – 1.5.

The categories of the forage grasses, legumes, and agricultural by-products productions are shown in the Map below.

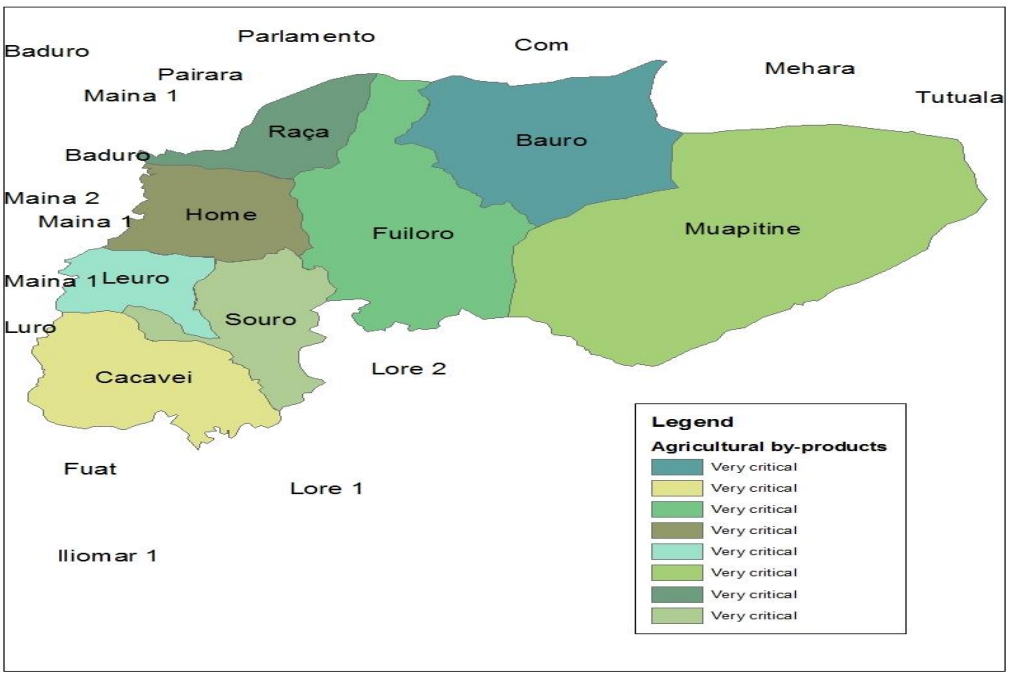


Figure 8. Map of the agricultural by-products availability in the study areas

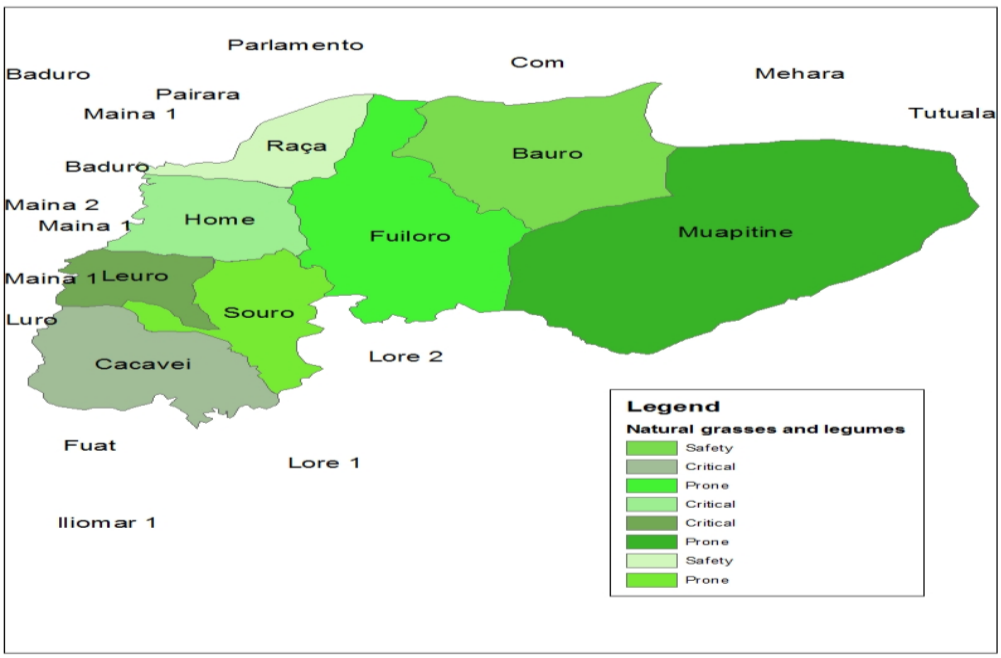


Figure 9. Map of the natural grasses and legumes availability in the study areas

4.4 Study 3. Designing an appropriate feed calendar as basis for feeding plan for Bali cattle

1. Feed Resources Availability

The major feed resources in 8 study areas in Lospalos, Lautem Municipality are shown in the Table below. In this study was identified some of the natural grasses, fodder trees and shrubs, improved grasses, and crop residue/ agriculture by products available locally depend on both wet and dry season that are very restrictive of their availabilities.

Soares *et al.* (2018) reported that the major feeds sources in Timor-Leste are natural pasture that consider low crude protein, low digestibility due to the high cellulose and lignin, fodders, legumes trees, rice and corn straws during the harvest time. The main food crops planted on dry land is maize, cassava, soybean and other agriculture by-products as sources of animal feeding.

The feed resources availability in the study areas of Lospalos are natural pasture and improved grasses, fodder trees, crop residues/ agriculture by-products are available depend on both wet and dry season that are very restrictive of their availabilities. According to survey and the data collected from the respondents identified feed resources in wet and dry season such as follows.

Type of feed sources:

Natural pasture:

- Roadside grass
- *Imperata cylindrical*

Improved grasses

- King grass *(Pennisetum purpuroides)*

Fodder trees and shrubs

- Gliricidia *(Gliricidia sepium)*
- Ipil-ipil *(Leucaena leucocephala)*
- Agati *(Sesbania grandiflora)*
- Waru *(Hibiscus tiliaceus)*

Crop residues/agriculture by-products:

- Corn stovers, Rice straw, Cassava leaves, Banana trees and leaves

Concentrates:

- Maize *(Zea mays)*, Soya bean *(Glicine max)*, Mung bean *(Vigna radiata)*

