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Sustainability analysis of beef production with Bali cattle in smallholder farms on Ceram Island, Indonesia

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List of abbreviations

ºC	Degrees Celcius
CBS	Central Bureau of Statistics
cm	Centimeter
CP	Crude Protein
CF	Crude Fiber
Dev	Deviation
DM	Dry matter
FAO	Food and Agricultural Organization of the United Nations
g	Gram
GE	Gross Energy
GoI	Government of Indonesia
GoMP	Government of Maluku Province
ha	Hectare
IDR	Indonesian Rupiah
kg	Kilograms
kJ	Kilojoule
ME	Man equivalent
MJ	Megajoule
QD	Quartile deviation
n	number of observations
s.e.	Standard error of mean
SI	Sustainability Indicator
Sus. Ind.	Sustainability index
USD	United States Dollar

1 INTRODUCTION

Since three decades, sustainability is a popular term used in almost every discipline including agriculture, environmental and economic studies. Related to agriculture, sustainability was defined according to the type of production systems such as crop production (Kilian et al., 2006; Subedi et al., 2009), livestock production (Vavra, 1996; de Boer and Cornelissen, 2002; Waltrick, 2003; Mollenhorst, 2005), or mixed system (Rigby et al., 2001; Dougill and Reed, 2004), depending on the background of the stakeholders such as farmers, policy makers, researchers and consumers. Although there is still no general consensus in defining the term, the practical definition of the term refers to the ability of the system to maintain the production in a long period of time.

Recent studies in the literature showed a clear consensus to move forward from defining the sustainability to estimate it by using tools and indicators. By estimating the level of sustainability, the strengths and weaknesses of farming systems can be distinguished. This may serve as a guideline for decision makers in planning interventions and strategies in order to improve the farm performance in terms of its long term productivity that in turn is expected to improve the living conditions of farmers and rural areas.

Livestock production systems in Indonesia are generally small-scale with one to three cattle per household, raised mostly in the eastern part of Indonesia on wet and dry lands under traditional management (Hadi et al., 1999). The traditional system is characterised by low levels of economic efficiency derived in a diversified agricultural system, based on a few ha of land to support household needs (Devendra and Thomas, 2002). On the other hand, demand for livestock products on local, national and regional level have increased sharply since the last decade. Pengely and Lisson (2003) predicted that the demand will be doubled by the year 2020 as a result of increasing human population which already reached about 231 million people in 2009 (CBS, 2010). Thus, livestock production will be expected to produce more to satisfy the increasing demand.

In 1999 the national government of Indonesia released the regulation no. 22 to assign a greater responsibility for the provincial governments to manage their own area to achieve food and income sufficiency for the people (GoI, 1999). The regulation mandated every provincial government, including Maluku province, to improve the living conditions of farmers while increasing the production to satisfy the local demand by creating own development pathways.

In Maluku province, Ceram Island and Buru Island were selected as the main agricultural areas to support the provincial food security policy, in terms of both crop and livestock production, based on the regulation no. 421/2005 (GoMP, 2005). The development paths are based on the project of distributing Bali cattle directly to two different ethnic groups on Ceram Island. They are indigenous farmers who live as crop farmers, livestock keepers and fishermen (Lebel, 1999), and transmigrant farmers who came gradually since 1954 as part of a national transmigration project, settled on the Island and live as food crop farmers mainly producing rice and later became cattle keepers. This project aimed to increase beef production in the province in order to fulfill the increasing market demand (Attamimi, 2003). The fact that the province is composed by islands and is rich in water resources did not deny the importance of beef production in the province. Beef production, dominated by Bali cattle was meant to reach the provincial consumption target of 4.5 kg meat/capita/year in Maluku by 2012 from 2.7 kg/capita/year in 2002 (Dinas Pertanian Provinsi Maluku, 2005), to complement the protein consumption from fish of 4.0 kg/capita/year (Martianto et al., 1993). The Central Bureau of Statistics of Maluku Province (2010) reported the increasing demand for beef from 1.6 ton in 2000 to 3.8 ton in 2007. The high demand for Bali cattle in recent years on local and regional markets to provide meat created pressure on their population, leading to a selling of cattle. Decisions for selling animals were taken to realise immediate gains rather than applying a long-term management. Consequently, the population of Bali cattle decreased from 76,864 heads in 2004 to 70,402 heads (CBS, 2010). Hence, strategies and interventions should be developed in favour of a sustainable increase of the production by analysing the production systems, taking into account the national commitments to the principles of sustainable development, and then focussing attention towards resource efficiency, environmental and sustainable production issues (Hadi et al., 2002).

To understand current production conditions, the general hypothesis of this study is: resources, productive and reproductive performance of beef production in the mixed farming systems on Ceram Island differ according to the migratory status of the farmers, leading to different levels of sustainability, productivity of beef production and economic efficiencies. Therefore, different strategies and interventions are needed to improve the systems. The study aims at contributing to the knowledge base needed for the design of sustainable beef production systems on the Island.

The specific objectives can be mentioned as:

- To characterize and compare the farming systems and beef keeping management of Bali cattle,
- To develop a set of sustainability indicators based on locally identified issues,
- To evaluate current sustainability of beef production with Bali cattle in indigenous and transmigrant farms.

2 LITERATURE REVIEW

2.1 Sustainable livestock production

2.1.1 Definition of sustainability

The concept of sustainability was first used in forestry in Germany by the mining administrator von Carlowitz in the 18th century (Becker, 1997; Cornelissen, 2003; Potchanasin, 2008). The term used was "Nachhaltigkeit", equivalent with the term "sustainability". This term was used to describe the maintenance of long-term productivity of timber plantations to continuously provide heating and construction poles for the mining industry.

The terms "sustainability" and "sustainable development" were used worldwide by researchers, policy makers and private enterprises after the report of the World Commission on Environment and Development (WCED) published in 1987 (de Wit et al., 1995; Hardi and Zdan, 1997; Lopez-Ridaura, 2005; Mollenhorst, 2005; Potchanasin, 2008). The definition by the report mentioned that the sustainable development meets the needs of current generations without compromising the ability of future generations to meet their needs and aspirations (Brundtland, 1987). The message behind the concept was not only the need to measure the sustainability of a system quantitatively, but also the need to monitor it over time (Waltrick, 2003).

Afterwards, many definitions were given of the term in the literature, resulting in no generally agreed upon definition of the term (Mollenhorst, 2005). The term "sustainable agriculture" was first used in the late 1970s by Lady Eve Balfour in the International Federation of Organic Agriculture Movement (IFOAM) conference in Switzerland (Balfour, 1977; Rodale, 1990), but the science and practice of it is as old as the origins of agriculture (Altieri, 1987). It then was employed in a variety of concepts and perspectives related to agricultural practices (Neher, 1992), from the concept of agroecosystems (Altieri, 1987) to organic agriculture (Casado et al., 2009).

There are at least four common aspects that define the term (Table 2.1). The majority of authors agreed that environmental quality and ecological soundness must coincide to arrive at sustainability in agricultural systems. This aspect emphasises the complex interactions among soil, water, plants, animals, climate and people in ecosystems (Sullivan, 2003). The goal is to achieve harmony among factors, where the interactions reach a stage of equilibrium without damaging one another by efficiently using the resources through incorporating natural processes into agricultural production and the use of advanced knowledge and practice (Rasul and Thapa, 2004).

Table 2.1. **Aspects used in defining sustainable agriculture**

Authors	Aspects			
	Environmental quality and ecological soundness	Socio-economic viability	Productivity	Time dimension
Altieri (1987)	√	√	√	√
Hauptly et al. (1990)	√		√	
De Wit et al. (1995)	√	√	√	√
Vavra (1996)	√	√	√	√
Hansen and Jones (1996)		√	√	√
Olesen et al. (2000)	√	√		
Sullivan (2003)	√	√		√
Waltrick (2003)	√	√		
Earles (2005)	√	√	√	
Mollenhorst (2005)	√	√		
Matthews et al. (2008)	√	√		

But no matter how well producing the system is, almost all authors agreed that no agriculture is sustainable if it is not socio-economically viable. It means that the system is acceptable by the community and it is profitable or able to provide family income and a living standard through its ability to produce the same quality and quantity of products with the given inputs indefinitely (Vavra, 1996).

Productivity is another aspect explicitly stated by some authors, while others subsumed it onto the (socio-) economic aspect. Altieri (1987) argued that a system must be productive over the long run or it cannot be sustained economically, no matter how ecologically sound it is.

Although all authors implicitly agreed that the time dimension is an important element in sustainability, fewer authors stated it explicitly in their sustainable agriculture definition. De Wit et al. (1995) argued that the level of sustainability could only be expressed in terms of its life expectancy, which was described by Hansen and Jones (1996) as uncertain period of time that is to come.

To conclude on the definition of sustainable agriculture, it can be stated that it is the capability of a system to maintain the existent levels of crop and livestock production to meet the needs of the current as well as the future population. This without disturbing environmental quality, in terms of resources (soil, water, land) and ecological soundness, which refers to the concept of complexity and diversity of biology and environment, and without compromising the ability of future generations to meet their needs (Campbell and Heck, 1997). This is done by using the natural environment in a socially acceptable way, in order to achieve self-reliance, equity and quality of life for a long period of time.

2.1.2 Sustainable livestock production systems

The definition of sustainability in livestock production systems was reviewed by many authors. Vavra (1996) suggested that sustainable livestock production means that the system is able to harvest the same amount of animal products from a given land-base indefinitely. Or, in other words, the harvested products do not decay the ability of the land to continue producing the materials for further off-take. In line with this definition, Liinamo and Neeteson-van Nieuwenhoven (2003) proposed two important aspects for defining breeding goals aimed at supporting sustainable production:

a. building on a long economic and productive life of animals without disturbing welfare in specific environments
b. optimising input/output and feed efficiency with sustainable feed resources.

Here, the productivity of livestock is the important aspect for sustainability with the emphasis on improving the efficiency of production per unit of products, shifted from the sole emphasis on increasing the quantity of production (Olesen et al., 2000; Liinamo and Neeteson-van Niewenhoven, 2003).

However the definition above does not consider the integrity of the ecosystem which covers the interaction of native plants, animals and the environment. A more comprehensive definition was provided by Torp-Donner and Juga (1997). The environment, biodiversity, ethical aspects and economy are criteria suggested by the authors that should be accounted for in short term as well as long term economic value. Air quality and surface and ground water quality are examples of environmental aspects proposed by the authors that should be taken into account when assessing sustainability, while biodiversity is dealing with the sustainable use of genetic resources and maintaining the variability of genetic resources for future use. The ethical aspect consists of human attitudes to support the sustainability, for instance, by paying a higher price for organic products, and attitudes towards animal production, which include animal fertility, welfare and health, which have genetic resistance to production-related diseases such as foot and mouth disease, bovine spongiform encephalopathy and contagious bovine pleuropneumonia. The economic aspect is meant to assess the production, environment, biodiversity and the ethical aspects in terms of costs and benefits.

Although the environment and ethical aspects are very difficult to evaluate economically, they should be taken into account in every production scheme in the frame of sustainable livelihoods. The focus should be on combining ecological and economic aspects so as to ensure that what is economically sound in the short term is ecologically sound in the long term (Heitschmidt et al., 1996; Torp-Donner and Juga, 1997).