The survey and Focus Group Discussion with stakeholder and household identified the feed resources availabilities by villages in Lospalos Administrative Post.

Table 18. Feed resources availability by villages in Lospalos

Villages	Feed Resources
Bauro	Crop residues, fodder trees and shrubs, improved grasses, natural pasture
Raça	Natural pastures, fodder trees and shrubs, crop residues
Fuiloro	Natural pastures, fodder trees and shrubs, crop residues improved grasses
Home	Natural pastures, crop residues, fodder trees and shrubs
Muapitine	Natural pastures, crop residues, fodder trees and shrubs, improved grasses
Souro	Natural pastures, fodder trees and shrubs, crop residues
Leuro	Fodders trees and shrubs, crop residues, and natural grasses
Cacavei	Fodder trees and shrubs, crop residues, and natural grasses

The feed resources in every village in Lospalos Administrative Post can be identified and categorized as seasonal feed sources that are available in the wet and dry season as follows:

Table 19. Feed resources availability and utilization in wet and dry season in the study areas

	Season	
Feed Resources	**Wet**	**Dry**
Crop residues	√	
Fodder trees and shrubs	√	√
Hay	-	-
Silages	-	-
Natural pasture	√	√
Weeds	√	-
Improved forages	√	-
Industrial by products	-	-
Concentrates	√	-

The types of feed resources in the study area differ between wet and dry season. Fodder trees and shrubs and some of crop residues are available in dry season, while natural pasture combined with improved grasses are more important in the wet and dry season due to their better availability in the wet season. However, the feed resources available for the cattle to meet their energy requirement are not enough to overcome the feed energy shortage. The fodder trees and shrubs are feed resources used by household to feed their cattle throughout the years. Farmers are depending on native grasses in the wet season for their cattle. Bermuda grass are dominantly growing almost in the area but the amount required to the cattle are not enough, so the farmers have to choose another alternative feed sources for feed they cattle.