Hence, among the criteria mentioned above, there are four criteria agreed by all authors in defining sustainable livestock production systems: Animal productivity, ethics, the impact on the environment and the respective economic results. Contribution of livestock to food security, biodiversity as well as animal health related to consumer safety and food quality are the topics of relevance for the sustainability concept in the context of livestock production system (Valle Zárate, 2007).

2.1.3 Assessment of sustainable livestock production

Many scientists showed agreement on the statement that sustainable agriculture, particularly livestock production, can be attained through the development of long-term, resilient and profitable production systems. However, these systems will have to await the test of time. Because at the end, all aspects, disciplines and criteria used to define sustainable agriculture must be defined towards time. This is because sustainability always deals with a time dimension, which extends from the present to some future time. We may not know whether a particular system has a high, medium, or low level of sustainability for a decade or more (Parr et al, 1990; Hansen and Jones, 1996). The way to answer the question of how to determine the sustainability of a system is by abandoning the assumption that sustainability is an endpoint, but helps to reduce to a maximum the stresses a system could tolerate in order to maintain the future option (Vavra, 1996).

After the Brundtland report was published in 1987, many criteria for translating sustainability issues into measurable indicators were proposed (De Wit et al., 1995; Hansen and Jones, 1996; Waltrick, 2003; Mollenhorst, 2005). De Wit et al. (1995) put forward to use criteria derived from issues of un-sustainability such as land scarcity, soil degradation, inefficient use of resources, environmental degradation and declining biodiversity. Torp-Donner and Juga

(1997) argued that these criteria were too general, and from these criteria it is a long way from developing a practical measurement for assessing the sustainability of livestock production systems.

In assessing the sustainability of Flemish dairy farms, van Passel et al. (2007) used the terms “sustainable value” and “sustainable efficiency” as indicators. The first referred to the monetary measure of sustainability, based on the assessment of capital values beyond the economic dimension. The latter referred to the efficient use of capital resources, where the more efficient the resources are used, the more sustainable the system is (van Passel et al, 2007). Those indicators were then compared with a benchmark or reference value that allows comparison between one farm with another. The approach does not indicate whether the farms’ capital resources were used sustainably, but it indicated how the farmers contributed to a more sustainable use of those resources by calculating the level of efficiency in using those resources. Although it is found that performance of economic and environmental dimensions can be measured using empirical models, the approach failed to measure the performance of the social dimension as it is hard to quantify.

De Boer and Cornelissen (2002) employed three steps to come up with a list of sustainability indicators in assessing egg production systems in The Netherlands. First, by identification of relevant issues regarding egg production in the country, by employing literature data and expert consultation. Second, they transformed the issues into indicators, addressing the criteria that the indicators should be measurable, should discriminate the systems, the information should be available, and target values should exist. Third, they assessed the sustainability using those indicators. The contribution of each indicator was calculated as relative deviation of the actual values from the reference values. Mollenhorst (2005) complemented the approach by including a number of stakeholders in a participatory approach to select indicators. This was done, taking into account that indicators depend heavily on the perceptions of stakeholders involved in the discussion, and that those perceptions about sustainability vary within communities and will change over time.

Indicators

Indicators are sustainability aspects that have been translated into measurable criteria or parameters and are used as a tool to quantitatively represent the sustainability issues in practical planning and farm design (Hargen and Meyer, 1996; Becker, 1997; Bell and Morse, 1999; Cornelissen, 2003; Mollenhorst, 2005). The selection of indicators depends strongly on the system in which the study is conducted, the boundary of that system and the way in which indicators are derived. There are two main ways to derive indicators: top-down approach and bottom-up approach. The top-down approach identifies indicators according to a scientist's point of view (Hardi and Zdan, 1997; Lopez-Ridaura, 2005). All relevant indicators were listed, covering all sustainability dimensions that appeared in the literature, and were scrutinized by experts. This approach can expose trends between regions and over time that might be missed by a more casual observation (Rigby et al., 2006). However, this approach tends to treat every production system similarly, without considering the differentiation in objectives, resources and the management of the systems. Yet, it often failed to engage local communities as the end-user of the indicators.

The bottom-up approach uses stakeholder opinion and participation in defining sustainability indicators (Howlett et al., 2000; Woodhouse et al., 2000; Dougill and Reed, 2004; Mollenhorst, 2005; Viley, 2007). This method is more adapted and suitable for assessing the sustainability aspect at farm level since all indicators are raised in accordance with the availability of resources and the relevancy to the particular farming system. However, the limiting factor of using the bottom-up method is the difficulty in determining the stakeholders and the level of participation (Hardi and Zdan, 1997; Mollenhorst, 2005). Moreover, indicators derived by a participatory approach alone may not have the capacity to accurately monitor sustainability (Rigby et al., 2006). Thus, there is increasing awareness for the need to develop a third approach, which combines the top-down with the bottom-up approach to capture better indicators.

In selecting indicators for a sustainability assessment, criteria are needed. Relevance, scientific quality, sensitiveness and data management are criteria proposed by several authors (Table 2.2).

Table 2.2. Selection criteria for sustainability indicators

Relevance[2,3,4,5] - relevant to the issues of concern - relevant to the ecosystem and geography	**Scientific Quality**[1,2,3,4,5] - standardized measurement - comparable between indicator values and target - data and method accessible to all
Sensitiveness[1,2,4,5] - considers equity and disparity - considers ecological condition - considers economic development - sensitive to changes over time, space and community	**Data Management**[1,2,4,5] - easy to measure, and to interpret - data available and quantifiable - transparent - widely accepted and user-friendly

Sources: [1]Bernstein (1992); [2]Becker (1997); [3]Hardi and Zdan (1997); [4]Cornelissen et al. (2001); [5]Mollenhorst (2005).

To validate the indicators, Meul et al. (2009) proposed two evaluations, namely accuracy evaluation and credibility evaluation. Accuracy evaluation relates to the degree to which the indicator is consistent with its intended application, by considering the scientific quality of the indicator. This can be done by employing expert judgements to evaluate its relevance and reliability (Meul et al., 2009). Credibility evaluation, however, involves an end-use validation (Bockstaller and Girardin, 2003). It is meant to evaluate the willingness of potential end-users of the indicators (for instance, farmers and policy makers) to effectively use the indicators in practice. This may be done through a survey where the end-users of the indicators can point out the strengths and weaknesses of the indicators (Meul et al., 2009).

Threshold values

Threshold values are the reference values used as baseline in analysing sustainability (Zhen and Routray, 2003). Van Passel et al. (2007) used the term ‘benchmark’ to refer to the threshold, while de Boer and Cornelissen (2002) and Mollenhorst (2005) used the term ‘reference value’. Until recently, as with interpreting sustainability, there has been no general consensus about how to define the threshold values. It can be based on scientific knowledge, expert judgement, political goal, or performance target (Mollenhorst, 2005; van Passel et al., 2007). The latter can be defined as the average performance of the system, or the maximum performance of the system that could be achieved. Further, Zhen and Routray (2003) divided the threshold into three types: (a) historical level, refers to the condition before some changes took place, such as pre-farming or pre-disturbance, (b) desired level, usually set by researchers as the optimal performance of the system, and (c) potential level that is usually set by biophysical constraints. However, Woodhouse et al. (2000) argued that the identification of threshold values for indicators is something which should again involve local stakeholders rather then simply be determined by researchers.

Visualizing the sustainability

Different methods to present the results of a sustainability assessment were proposed. Mollenhorst (2005) divided these methods into two categories. First, visual presentation, aggregating the value of sustainability into a radar diagram (Rigby et al., 2001; Reed et al., 2006; Meul et al., 2009) or a bar diagram (de Boer and Cornelissen, 2002; Mollenhorst, 2005). Second, numerical aggregation, aggregating the value of indicators into a single index (van Passel et al., 2007).

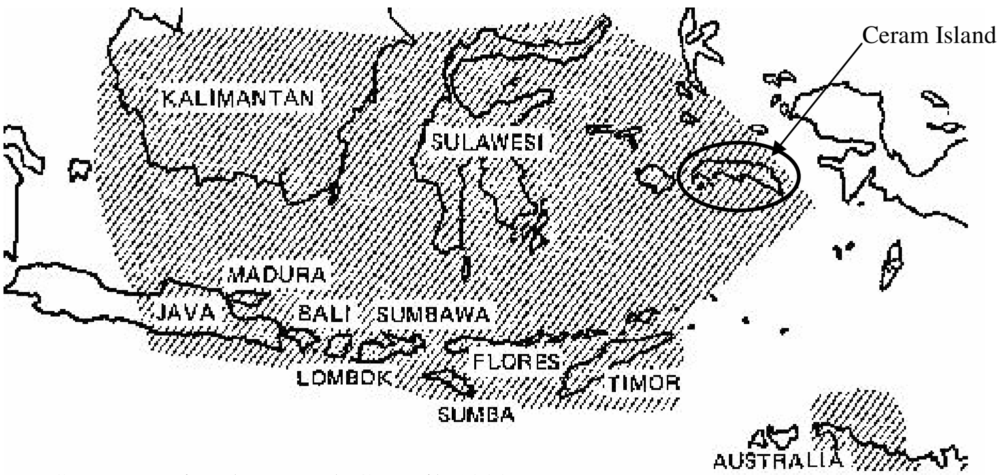
Ten Brink et al. (1991) visualised the indicators with the AMOEBA approach, an acronym for "a general method of ecosystem description and assessment". This approach was already applied for livestock production systems (de Boer and Cornelissen, 2002; Mollenhorst, 2005; Siegmund-Schultze et al., 2010). In this method, the shape or volume of the AMOEBA graph can actually illustrate the strengths and weaknesses of the studied parameters in the farming system. No subject is expected to perform best in all categories, which would result in a convex polygon of the AMOEBA graph. The polygon will rather be "amoeba-shaped" due to a combination of lower and higher values of the chosen indicators (Siegmund-Schultze et al., 2010). A recent development of this method can be seen in the MOTIFS approach, an acronym for "monitoring tool for integrated farm sustainability" (Meul et al., 2009). As with AMOEBA, MOTIFS was meant to allow the user to monitor the level of farm sustainability in three dimensions, namely economic, ecological and social, depicted in a radar graph. Moreover, MOTIFS is designed to provide the results on three levels. Level 1 provides a general overview of farm sustainability, level 2 provides an overview of each dimension, and level 3 visualizes the score of indicators in a specific theme.

2.2 Beef production with Bali cattle in Indonesia

2.2.1 Breed description and population dynamics

The Bali breed is one of the existing indigenous cattle breeds in Indonesia, besides Madura, Sumban-Ongole, Javan-Ongole, Grati, Aceh and Pesisir (Martojo, 2003). Analysis of mitochondrial, Y-chromosomal, and microsatellite DNA indicated that the maternal and paternal origin of Bali cattle was Banteng (Mohamad et al., 2009). This confirmed the assumption that it is the domesticated direct descendant of the wild Banteng, which is now under national conservation as an endangered species in three National Wild Conservation Parks (Ujung Kulon, Baluran and Blambangan) in Java. It is believed that the domestication process started about 3500 BC (Payne and Rollinson, 1973; Rollinson, 1984; Martojo, 2003; Sumantra and Sumitayati, 2005; Litbangnak, 2008, Mohamad et al., 2009).

As the largest concentration of Bali cattle is found in the island of Bali, it would be reasonable to assume that the centre of domestication was Bali Island (Payne, 1990). The cattle then spread out in almost all Indonesian territory (Figure 2.1): to Lombok Island in 19th Century (Hardjosubroto and Astuti, 1993), Timor Island in 1912 and 1920 (Litbangnak, 2008) and South Sulawesi in 1920 and 1927 (Pane, 1991; Litbangnak, 2008). Populations are also found in small number in Sumatra, Malaysia, the Philippines and northern Australia (National Research Council, 1983; Sumantra and Sumitayati, 2005).



Source: National Research Council, 1983

Figure 2.1. **Distribution of Bali cattle**

There are several taxonomical names for the Banteng/Bali cattle. Some of these names are *Bos javanicus, B. sondaicus, B. sundaicus, B. bantinger, B. banten, Bibos banteng and Bibos sondaicus*. The first is the most used in literature and is now the accepted name (National Research Council, 1983).

The breed has been described by several authors for decades as remarkably pure and uniform in type (Payne and Rollinson, 1973; National Research Council, 1983; McCool, 1991; Hardjosubroto and Astuti, 1993; Kusumaningsih, 2002; Martojo, 2003; Litbangnak, 2008), as they were kept separate from other breeds such as Ongole (*Bos indicus*) (Mohamad et al., 2009). This is because since 1913, the colonial policy did not allow the introduction of other types of cattle into the island of Bali to maintain the purity of the breed (National Research Council, 1983). McCool (1992) described the Bali cattle as having a deer-like appearance and temperament and distinguished them from the red deer for their striking colour patterns and the heavier average mature size of a Bali cattle of about 300kg (Kirby, 1979). The hair colour for juveniles is very distinctive, usually reddish-brown (Payne and Rollinson, 1973; Martojo, 2003) or gold (McCool, 1991), except for a clearly defined white oval area on the hindquarters that extend along the belly, and also white socks reaching from the hooves to just above the hocks. There is a well-defined narrow band of black hair running along the back from behind the shoulder to the tail. Females retain this morphology in adulthood. In bulls, but not in cows, the red hair over the whole of the body begins to darken at 12–18 months of age (Martojo, 2003) and by maturity or about 3-year-old is almost black, even though the band of black hair on the back is still visible (Payne and Rollinson, 1973; National Research Council, 1983; Hardjosubroto and Astuti, 1993; Martojo, 2003). In castrated bulls, black hair on the whole body changes to red again within four months of castration (Rouse, 1972; Maule, 1990; Kusumaningsih, 2002). Occasionally, black and white cows are seen without changing in colour until adulthood for both, males and females (McCool, 1991). These types are called “injin” (Hardjosubroto and Astuti, 1993).

Bali cattle are humpless cattle (Figure 2.2). They have a brad head, a short neck, a well-developed dewlap, a broad chest, and the fore-legs are more powerful than the hind-legs (Payne and Rollinson, 1973; National Research Council, 1983; Litbangnak, 2008). The hide is generally fine and dry and is considered to be superior to that of other cattle of Indonesia. The cow is lighter than the bull, the head being narrower, and the horns are only 10 – 20 cm in length, whilst in the bull they can attain a length of 20 to 30 cm (Payne and Rollinson, 1973). The cows have the long withers and short back of the males, but the dewlap is smaller, the legs are fine, but strong. The udder is poorly developed and hairy. Behaviour, biology, and function as well as the advantages and disadvantages of Bali cattle are listed in Table 2.3. More details of Bali cattle performance are presented in chapter 2.2.3.

(a) (b) (c)

Figure 2.2. Bali cattle: (a) Female; (b) Juvenile; (c) Male

Table 2.3. Behaviour, biology, functions, advantages and disadvantages of Bali cattle

Variable	Condition/Location	unit	Description/Average value
Behaviour	In wild/forest area		Deer-like temperament: timid and easily upset. Easily get into a state of shock[2,7]
	On-farm (village-based management system)		Tractable[2]
Biology			
Longevity		Year	Up to 16[7]
Puberty	Male	Months	20 – 26[7]
	Female	Months	18 – 24[7]
Fertility		Percent	70 – 85[1,3,6,16]
Oestrus cycle			
Length	Young adult	Days	20 – 21[7,10]
	Older adult	Days	16 - 23[7,16]
Duration		Hours	15 – 48[1,7,16]
Seasonality	August - January	Percent	66[16]
Sexual maturity	Male	Months	23 – 36[1,6,16]
	Female	Months	13 – 24[1,2,6,16]
Age at first calving		Months	28 – 40[1,2,16]
Gestation period		Days	282 – 286[1,6]
Conception rate		Percent	80 – 90[4,6,16]
Male:female ratio at birth		Percent	48-51 : 49-52[6,16]
Calving interval		Months	11 – 17[2,6,3,16]
Weaning age		Months	6[11,13]
Calf mortality			
Until weaning		Percent	4 – 52[3,5,6,7,8,9,15,16]
After weaning, up to one-year-old		Percent	3.6 – 3.9[6,7]
Adult mortality		Percent	2.7[2]
Function	Bull		Draught, meat[1,14,16]
	Cow		Draught (light work), meat[14,16]
	White cattle (injin), in Bali and Lombok Islands		Cultural offering and religious rituals[1,14,16]
Advantages	• Ability to maintain bodyweight in poor environment and nutritional conditions[4,12] • Resistance to ticks and tick-borne diseases[4,12] • Good work capability[4,12,14] • Good beef performance[4,12,14] • High fertility rate and relatively short calving interval [1,12]		
Disadvantages	• High calf mortality[5,12] • Susceptible to Jembrana disease, Bali Ziekte disease and Malignant Cattarhal Fever[1,4,12] • Slow growth rate[12] • Small body size		

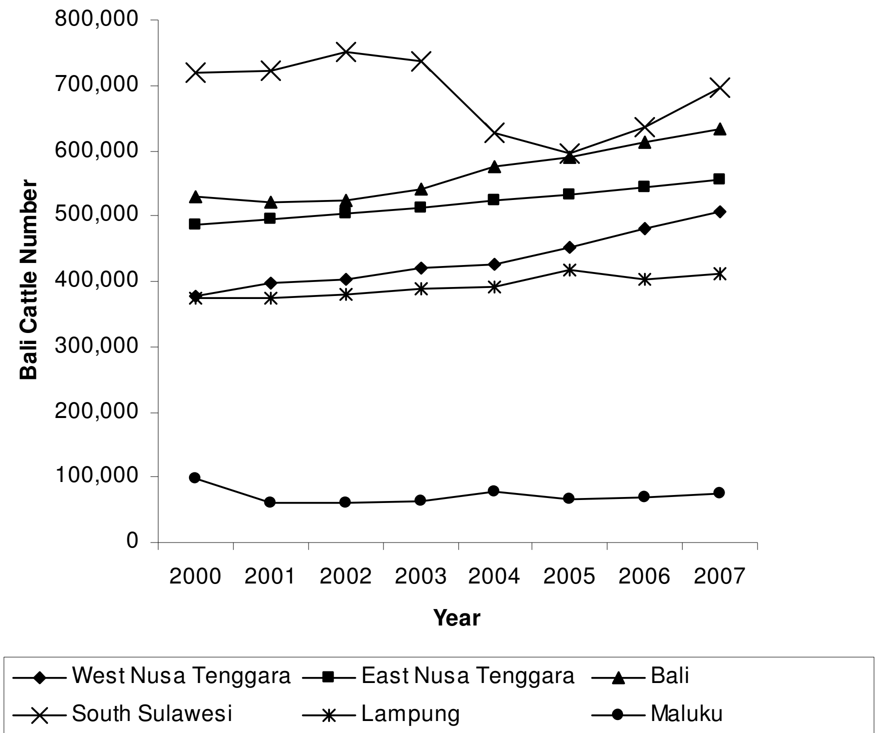
Sources: [1]Payne and Rollinson, 1973; [2]Sumbung, 1977; [3]Darmadja, 1980; [4]National Research Council, 1983; [5]Wirdahayati and Bamualim, 1990; [6]Pane, 1991; [7]McCool, 1992; [8]Wirdahayati, 1994; [9]Jelantik, 2001; [10]Fordyce et al., 2003; [11]Utoyo, 2003; [12]Kusumaningsih, 2002; [13]Talib et al., 2003; [14]Sumantra and Sumintayati, 2005; [15]Jelantik et al., 2008; [16]Litbangnak, 2008.

Note: Jembrana Disease is an acute lentivirus infection in Bali cattle in Indonesia, causing 20-70% case fatality rate in Indonesia (Kusumaningsing, 2002).

Bali ziekte disease is a disease characterised by dry eczema until severe skin necrosis and susceptible in Bali cattle and banteng (NRC, 1983)

Malignant cattarhal fever is an acute and fatal disease affecting species of the subfamily Bovidae and family Cervidae, extremely susceptible in deer and Bali cattle. This disease was distributed worldwide and caused by herpesvirus (Payne and Rollinson, 1973).

Bali cattle make a significant contribution to the Indonesian beef cattle population (Kusumaningsih, 2002). There are more than 27% of the total cattle population in Indonesia that has been reported as 11,514,871 head in 2007 (Ditjenak, 2009). Most of them are concentrated in 5 provinces namely South Sulawesi, Bali, East Nusa Tenggara, West Nusa Tenggara, and Lampung (Figure 2.3). About 2.5% can be found in Maluku which are concentrated in two islands, namely Ceram and Buru Islands. The number of Bali cattle slightly decreased from 2000 to 2007 in Maluku, but increased in other provinces.



Source: Ditjenak, 2009

Figure 2.3. Population dynamics of Bali cattle in six provinces in Indonesia from 2000 to 2007

2.2.2 Production systems

Despite an emphasis on crop production, mixed farming systems, where crops and animals are integrated on the same farm, are forming the backbone of smallholder Indonesian agriculture, particularly in the eastern islands of Indonesia. The term smallholder refers to families which practice labour-intensive forms of farming with low levels of purchased inputs and with no more than a few ha of land for the more-or-less exclusive use of the household (Waters-Bayer and Bayer, 1994). Smallholder farming households aim at allocating their resources in order to meet their household needs, which include income, consumption and financing as material concerns, self-esteem, status, security, leisure and happiness (Siegmund-Schultze, 2002), or to borrow Chantalakhana et al. (2005) words: “to ensure that their physical as well as psychological needs are met”.

Under this smallholder mixed farming system, annual crops (for instance, rice [*Oryza sativa*], cassava [*Manihot esculenta*], maize [*Zea mays*] and vegetables) and perennial crops (clove tree [*Syzygium aromaticum*], rubber tree [*Ficus elastica*], coconut tree [*Cocos nucifera*], cocoa tree [*Theobroma cacao*]), large and small ruminants (cattle, goat, sheep) and non-ruminants (pig, horse), including poultry, are integrated, and land ownership is rather small, ranging from 0.25 ha (Djajanegara and Diwyanto, 1995) to 5 ha (Devendra and Thomas, 2002). The cattle number is ranging from 1-3 head/farm in Java (Hadi et al., 1999) to 20-50 head/farm in several private farms in eastern Indonesia such as West and East Nusa Tenggara, and South Sulawesi provinces (Djajanegara and Diwyanto, 1995). The production is subsistence-oriented and gains less than 30% of the gross farm product from livestock (Djajanegara and Diwyanto, 1995). This type of system is dominating the production of livestock in most regions of Indonesia, particularly in wet and dry lands, such as Maluku.