The restrictive of the feed resources in the study areas can be influenced by the characteristics of household in preparing the feeds in wet and dry season.

The reason is because in the wet season all natural grasses are growing well and providing enough feed for the cattle so the HH only tied their cattle in the open area or surrounding the houses and sometimes they prepared feed for their cattle. Reversely, when the dry season is coming the majority of the HH frequently prepared feed for their cattle. This is because of the supply of natural grass that has been reduced due to drought in the summer so that they can use a large number of fodder trees and shrubs as the main feed in dry season.

2. Major cause of feed scarcity

The feed availability and utilization are the factors determine the productivity of the cattle. However, the quantity of the feed is not good provided due to some factors affected such as drought, overgrazing, land scarcity, crop expansion and flood in the study areas.

Table 20. The major causes of feed resource constraint in the study areas

Major constraint	Score	Rank
Drought	92	1
Overgrazing	0	5
Land scarcity	45	2
Crop expansion	7	3
Flood	13	4

According to the result of the study, drought was a major cause of feed resource constraint in summer. Farmers were asked to rank the identified major cause of feed resource constraint where drought was the rank 1, following was the land shortage that only used as crop production without development of forage crops as feed for the cattle with ranked as rank 2. Crop expansion was also the cause of feed constraint because the household expand their land area for crop production to human consumption, while it can be provided the residues as feed for the cattle. Crop expansion was ranked 3rd, following 4th for flooding and 5th for overgrazing on pastures especially in summer.

3. Seasonal feed calendar

The survey study in 8 villages in Lospalos Administration Post, Lautem Municipality was identified the feed resources available by months through interview and FGD found that the potency of forage crops and agriculture by-products with high, good, fair, and less availability. Natural grasses, fodder trees and shrubs, improved grass, and crop residues are very important feed resources for livestock in the study areas. Table below is seasonal feed calendar indicating animal feed available by months.

Table 21. Seasonal feed calendar by months in the study areas

Feed Resources	January	February	March	April	May	June	July	August	September	October	November	December
Crop residues	O	O	XX	XXXX	XXXX	XXXX	XXXX	XX	X	X	O	O
Fodder trees & shrubs	XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXX	XX	XX	XX	XXX
Hay	O	O	O	O	O	O	O	X	X	X	O	O
Silage	O	O	O	O	O	O	O	O	O	O	O	O
Natural pasture	XX	XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXX	XX	XX	XX	XX
Improved grasses	XX	XX	XX	XX	XX	XX	XX	X	X	X	X	X
Rice straw	O	O	O	O	X	X	X	X	O	O	O	O
Corn stovers	O	O	XXX	XXX	O	O	O	X	XX	XX	O	O
Concentrate	O	O	X	X	O	O	O	X	X	O	O	O

XXXX = highly availability, XXX = good available, XX = fairly available, X = less available, O = not available

The major crops grown in household rearing cattle are corn, but this was only used in the month of March and April for the first cropping time. Second cropping usually starts to grow in May and harvested in August but the amount of the residues were not the same with the first cropping. Fodder trees and shrubs are highly available from the month of February to August and gradually reducing by the month of September to November. Natural grasses are high available during 5 months. It was started from March to July, but it was gradually reducing when the summer was coming on the month of September to November. Improved grass such as King grass is growing in some of the study area. It was found in Fuiloro, Bauro, Muapitine but the amount was too small cannot provide feed for long days. Concentrate was available when harvested corn in two cropping time, but the volume was too small, and it was the food for the people.

4. Feed Mapping

The major native grasses and legumes are growing dominantly in the pasture by the study area can be seen in the Table.

Table 22. The major native grasses and legumes available in the study areas

Villages/ Major Forages	Scoring system 1 – 5 (1 = lowest score, 5 = highest score)				
	Perennial grassy weeds	Roadside weeds	Imperata	Bermuda grass	Legume trees and shrubs
Bauro	2	3	1	4	5
Raça	3	2	1	5	4
Fuiloro	3	2	1	5	4
Home	2	3	1	5	4
Muapitine	2	3	1	5	4
Souro	2	3	1	5	4
Leuro	2	4	1	3	5
Cacavei	2	4	1	3	5
Total Scores	18	24	8	35	35

Table above indicates the feed sources available in the study area that can be utilized as cattle feedstuff. Based on the available feed resources would be constructed a feed mapping per study areas according to the survey results through interview with

respondents and direct observation by researchers in every location of the study. Mapping the feed types was organized by using ArcMap 10.8.2 software.

Figure below describes the feed resources mapping by villages in Lospalos Administrative Post.

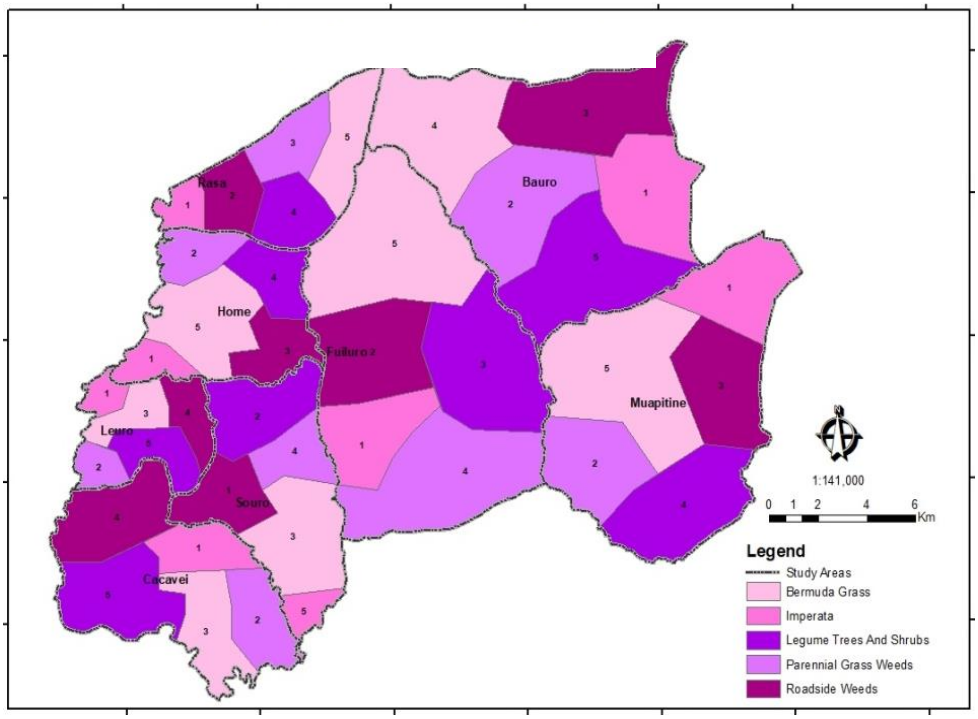


Figure 10. Feed resources mapping by villages in Lospalos Administrative Post

There is 1 to 5 scoring systems based on feed availability in the study areas. The research results show that legume trees and shrubs dominate in the 3 study areas (Bauro, Leuro and Cacavei). Bermuda grass dominated in the 5 study areas (Raça, Fuiloro, Home, Souro, and Muapitine), following perennial grassy weeds, roadside weeds, and imperata are restricted in all study sites.

5. Feed planning

Based on the current situation of the household reared Bali cattle are in the traditional way. Feeding was not serious attention on the quality and quantity of feed resources availability in the study areas. Aside this, no concentrate supplementation was done in the study areas. Therefore, the cattle's production performance was not reached the target required by the farmers.