Bosma et al. (2001) classified the management strategy of cattle raised in Indonesia into 4 types:

1. “*Low maintenance*”, cattle are kept as possible reserve for emergencies and future investments, but there are little or no investments for feed and health.
2. “*Livelihood maintenance*”, cattle are kept under extensive management for production of progeny and meat to sustain the family, but there are little investments. Animals may be kept in several herds to spread risk.
3. “*Farm household support*”, cattle and buffalo are kept to produce manure and labour and are a possible reserve for emergencies and future investments, mostly when the adult animals are exchanged for younger ones. Animal labour can be used for ploughing and hauling, also to obtain cash income.
4. “*Market oriented management*”, cattle are kept for marketing: beef production.

In terms of ownership of cattle, there are at least three types of cattle ownership in Indonesia (Sondakh and Kaligis, 1991; Bosma et al., 2001; Attamimi, 2003; Widiyaningrum, 2006; Guntoro, 2008):

1. Owner himself takes care of his animals
2. Owner shares taking care of his animals with another farmer (caretaker), who does not own cattle himself. In this case, housing, feeding, and management of the cattle are the duty of the caretaker. The land used to keep the cattle can be owned by the caretaker or by the cattle owner. This type of ownership is called "*gaduhan*".
3. Combination between no.1 and 2

In particular for *gaduhan*, the arrangement can be as follows:

a) The offspring is divided between the owner and the caretaker. Usually the first calf is for the owner and the second one for the caretaker; this arrangement allows the caretaker to start his own cattle production.

b) The caretaker receives "allowance" as agreed between caretaker and the owner in return for his services.

The gaduhan cattle ownership is common in Ceram, and can also be found in other parts of the country such as Sumatra and Sulawesi (Sondakh and Kaligis, 1991), East and West Nusa Tenggara (Bosma et al., 2001), and Java (Widiyaningrum, 2006; Guntoro, 2008). Usually, the owners are rich people who live in big cities, such as Ambon for the Ceram case, and the caretaker is one of the families or followers in the villages (Attamimi, 2003).

In an attempt to modernise this subsistence livestock production, the National Government of Indonesia (GoI) created in 1990 a development program called Beef-Nucleus Estate Smallholder (Beef-NES). This program was first introduced in Lampung Province (Adnyana et al., 1996), West and East Java (Hadi et al., 1999) and Bali (Ambarawati et al., 2004). The system aimed to improve the managerial capability and welfare of smallholder livestock keepers. Three types of production systems were tested (Hadi et al., 1999):

1. Beef-NES Fattening system

   The owner (private national companies engaged in fattening and import of cattle and beef) provides cattle, concentrates, technical assistance and purchases the output (cattle) after the period of 60 – 180 days. The farmer provides land, labour and forage and is responsible for cattle feeding and maintenance.

2. Beef-NES Breeding system

   The company provides heifers or cows, semen, AI service, concentrates, vaccines and other medicines as well as technical assistance and purchases the output. The farmer provides land, labour and forage and is responsible for cattle feeding, rearing and maintenance.

3. Beef-NES Forage system

   The company provides seeds, fertilizer and technical assistance, and purchases the output. The farmer provides land and labour, and is responsible for producing forage.

Out of these three systems, only the Beef-NES fattening system was reported as a successful system (Adiwisono, 1996; Adnyana et al., 1996; Hadi et al., 1999). Other provinces that were not involved in the Beef-NES scheme were assisted through the governments' cattle distribution program through several additional schemes, such as *Inpres Desa Tertinggal* (Presidential Instruction Aid for Least Developed Villages) and *Bantuan Presiden* (Presidential Aids) as in Maluku Province (Attamimi, 2003).

2.2.3 Performance of Bali cattle

Bali cattle were used as draught animals, mainly for ploughing and levelling in the traditional farming practices in Java and Bali (Pane, 1990). Bali cattle can sustain pulling a draught load equivalent to 11% of its live weight while walking at a speed of 2.5 – 3.6 km/hour for the duration of 3 - 4 hours per day and for 20 to 60 days per year (Winugroho and Teleni, 1991). The average draught load varied among locations with an average of 40 – 60 kg, depending on the work type (ploughing or levelling) and soil type (dry or wet) (Bakrie and Mas'um, 1991).

The productivity of Bali cattle in Indonesia, Malaysia and Australia was reviewed by a number of authors (Devendra et al., 1973; McCoster et al., 1984; Talib, 2003). Table 2.4 compares the average production performance of female Bali cattle in extensive farming systems of different provinces in Indonesia and Australia. The variation of body weight within the different age stages and among locations may be attributed to differences in management and environmental conditions, particularly feed availability and quality (Pane, 1990). The author assumed that genetic differences may have caused the apparent tendency for lower body weights in South Sulawesi.

These figures are the highest among the indigenous cattle breeds in Indonesia (Oka and Darmadja, 1996; Mastika, 2003; Martojo, 2003). Wirdahayati (1994) indicated that the Bali cattle can be more productive than a *Bos indicus* genotype such as the Ongole, under conditions of poor nutrition and poor management in smallholder farms in eastern Indonesia. Talib (2001) showed that under good nutrition and good management, calf mortalities of Bali cattle can be reduced sharply from 7% to 3% in extensive farming systems in eastern Indonesia. Jelantik et al. (2008) reported that calf mortality can even be reduced from 6% to 0% with provision of protein supplementation.

Bali cattle are very prolific animals. Toelihere (2002) reported that the breed can produce a calf every year in the poor environmental and climate condition such as in the provinces of West and East Nusa Tenggara and Bali. The Bali cows can produce 11 calves or more during their lifetime (Sumantra and Sumitayati, 2005), although twinning is not common in Bali cattle (National Research Council, 1983).

Table 2.4. Production traits of female Bali cattle under extensive farming systems in four provinces in Indonesia

Traits	Unit	Bali	East Nusa Tenggara	West Nusa Tenggara	South Sulawesi	Sources
Birth weight	kg	16 – 17	12 – 14	13 – 14	12 – 13	Pane, 1990; Talib et al., 2003
Weaning weight	kg	82 – 86	71 – 79	72 – 84	64 – 70	
Yearling weight	kg	127.5	100 – 115	118 – 130	99 – 112	
Weight at puberty	kg	167 – 170	154 – 180	160 – 183	150 – 225	
Mature cows weight	kg	264 – 303	222 – 235	238 – 242	211 – 224	
Daily weight gain up to 6 months	kg/day	Male (Australia): 0.32 – 0.37[2] Female (Australia): 0.28 – 0.33[2] Traditional system (Bali) : 0.23 – 0.27[3] Grassland-based rearing system (Bali): 0.36[4] Improved pasture (Bali): 0.25 – 0.44[9] Intensive production system (Australia): 0.87[5]				[1]Payne and Rollinson, 1973 [2]Kirby, 1979 [3]Nitis and Mandrem, 1978 [4]Sumbung et al., 1978 [5]Moran, 1978 [6]National Research Council, 1983 [7]Sutardi, 1991 [8]Bamualim and Wirdahayati, 2003 [9]Litbangnak, 2008
Lean meat yield	%	38 – 44[1]				
Carcass weight	kg	148 – 239[1]				
Dressing percentage	%	52 – 60[1,7]				
Meat in carcass	%	69 – 80[1]				
Bone in carcass	%	14 – 18[1]				
Fat in carcass	%	4 – 14[1,9]				
Lactation milk yield	kg	600 – 900[6,8]				
Daily milk yield	kg/day	0.79 – 2.8[6,8]				
Lactation length	days	90 – 305[6]				

Note: age at weaning was 6 months

2.2.4. Socio-cultural and economic benefits of Bali cattle keeping

Beef cattle production is an important component of many smallholder farming systems throughout Indonesia (Hadi et al., 1999; Ambarawati et al., 2004). Beef shared 20 – 25% of the total national meat consumption in 1990 – 1997 (Hadi et al., 1999), they contributed 30% to the Indonesian livestock sector income, which accounted for 6.4% of the total National Gross Domestic Product in 1992 - 1993 (Djajanegara and Diwyanto, 1995). According to Fisher (1985) the sale of cattle, particularly Bali cattle, is a major source of foreign exchange and an asset to the growing tourist industry on the national level. Bali cattle as a means of beef production have been acclimatized over the years in the eastern islands of Indonesia and have been integrated into the rural smallholder economy in marginal areas for various reasons. Reasons to keep the breed were reported as source of progeny (calves), and safe deposit (source of cash in emergencies), insurance for crop harvest failures, beside the manure used as fertilizer, draught power in tillage work and transporting farm products, and commercial purposes in the fattening and beef industry (Payne and Rollinson, 1973; National Research Council, 1983; Inness, 1988; Hadi et al., 1999; Kusumaningsih, 2002; Martojo, 2003; Sumantra and Sumitayati, 2005; Litbangnak, 2008). The "*injin*" Bali cattle serve for cultural and religious rituals in Bali Island, such as "*gerumbungan*", or cattle racing festivals in Buleleng district, and within the "*pitra yadnya*" ritual as a means of transportation of the human soul to heaven, according to Bali's Hinduism (Sumantra and Sumitayati, 2005; Litbangnak, 2008).

The economic benefits of Bali cattle were reported by Paris (2002) for transmigrant households in South Sumatra Province. Her study used two models of farming systems: without and with livestock (on average one Bali cattle, three goats and 23 chickens) and showed that the net income of farming households with livestock was 75% higher than in those without livestock. Cattle contributed 57% of the livestock revenue, followed by chicken, 27% and goats, 16%. Similar results were reported by Bosma et al. (2001) for East Kalimantan Province. According to the authors, the mean income per one head of adult cow per month was IDR 89,800 (USD 1 = IDR 9300), while the overall mean per capita rural income per month was IDR 143,219. It means, one cattle could contribute 63% of the total per capita rural income in East Kalimantan. Moreover, the authors mentioned that farmers having cattle had a visibly higher living standard than those who had none.

In Ceram Island, Maluku Province, Bali cattle make a significant contribution to the Gross Domestic Income. For the period of 1983 – 2000, among several agricultural sectors in

Ceram, the livestock sector was the second most important, after food crops (CBS, 2002). The main contribution came from the export of live cattle that reached 15.8% of the total population in year 2000 of 36,107 head (CBS, 2002). Unfortunately, there are no official reports available from 2000 onward.

2.3 Smallholder farming systems on Ceram Island, Indonesia

2.3.1 Feed Resources

The natural grasses found in Ceram Island, as well as in other parts of Indonesia, are *Axonopus, Brachiaria, Dichantium, Imperata, Panicum* and *Paspalum* genera. Legume trees to be found in Ceram are *Erythrina, Gliricidia, Leucaena* and *Sesbania* (Hidayati et al., 1999).

Feed resources from fruit production can be mentioned as jackfruit leaves, banana leaves, pineapple, and papaya by-products (CBS, 2002). Attamimi (2003) estimated the contribution of these resources when they are utilised in their optimal level for cattle feeding, which was as much as 20% of total feed resources.

Horticulture by-products can also contribute to enrich the feed resources on Ceram. From the total vegetable production in Ceram, which is about 26,000 tons/year, 10% are waste and unutilised (CBS, 2002). It means, about 2,600 tons of forage is wasted every year on Ceram that could at least partially be useful for feeding cattle.

The main agricultural by-products come from staple crops, thus carbohydrate production. Rice, as the main crop planted by the transmigrants (Saono and Sastrapradja, 1995; CBS Kairatu District, 2006), produced straw and rice bran that could be used for animal feed (Nader et al., 1998; Nader, 2000; Drake et al., 2002). Jelantik et al. (2008) confirmed that by supplementing rice bran on a daily base to yearling Bali cattle, they can gain more weight than those without rice bran supplementation.

Djajanegara and Rangkuti (1995) reported that Alang-alang grass (*Imperata cylindrical* Beauv.) has at least the same nutritive value as elephant grass (*Pennisetum purpureum*) when cut at 30-day intervals. Currently the use of this grass is for roofing material for houses in rural areas.

All these by-products are highly under-utilised at present, being left, for the most part, to rot or to be burned (Attamimi, 2003). To achieve efficient utilisation for these by-products, it is essential to have knowledge of their nutritive values and palatability. Details about potential feed resources in Ceram are summarised in Table 2.5.

Table 2.5. Potential feed resources in Ceram Island

Forage type	Name	Availability [1] (kg/year)	Product	State of utilisation
Grasses	King grass	n a	Leaves	Fresh , dried
	Napier grass	n a	Leaves	Fresh
	Paspalum sp	n a	Leaves	Fresh
	Dichantium sp	n a	Leaves	Fresh
	Panicum sp	n a	Leaves	Fresh
Legume trees	*Sesbania* sp	n a	Leaves	Fresh
	Erythrina sp	n a	Leaves	Fresh
	Gliricidia sp	n a	Leaves	Fresh
	Leucaena sp	n a	Leaves	Fresh
	Calliandra sp	n a	Leaves	Fresh
Fruit residues	Banana	1,670,600[2]	Leaves, stem, peeling	Fresh
	Papaya	646,770[2]	Leaves, fruits	Fresh
	Jackfruit	783,070[2]	Leaves , fruit	Fresh
	Pineapple	378,340[2]	Fruit, starch	Fresh
Vegetable residues	Spinach	150,000[3]	Leaves	Fresh
	Kangkung	301,100[3]	Leaves	Fresh
	Eggplant	344,400[2]	Leaves, fruit	Fresh
	Tomato	495,300[2]	Leaves, fruit	Fresh
	Chinese Pocsay	226,500[3]	Leaves	Fresh
	Cabbage	317,600[3]	Leaves	Fresh
Beans	Soy bean	142,400[4]	Leaves, nuts	Fresh, processed
	Ground nuts	342,900[4]	Leaves, nuts	Fresh, processed
	Cow pea	11,500[4]	Leaves, nuts	Fresh, processed
	Green bean	144,000[4]	Leaves, nuts	Fresh, processed
Staple food	Rice	n a	Straw, bran, broken rice	Fresh, dried, treatment
	Maize	n a	Straw, cobs, grain	Fresh, dried, treatment
	Sweet potato	1,629,600[5]	Leaves, tubers	Fresh, dried
	Coconut	224,050	Copra , cake	Fresh, dried, processed
	Cassava	6,998,500[5]	Leaves, stalks, tubers	Fresh, dried, treatment

Note: 1). 10% of the total production (CBS, 2002) assumed to be wasted and can be used for feeding cattle
2). The yield of fruits, not including leaves 3). The yield of leaves
4). The yield of nuts, not including leaves 5). The yield of tubers, not including leaves and stalks
n a = data not available
Source: Attamimi, 2003.

2.3.2 Population and socio-economic conditions

The total population of Ceram Island is about 419,201 people (CBS, 2006) with an average density of 22 people per km^2. It consists of two main groups; indigenous people and the transmigrants, who came gradually since 1954 from other parts of Indonesia, mostly from Java and Bali islands and settled in the Island, which are approximately 14% of the total population (about 48.231 people). The majority of the Island population is Muslim, namely 67% (Bahuchet and Grenand, 1995). Other religions were Christian (28%), Hinduism and Budhism (1%) and traditional religion (4%) (CBS, 2002).

Indigenous smallholder systems

The indigenous people of Ceram Island consist of 5 groups, i.e. Alune, Lumoli, Nuaulu, Seram and Wemale (Hidayati et al., 1999). Of these groups, only Wemale people live in the mountainous areas, while the others live in coastal areas. They live as crop farmers, livestock keepers and fishermen (Lebel, 1999). The staple food is sago (*Metroxylon sago*).

The agricultural system practiced by the indigenous people on Ceram Island is a combination between crop, livestock, forestry and fishery production. Crop production is dominated by dry land agriculture. There are several agro-ecological terms used by indigenous people (Efendi, 1987; Yogaswara and Zaenaly, 1999; Syuryadi, 2008): *Ewang, Aong, Kebong* and *Dusun* (Table 2.6). Ewang is a parcel of land in the forest area, about 5 km from the village (Syuryadi, 2008) that is newly opened by a farmer and has not been cultivated (Efendi, 1987). The main production of this site is wood and sugar palm (Yogaswara and Zaelany, 1999).

Table 2.6. Agro-ecological terms and respective production on Ceram Island

Agro-ecological term	Main production
Ewang	Wood, sugar palm
Aong	Banana, cloves, sago palm, pasture
Kebong	Cassava, banana, sweet potato, maize, taro
Dusun	Sago palm, clove, nutmeg, coconut, fruit trees

Sources: Yogaswara and Zaelany, 1999; Kaya et al., 2002; Syuryadi, 2008.

Aong is a site that has been fallowed (Yogaswara and Zaelany, 1999; Syuryadi, 2008). This site is normally being used for grazing livestock and planting several crops such as banana, cloves and sago palm. Kebong is a garden (Kaya et al., 2002). It is located within 2-4 km from the village. The cropping phase in this site usually lasts 3 – 4 years (Kaya et al., 2002).

Usually various plants are cultivated, such as cassava and sweet potato using a shifting cultivation system. This system can be classified into two types: traditional and transitional (Hidayati, 1998). *Traditional shifting cultivation system* means using traditional techniques with long fallow periods, between 10 – 20 years (Kaya et al., 2002**).** This system was and is still practiced by people in the hinterland and mountains, with limited influences from outside (Hidayati, 1998). *Transitional shifting cultivation system* is usually done by people who live in coastal areas and have been influenced by regional development. They usually live closer to urban areas. Land for farming has been decreasing, so that the fallow period is shortened (Hidayati, 1998) to 5 – 10 years (Kaya et al., 2002). Dusun is located 4 – 8 km from the village (Syuryadi, 2008). The term dusun is actually extended to all agroforestry systems containing perennial crops (Kaya et al., 2002) such as cloves, coconut, nutmeg or cocoa beans. The management of dusun usually involves a customary practice regulation called *sasi* (Kaya et al., 2002; Harkes and Novaczek, 2002). Sasi is a conservation mechanism that encompasses spatial and temporal prohibitions on harvesting crops, cutting wood or other products from forest, tidal zone or marine territory of a village (Harkes and Novaczek, 2002).

Livestock, particularly cattle, are raised in Aong land or in the forest (Syuryadi, 2008). Some are kept in the backyard at night and released in the morning for grazing. Regarding marketing activities, women are dealing with crop products, while men are dealing with forest, fishery or livestock products.

Apart from agriculture, some off-farm activities are also done by indigenous people in order to generate income for the household. Usually women in the household (wife and or daughters) produce some food for selling and men (husband and or son) work as hired labor in other farms or private companies, or as carpenters in construction projects (Hidayati et al., 1999; Attamimi, 2003).

Hayes (1999) argued that one obstacle blocking their development is that they are 'investment-poor' or they simply cannot afford the modern inputs which could improve the productivity of their land. They do not appear to be making much money from their tree crops as well as livestock production, the traditional source of cash in the region. He also pointed to cultural and attitudinal obstacles to development, and a preference to hold on to their traditional way of farming as long as possible; for example, paddy fields, unusual for indigenous farmers, are sometimes described by indigenous farmers as 'dirty system', because it is cultivated in "swamp-like" soil types.

Transmigrant smallholder system

In 1954 the Government of Indonesia (GoI) launched a transmigration programme for the first time to Ceram Island aimed at reducing population pressure on Java (Fearnside, 1997). It is a part of the national transmigration program planned and financed by the national government since the colonialisation period in the early 1900s (Leinbach, 2003) and later being supported by the World Bank (Fearnside, 1997). This program created another group called *transmigrants.* Transmigrants are actually consisting of three groups (Leinbach and Smith, 1994; Leinbach, 2003). The first group is a sponsored transmigrant group. This group received extensive support from the government in the form of transport fees, land, house and social services for the first 5 years. The second group is called local transmigrant. They originate in or near the settlement areas and received the same benefits as the first group. The last group is called spontaneous transmigrant. They moved on their own expenses and settled in their area of choice. They received less support from the government, notably a scheme of credits rather than subsidies like the first two groups. The first two groups occupied most of the fertile mainlands in Ceram Island such as Pasahari in the north and Kairatu in the south. These two mainlands represent 68% of the most important mainland on Ceram Island (Yogaswara and Zaelany, 1999). These settlement areas were established by first opening the forest area outside the indigenous villages.

Agriculture is the intended activity for the vast majority of transmigrants so far (Leinbach and Smith, 1994). Under the supported transmigration programme, each family received a 0.25 ha house lot and home garden, 1.0 ha of potential *sawah* area (paddy field) and 0.75 ha of *ladang* or dryland farming area (Holden et al., 1995, Leinbach, 2003).

Transmigration has significantly contributed to the rice production on Ceram Island. The creation of *sawah* (paddy fields) and the support of rice cultivation through provision of infrastructure in the fields, particularly in the transmigration settlements, and research for breeding new seeds reflect this. Most of the *sawah* areas are rainfed, and only a small number of them, particularly in Waitimal and Waihatu in Kairatu district are irrigated (Attamimi, 2003).

In general, the transmigrant people practice permanent land use, providing a wide range of products with a high (food) value apart from rice, such as fruits, vegetables, meat, eggs and medicines (Gany and Halli, 1993). In their backyard, the transmigrant peasants cultivate a large number of different plant species of annual herbs, perennials, shrubs and trees of up to 250 species in one village (Reijntjes et al., 1992).

Livestock production, particularly beef production, has been practiced by the transmigrant farmers since 1985 (Anonymous, 1999), when the Government of Maluku province distributed Bali cattle in the scheme of Presidential Aid (*Bantuan Presiden/Banpres*), as explained above. The programme aimed to provide draught power in order to increase the paddy production. Besides, manure from cattle should be used as fertiliser and crop residues as feed for the cattle. However, the cattle were also used as a source of meat and cash by the beneficiaries (Anonymous, 1999).

Leinbach (2003) indicated that more than 58% of transmigrants had off-farm businesses in many transmigrant villages in Indonesia. The off-farm business varied from home industry such as basket making, *tempe* (made by controlled fermentation that bind the soybeans into a cake form) and *tofu* (bean curd) production, both used as a staple source of protein, cassava chips and sewing, to pedicabs (*becak*) driver. This differs according to several socio-economic conditions like age, educational level and the size of land owned by a transmigrant farmer. Leinbach and Smith (1994) concluded that the greater the size of land owned by a family, the less likely it will be that the family will own and operate another business. On the other hand, the better the educational level, the more probably a farmer owned a business other than agriculture.