A feeding plan is designed to provide information on the requirements of an individual to ensure they are fed in a way that promotes good health and prevents negative

effects. A feeding plan can be given to the farmers who are looking after an animal to ensure they feed the animal in a suitable manner. From that reason a feed plan was done based on the feed resources that locally available in the study areas with the objective to provide information to the farmers on how to feed their cattle with selected feeds contain protein, energy, vitamins, and mineral sources for animal feedstuffs according to the cattle's growing stages. Table below is feed planning for the households who keep the cattle in the study areas.

Table 23. Feed planning for smallholder cattle farmers in the study areas

Stage of cattle	Type of fodder	Type concentrate	Others	Frequency of feeding
Cow	Leucaena+Ricestraw+Corn stover+Roadside grass (10%/body wt/day)	Corn 2%/ body wt/day	Mineral supplementation	Fodders 2x daily Corn 1x daily
Bull	Leucaena+Gliricidia+Rice straw+Roadside grass (10%/body wt/day	Corn 2% /body wt/day	Mineral supplementation	Fodder 2x daily Corn 2x daily
Fattening	Leucaena+Gliricidia+King grass+Roadside grass (adlibitum)	Corn+mung bean (2%/body wt/day	Mineral supplementation	Fodders 2x daily Corn 2x daily
Steer	King garss+Roadside grass+Leucaena (10%/body wt/day	Corn (2%/body wt/day	Mineral supplementation	Fodders 2x daily Corn 1x daily
Heifer	King grass+Roadside grass+Leucaena (10%/body wt/day	Corn+rice bran (2%/body wt/day	Mineral supplementation	Fodders 2x daily Corn 1x daily
Calf	Kinggrass+Leucaena+Roadside grass	Rice bran	Mineral supplementation	Fodders 2x daily Corn 1 x daily

V. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Smallholder Bali cattle farming in the study area is conducted in semi-intensive and extensive systems. The average of cattle been reared was of 13.02 ± 18.40. This can be categorized as a smallholder farm conducted by household in the study area.

The household tied their cattle in open stable or surrounding their houses during the night time. Generally Bali cattle are reared by household is quiet small scale with minimal only 2 - 6 cattle per household are tied behind their houses. Cut and carry system is very common in study area due to the availability of fodder trees and shrubs both in the wet and dry season. However, feeding habits applied by household is depending on the wet and dry season.

The reproduction efficiency on Bali cattle reared by household in the study areas on 837 heads of Balines productive cows. The variables observed were age at first mating (21.36±2.4), age at first calving (33.4±2.4), days open (257.3±52), calving interval and calving rate were 20.6±2.4 months and 42.3±27.7%, respectively.

Agriculture by-product production (DM) with the estimation of carrying capacity of forage was in the category of very critical condition in 8 study areas, while the forage grasses and legumes were in the category of safety in Bauro and Raça, category prone in Fuiloro, Souro and Muapitine, and the critical category in Home, Leuro, and Cacavei.

Feed calendar and feed mapping were provided as information on feed resources availability by season, Fodder trees and shrubs, natural pasture, crop residues are the major feed resources availabilities in the study areas. Whose feed resources are as basis for designing an innovative feed planning system for the Bali cattle farmers.

5.2 Recommendation

- Rearing system is needed to change through intensive and integrated crops-livestock farming system;
- Needed to upgrade local Bali cattle production and reproduction systems using cross-breeding through artificial insemination technology;
- Needed to develop an applicable feeding system strategy analysis potential of development forage and legumes. Cultivate improved forages such as King grass;

- Elephant grass, Leucaena, to provide enough feeds specially in the dry season;
- Needed to construct appropriate housing and conducted intensive rearing system to their cattle;
- Needed more intensive extension services and strengthening the capacity of smallholder farmers on provision of feed resource should focus on solving for livestock feed shortage in the study areas;
- Expected to design feed planning that provides information on the type of feed utilization included nutritional requirement for the cattle reared by household in the study areas.

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APPENDICES

Appendix Figure 1. Data collection on household characteristics

Appendix Figure 2. Collecting sample of grasses and drying in the Laboratory

Appendix Figure 3. Collecting sample of agricultural by-products and drying in the Laboratory

Appendix Figure 4. Measuring of the body dimension of the cattle