Traditional authorities

The indigenous people in Ceram have a very ancient but stable autonomous government, consisting of legislative and executive bodies (Figure 2.4) (Hidayati et al., 1999). The legislative body is known as *Saniri Negeri,* which comprises all clans in the village. This institution is responsible for electing the *Raja*. The executive body consists of the Raja and *Saniri Besar* (village council). Raja is the head of the village government and the traditional leader of the village communities. In the past, these two positions were managed separately by two persons (Yogaswara and Zaelany, 1999). In governing the village, the Raja is supported by the *Marinyo* who helps the Raja to disseminate information, the *Kapitan* advised the Raja in developing war strategies in the past, and in the present situation acts as safeguard for village security. The Raja makes decisions after considering the suggestions from the Saniri Besar (Village Council) that consists of government staff, traditional leaders and *Kewang*. The Kewang is a traditional institution that is authorised to manage natural resources and the people's economy as well as to control the implementation of traditional regulations (Yogaswara and Zaelany, 1999; Harkes and Novaczek, 2002). Unfortunately, there is no indication in the literature of how the judicial power is being organised.

The traditional authority is being systematically abolished by the GoI with the issuance of Law No. 5/1979 regulating the village government. The law does not accommodate the traditional governmental system. The change creates confusions among the indigenous people in Ceram (Hidayati et al., 1999) and in nearly 67,000 villages in Indonesia (Thorburn, 2006). By losing their customary authority, the indigenous people also lost their control over their lands and resources, as the village government has no power to protect their own people (Thorburn, 2006). To accommodate indigenous structures and offices, almost all *Raja* were automatically appointed as the *Kepala Desa* (Head of the village) and get monthly salary from the national government of Indonesia. Other functionaries such as *marinyo, kapitan, kewang*, and *clan leaders* took most of the other positions in the new village government, although their number did not fully fit the number and nature of village government positions available and pre-existing politico-religious designations and roles (Thorburn, 2006). Another contentious aspect of the law involved the territorial issue as well, namely the merging and splitting of villages. Thorburn (2006) argued that these changes created innumerable conflicts over control of land and sea territories as the traditional villages had their own customary territorial units.

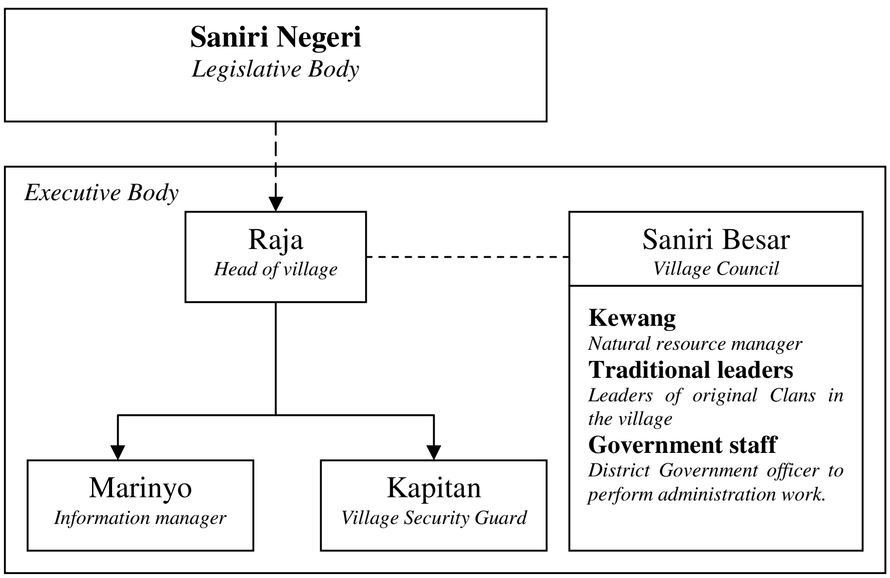


Figure 2.4. Village traditional authorities in Ceram and Ambon Islands
Summarised from Hidayati et al., 1999; Yogaswara and Zaelany, 1999; Harkes and Novaczek, 2002; Thorburn, 2006

The transmigrant group as newcomers on the Island created sub-groups among them according to the original area where they came from and period of coming (Leinbach, 2003). These sub-groups have a very strong relation within them. The settlement areas were given to the transmigrants by the government who created the villages and conducted meetings to select village government people for administrative purposes (Attamimi, 2003). Unlike in indigenous villages, the head of the village (*Kepala Desa)* in transmigration settlement areas is the person elected by the villagers. He or she should meet the legal criteria to serve as the head of the village. These criteria are defined by the national government under the law No.

5/1979, which includes age, educational background, literacy, Indonesian speaking ability and knowledge of the national law (Thorburn, 2006).

Land tenure

There is limited scientific documentation describing land tenure on Ceram Island. Some authors described the common land tenure in Indonesia with only some examples from Maluku Province and Ceram Island specifically (Hidayati et al., 1999) or some other parts of Maluku Province such as Aru archipelago (Hidayat, 1999) and Saparua Island (Syuryadi, 2008).

Communal land rights by indigenous people in Maluku can be categorised as:

1. Customary land rights (*tanah adat* or *petuanan* or *hak ulayat*). This type of land tenure is common in Maluku including Ceram Island but not in other parts of Indonesia. This land category can be divided into three ownerships:

    a. *Tanah dati* (Clan-owned land). The land category belongs to the lineage or clan. The clan leader is appointed as responsible person to manage and receive the output from the land. The average size of the land is 2 – 3 ha in Saparua Island and in some villages of Ceram Island (Syuryadi, 2008).

    b. *Tanah pusaka* (heritage land). This land category belongs to a family as heritage from the parents or grandparents. This land can be attached in "*tanah dati*" or as a new site in the forest area. The average size of it is 0.1 – 1.5 ha (Syuryadi, 2008).

    c. *Private land.* This land category belongs to an individual who first established a crop garden with slash and burn system in a parcel of land nearby the village or in the forest area. The permission for having private land can be received from the Raja.

These land rights categories are defined publicly and are recognized by the norms of tradition and generally accepted by communities (Hidayat, 1999). Evers (1995) used the terms "ownership" and "right of use" to describe these land rights categories in English although these are only approximations. This is because the traditional Maluku's rights to which they refer have no exact equivalents in Western law (Evers, 1995; Hidayat, 1999).

2. *Onderneming* or *perkebunan* (land rights for estate plantations). This type of land tenure can be found everywhere in Indonesia, especially in Java, Sumatra,

Kalimantan, Sulawesi, Maluku and Papua. This category belongs to the owner of an estate plantation since Dutch colonial reform in 1900s (Hidayat, 1999). Thorburn (2006) argued that in Ceram Island, this type of land right is attached to *tanah dati*. Only with the permission of clan leaders who owned the land, this land right can be used for estate plantations or logging purpose.

Land use in North Ceram has been reported by Yogaswara and Zaelany (1999) as described in Table 2.7.

Table 2.7. Land use in North Ceram

Type of land use	Area (ha)
Land owned by the government, partly used for governments estate plantation, offices, and partly used by indigenous farmers	869,930
Non described land use and ownership	83,140
Fallow and swamp	50,530
Non productive land	12,380
Paddy field, pasture and other agricultural productions	6,190
Human settlement	186
Total area	**1,022,356**

Source: Yogaswara and Zaelany, 1999

The lands used for settlements and agricultural production make up only 0.6%, including pastures used for animal grazing. Lands that are not used until now to a total of 99.4%. The government uses the term “sleeping lands” in addressing these unoccupied lands. Yogaswara and Zaelany (1999) argued that the sleeping lands concept of the government is actually incorrect because the production systems practised by indigenous people in North Ceram, namely slash-and-burn agriculture and hunting animals, using fallow periods which have specific ecological importance. In this way, the lands play important roles in the subsistence production systems of the indigenous people. Most of the land for paddy fields and agricultural production in table 8 are representing the one used in transmigrant villages where intensive and semi-intensive agriculture production is being practised.

In the case of Kairatu district, Hayes (1999) divided the land use as wet lands and dry lands (Table 2.8). Again, when the author mentioned forest here, it also includes tree crops planted by farmers such as cloves and nutmegs and sometimes pasture for grazing animals.

Table 2.8. Area and distribution of land use in Kairatu district

Type of land use	Area (ha)
Wet land:	
• Land planted by sago	1,300
• Paddy field	497
• Unused wet land	303
Dry land:	
• Forest	122,360
• Non described land use and ownership	11,700
• *Kebong* (garden)	6,100
• Human settlement	1,790
• Conversion land	518
Total	***147,811***

Source: Hayes, 1999

Economic situation

Since centuries, Ceram is known as the centre of agricultural production in Maluku and served the majority of the population in other islands in Maluku Province, particularly in Ambon, Haruku, Saparua, Banda islands and even the eastern part of Papua Province. But compared to other islands in Maluku Province, Ceram Island has the lowest annual income per capita, which was only USD 69 in 1999 whereas the Provincial GDP was USD 223 (CBS, 2002).

Ceram Island has 10 central markets to support the economic activities beside village markets that exist in almost every village in Ceram Island (CBS, 2006). The biggest market is located in Masohi, the capital of the Central Maluku regency. This market served as a wholesale market for agricultural products before distributing them to other markets in and out side the Island (CBS, 2006).

The establishment of oil exploration with international companies from Kuwait, China and Australia in the eastern part of the island since 1994 and private-national seafood exporting companies from Java (Jakarta) in the northern part, as well as private-national wood processing companies from Java (Jakarta) in the western part since 1990, increased the population and raised living standards, leading to an increase in the local demand for crop and livestock products (CBS, 2006). Yet they did not provide more opportunities for indigenous people on Ceram Island to be employed, but for a limited number of transmigrant people. This was concentrated nearby the production areas where most of the employers also came from other provinces such as East and West Java (Hidayati et al., 1999). Hence, the indigenous people do not seem to be actively taking advantage of developments in the region, or are excluded from development (Hayes, 1999).

3 MATERIALS AND METHODS

3.1 Study Area

The study was conducted on Ceram Island, which is located in the eastern part of Indonesia, in the province of Maluku (Figure 3.1). Ceram Island is the biggest island in Maluku with a total area of 18,483.87 km^2, and lies between 2°49' to 3°55' south latitude and 127°49' to 130°59' east longitude (CBS, 2002). It is divided into 3 regencies: West Ceram Regency with Piru as its capital city, Central Maluku Regency with Masohi as its capital city and East Ceram Regency with Bula as its capital city. The island was divided further into 10 districts. Those are West Ceram, Taniwel and Kairatu districts in West Ceram Regency, Amahai, Masohi, Tehoru and TNS districts in Central Maluku Regency, and Werinama, Bula and East Ceram in East Ceram Regency.

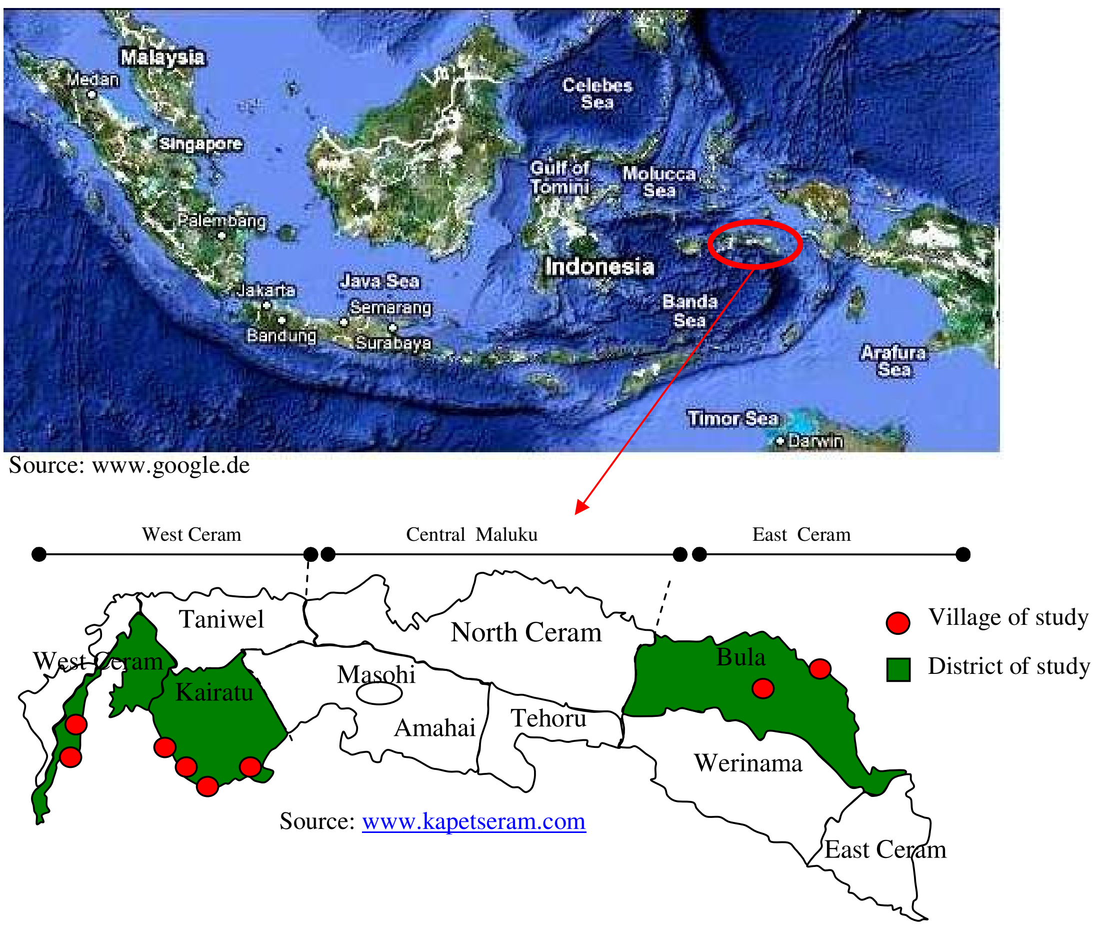


Figure 3.1. Map of study area (Ceram Island)

Climate

The climate on Ceram is greatly affected by the Binaia – Merkele ridge that runs east- west across the island (Leimeheriwa, 2002). The north coast is wettest during the north-west monsoon and the south coast wettest during the south-east monsoon. According to the Köppen classification system the climate of Ceram Island is a tropical rainforest climate (Af) in the west, with a mean temperature of about 26°C and without any clear dry period; the total rainfall in 2008 summed up to 2473 mm. Towards the east, the climate becomes slightly drier. The tropical savanna climate (Aw), defined as having at least 1 month with less than 60 mm rainfall, occurred in the east since 2004. In 2008, the rainfall ranged from 50 mm in January to 361 mm in June (Figure 3.2). The mean temperature of the coolest month was 21.4°C in the west, and 22.7°C in the east, the hottest month was 32.6°C in the west and 33.5°C in the east. The solar radiation was lower in August and higher in January, and ranged from 29% to 74% in both sides of the Island. There was a minimum of 12, respectively 13, rainy days per month in 2008.

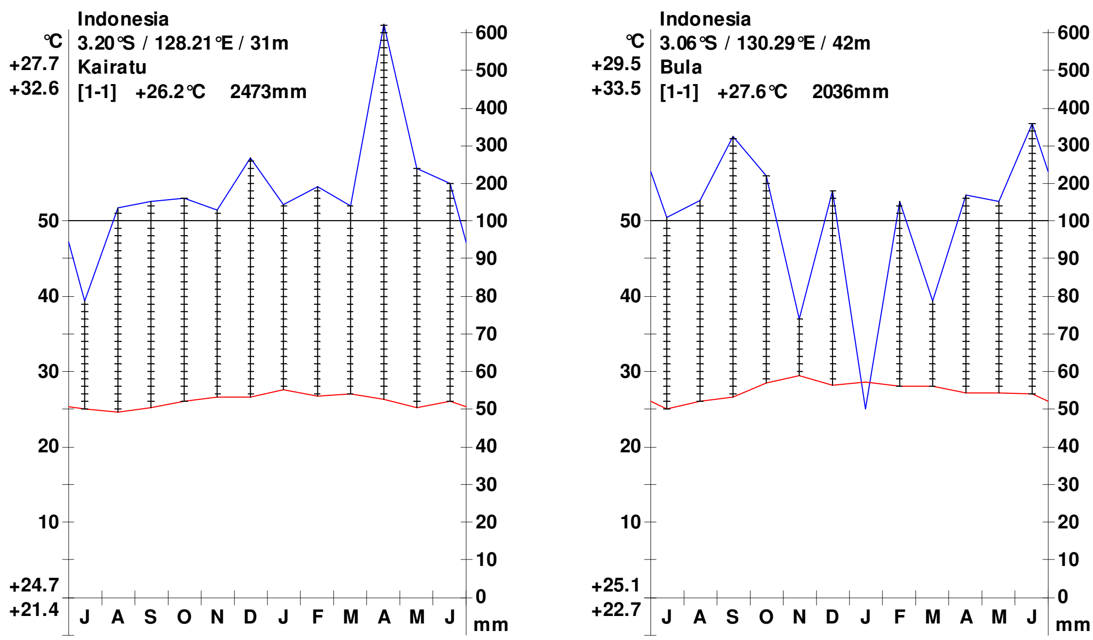


Figure 3.2. Climate diagrams of Ceram Island

Data sources: Geological station in Kairatu, West Ceram, and the statistical office of East Ceram Regency, Bula, both for the year 2008.

Note: Being located at southern latitude, the sequence of months starts with July

Relief and Soil

Geologically, Ceram Island is located in the convergence zone between the Eurasian, Indo-Australian and Pacific plates (Pairault et al., 2003). It consists of inner volcanic arc and an outer non-volcanic arc formed by sedimentary, metamorphic and some igneous rocks of Permian (Cooper, 1997) to Quaternary age (Pairault et al., 2003). The relief of the island is mountainous, with several highlands reaching more than 1,000 metres. The highest point on the island is the Merkele ridge, reaching 3,027m above sea level (Jackson, 1997; Cooper, 1997; WWF and McGinley, 2008). The majority of the island is still covered by primary rain forest. Only few lowlands exist in the island, which are very important for agricultural production, namely Kawa, Kairatu and Eti in West Ceram Regency, North and South Ceram in Central Maluku Regency, and Masiwang in East Ceram Regency (Table 3.1). Soil types found in Ceram are Inceptisols, Entisols and Mollisols (Susanto and Sirappa, 2007). Inceptisols are characterised by dark (brown to black) colour, smooth texture, with medium to high fertility. This type of soil has a wide distribution, from the lowlands to highlands. Entisols are found in the rocky area. This soil type is poor in organic matter, with low fertility. Mollisols are soils with high organic matter content and are moderate in fertility (Susanto and Sirappa, 2007).

Table 3.1. Lowlands on Ceram Island

Regency	Lowlands name	Size (ha)
West Ceram	Kawa	10,000
	Kairatu	1,300
	Eti	600
Central Maluku	North Ceram	40,000
	South Ceram	4,000
East Ceram	Masiwang	5,000

Source: Hidayati et al., 1999

3.2 Selection of districts, villages, farmers, cattle and key persons

The major economic activities on Ceram are agriculture, forestry, fishery, mining and trading (Table 3.2). Almost every village engages in agriculture. This study was focused on three districts, where agriculture is the major economic activity in terms of labour involved and area used for agricultural purposes. Those districts are West Ceram, Kairatu and Bula, where also all government's animal production development projects took place. North Ceram district was excluded as study area although agricultural production is its main economic activity. This was because of logistic difficulties in reaching the district by public transport, as the road was destroyed by a flood in 2008 and no regular schedule for small boats to go there from other districts existed.

Table 3.2. Major economic activities on Ceram

Regency	District	Major economic activity	Total area (km^2)
West Ceram	**Kairatu**	Agriculture	2,671.10
	West Ceram	Trading and Agriculture	696.73
	Taniwel	Forestry (timber)	678.52
Central Maluku	North Ceram	Agriculture	8,345.78
	Amahai	Trading and Services	1,739.07
	Tehoru	Forestry (Conservation area, national park)	534.22
	Masohi	Trading and Services (Government officers)	37.30
East Ceram	**Bula**	Oil Production, Agriculture	3,001.32
	East Ceram	Fishery	603.65
	Werinama	Oil Production	175.58

Source: Kapet Seram, 2010; CBS, 2006. Districts in bold are the study areas.

3.2.1 Selection of villages

There are two groups of people working in agriculture in Ceram. The indigenous farmers are simultaneously crop farmers, livestock keepers and fishermen and are regarded by the local government to have inadequate knowledge, skills and equipment to develop their economic capability (Lebel, 1999). The transmigrants came gradually since 1954 as part of a national transmigration project, settled in the Island and live as food crop farmers, mainly producing rice, and later became cattle keepers. Those two groups are living separately in their own communities, forming relatively homogenous villages and sub-villages in terms of origin and religion. The study was conducted in both, transmigrant villages and indigenous villages, with the pattern of purposeful selection as mentioned in Table 3.3.

Table 3.3. Criteria for village selection

Criteria	Features		
Ethnic group	Transmigrant	Indigenous	
Religion	Muslim	Christian	Muslim
Location	Easily reached by public transportation		
Production system	Mixed farm		

In total, 8 villages were selected. Those are four transmigrant-muslim villages, two indigenous-christian villages and two indigenous-muslim villages from three districts (Table 3.4).

Table 3.4. Villages where the study was conducted

District	Village	Ethnic group	Religion	Origin	Year of foundation	Total population (caput)	Population density (caput/km^2)	Total area (km^2)
West Ceram	Luhu	Indigenous	Muslim	Ceram	unknown	4235	35	121
	Olas	Transmigrant	Muslim	Sulawesi	1923	2800	56	50
Kairatu	Waisamu	Indigenous	Christian	Ceram	unknown	2063	59	35
	Kairatu	Indigenous	Christian	Ceram	unknown	6290	98	64
	Waihatu	Transmigrant	Muslim	East Java	1971	2628	103	25
	Waimital	Transmigrant	Muslim	East Java	1954	4721	236	20
Bula	Jembatan Basah	Transmigrant	Muslim	Central Java	2000	2475	123	20
	Bula	Indigenous	Muslim	Ceram	unknown	4783	251	19

Source: Kapet Seram, 2010; CBS, 2001

3.2.2 Selection of households (farmers and cattle)

The sample size was calculated based on the prevalence of raising Bali cattle among indigenous and transmigrant farmers. The overall percentage of farmers having cattle was around 26% on Ceram Island, with a prevalence of indigenous farmers having cattle of 35% (P_1) and that of their counterparts of only 17% (P_2). Using the following formula given by Lwanga and Lemeshow (1991):

$$n = \frac{\left\{\left(Z_{1-\alpha/2} + Z_{1-\beta}\right)^2 * \left(P_1\left(1-P_1\right)+P_2\left(1-P_2\right)\right)\right\}}{\left(P_2 - P_1\right)^2} \quad \text{...(1)}$$

with a 95% confidence level ($Z_{1-\alpha/2}$) and 90% power of estimation ($Z_{1-\beta}$) and adding a 10% rejection rate, the number of respondents per ethnic group was rounded to 60 farmers. Assuming all villages having the same proportion of farmers raising Bali cattle, 15 respondents in each village based on the household list available in the village offices were randomly selected (Table 3.5). A total of 120 households were recruited for this study, stratified by the factors ethnic group (indigenous vs transmigrant), district (West Ceram, Kairatu and Bula) and religion (Muslim and Christian).

Two to four farmers were selected from the 15 households per village to participate in the focus group discussions. Their selection was completely randomized by applying surveyselect procedure of SAS 9.1 software.

The equation (1) above assumed simple random sampling, while the study used stratified sampling. Under stratified sampling, some gain in precision is expected compared to simple random sampling, thus, the calculation provides a conservative estimation of required sample size.

Cattle from all households, who participated in the interviews, were used for body weight measurements. The selection of cattle was based on the availability of cattle and the ability of farmers, as well as research team to handle the cattle. A total of 479 cattle were measured. One breeding female per household, selected by the farmer as stated to be a "*mai*" (main breeding female in the farm), was sampled for applying a progeny history questionnaire.

Table 3.5. Sample size and factors considered for sampling

District	Ethnic group	Number of villages	Religion	Household respondents
West Ceram	Transmigrant	1	Muslim	15
	Indigenous	1	Muslim	15
Kairatu	Transmigrant	2	Muslim	30
	Indigenous	2	Christian	30
Bula	Transmigrant	1	Muslim	16
	Indigenous	1	Muslim	15
Total sample size				121

3.2.3 Selection of key persons

Key persons to be interviewed were:

a. Head of the village (*Raja*) and traditional leaders

   All village heads of the study villages were asked to participate in the study as a key person for interview and for focus group discussion. One traditional leader was chosen to be a key person with close consultation with the head of the village. The selection was based on his knowledge about the village history in general and the history of livestock production in the village in particular.

b. Market supplier

   Market suppliers were included as key persons based on their availability, ability and willingness to participate in the study.

c. Extension services and district agriculture officers

   People from the village extension service (PPL), responsible for livestock production, were asked to participate in the study as key persons for interview and focus group discussion.

   A district agriculture officer was asked to be a key person for interview, focus group discussion and local expert to assess the sustainability indicators towards their relevancy and sensitivity to the study area. In the focus group discussion, in every village of the study area, one staff member from the district agriculture office responsible for livestock production was asked to participate. The selection of the district agriculture staff was done by the district agriculture officer.

d. University lecturers

Lecturers of the Faculty of Animal Sciences in the Pattimura University in Ambon were contacted as local key persons to select sustainability indicators based on their assumed relevance and sensitivity to the local conditions. The selection of the lecturers was based on their knowledge on the local farm conditions, their experience on conducting research in the study area and their level of education. The selection was done in close consultation with the Dean of the Faculty and through personal communication.

3.3 Data Collection

Field work was carried out in three stages. The first exploratory study identified the production pattern and key features to be developed in the further study planning. The aim of it was also to contact and to give an overview of the study to the stakeholders in the study area. It was also meant to collect basic data needed to plan the final sample size. This stage was carried out from June to September 2008 in 4 villages namely Waihatu, Waimital and Kairatu in Kairatu district and Bula in Bula district. It was started by pre-testing the questionnaire in one transmigrant and one indigenous farm to test the relevance of the contents and the way it was presented in the specific conditions of both communities. There were 33 households involved in the household interviews. The body weight of 154 cattle was measured and their body condition scored.

The second stage was carried out from April to September 2009 in 8 villages, covering 88 households and 325 cattle. A comprehensive data collection was done in this stage, covering the topics of cattle distribution and performance, forage availability and quality, farm characteristics, production pattern, household socio-economic condition and indicators used for sustainability analysis. Different methods were employed to gather information, namely key person interview, household interview, progeny history questionnaire, structured observation, cattle measurement, forage sampling and laboratory analysis, participatory rural appraisal, and focus group discussion (Table 3.6).

The third stage was carried out in October 2010 covering again the 8 villages. This stage was used to finalize the selection of sustainability indicators defined in the previous stage and to collect additional data needed for estimating the sustainability from at least 75% of the respondents who participated in the second field work stage. Methods used in this stage were focus group discussion and pretesting of indicators by farmers.

Geographical data (longitude, latitude, elevation) of the geophysical stations in Kairatu and the statistical office of East Ceram Regency in Bula, where the climatic data is being measured, were collected using GPS.

To carry out the study, a research assistant (RA) was needed to help in preparing all the administrative purposes from national to village level regarding the permissions to do research in the study area. The research assistant was responsible for weekly data entering, logistics, accommodation and secondary data collection. Two enumerators (En) were employed to help in interviews with households, observation and measurement of cattle as well as collecting feed samples.

Apart from the data collected in the field, some data were taken from other sources, namely:

a. Department of Agriculture, Maluku Province

Data about government-funded projects done in the study area, implementation, evaluation and results of the projects. Data about current state of agricultural production, particularly cattle production.

b. Geological stations in Kairatu Districts

Climatic data was collected from the station: rainfall, temperature (max, min, and average) and solar radiation in a monthly base.

c. Regencies and provincial statistical body

Data on cattle distribution, agricultural production, weather in 2008, market prices from the last 3 years

d. Libraries of the Research Institute of Animal Production in Ciawi, the Faculty of Animal Sciences, Bogor Agriculture University in Bogor, and the Faculty of Animal Sciences, Pattimura University in Ambon

Data on Bali cattle performance, forage quality, farming systems and the natural frame condition as well as socio-economic conditions of the study area, from published and unpublished literature available in those institutions, either in Indonesian or in English language were collected as baseline to compare with the own findings.

Table 3.6. Methods used and data collected

Methods	Data collected
Key Person Interview	- Overview of the study area: history, current state, and future development opportunity - External and internal influences that affected the community - Overview of livestock production in the study area: history, current state and opportunities of future development - Overview of production system in the study area, marketing mechanism and supporting infrastructure
Household Interview	- Major household information: family size, sex, age, educational level and work status - Resource availability (land, labour, capital) - Family economic situation (income and expenses) - Family dietary pattern - Basic description of cropping system - General description of livestock production system - General description of cattle keeping management - Basic description of forest production and hunting activities - Problems, strengths and weaknesses in the household and on the farm
Progeny History Questionnaire	- Information about the main breeding female in the herd - Fate of the calves
Measurement and Interview or Observation	- Information about animal performance parameters: Age, sex, live weight and body condition score.
Forage quality	- Data on dry matter, ash, crude protein, crude fiber and gross energy from forage collected in the pastures, road sides and river banks
Participatory Rural Appraisal	- History of livestock keeping in the study area - Problems in husbandry - Development path of cattle keeping: past and present - Cropping season and household labour allocation - Availability of forage over a typical year - Interrelationship among livestock and between livestock and crop - Role and function of cattle in the production system
Focus Group Discussion	- Criteria for sustainability in the production system

Key person interviews

Key person interviews were carried out to collect general information according to the expertises of the key persons choosen.

a. Village authority leader and traditional leader.

Interview focused on:

- Peoples origin, number of households, number of labourers

- Land area, land rights and its use in the village,
- Infrastructure, available services
- Animal production, particularly beef production

b. Extension services and district agriculture officers.

The interview focused on:

- Current situation of the village's livestock production, specific situation of cattle/beef production, its weaknesses and strengths.
- Development trends of livestock production
- Services provided to the development of village agriculture and its influence on the village and its community

c. Market supplier and cooperation leader.

The interview focused on input supplied and marketing mechanisms of all farm products as well as market prices and their fluctuation in the last 5 years.

Household interviews

Household interviews, with closed and open-ended questions, were held with 121 farm households of transmigrant (n=60) and indigenous (n=61) cattle farmers to collect data on:

1. Socio-economic issues:

- Family members: number, sex, age, educational status, work status
- Land resources in hectare (ha): farm size, the area allocated for each crop and animal production, as well as for the homestead, land ownership (rented or own land), and the average distance to the household (km)
- Labour, including family labour available and applied per activity and marketing activities of every agricultural product
- Farm inputs and outputs: sale of products, purchase of inputs, other household income and expenditure and farm assets
- Family income and expenses: income from off-farm activities on a monthly basis, types of off-farm activities. Expenses for the family on a monthly basis, such as for health, school, food, clothes, transportation, electricity, water and entertainment

- Household dietary pattern: staple food consumed on a daily basis and its origin (from own production, bought from the market, gift, barter, etc), protein consumed from animals and crops on a weekly or monthly basis and at special occasions

2. Basic description of the cropping system:

- Crop types and their use: the crops cultivated, amount of home consumption, amount of selling, amount for feeding the different animal species
- Seasonality: period of time for each crop cultivated in a year
- Soil type and drainage system

3. General description of livestock production system:

- Animal species: the species and breeds reared on the farm
- Herd composition: head count number, age and sex of individual animals kept on the farm at time of interview
- Functions of livestock species: the aims of keeping animals on the farm, and which species for each function: income generation, home consumption, draught power, manure, for festivals, for weddings, for funerals, the death memory days, as gift, etc.
- Inputs in livestock production: all cash inputs as monetary investment for a year, availability of credits, including in-kind inputs, either from the government or derived from in-kind exchanges among farmers, health care and labour activities as well as their salaries
- Outputs from animal production: meat and egg by amount of home consumption and selling on a yearly basis and manure usability and draught power

4. Description of beef keeping management:

- Feeding management: description of source of feed including crop by-products and way of feeding, length of grazing time, supplementation given on a daily base including salt, water, and the price of feed supplement, including stall feeding
- Herd management: Who is the decision maker for the animal production in the family and who is responsible for rearing and feeding the animals? The availability of a stable was checked and information on the time period animals were kept in it was collected

5. Basic description of fishery activity
   - Seasonality: time period per year used for fishing
   - Input in fishery activity: all cash inputs per year
   - Output from fishery activity: fish and other sea-products used for home consumption and selling per year
6. Basic description of forest production and hunting activities
   - Outputs from forest production: quantity of fuel woods and crops used for home consumption and selling per year
   - Outputs from hunting activities: type and number of animals being hunted, and used for home consumption and selling per year
   - Monetary inputs for both activities per year including labour utilisation
7. Problems in animal production: types of problems in animals, particularly in cattle production: problems of feed, diseases, marketing and social crime affecting the animal (injuries or died because of people).
8. Strengths and weaknesses in the household and on the farms: what is good on the farm that farmers are proud, and what is not so good (problems) and deserves improvements. Explicit questions about labour, capital, income from agriculture production, particularly from animal production and expenditures on the farm.

Progeny history questionnaire

A Progeny History Questionnaire was used to recall data on cattle reproductive performances from the owners' memory. The questions in the Progeny History Questionnaire refer to the history of the main breeding female in the farm, which is a superior female and every farm has generally only one, known as "*mai*" in the local language. The information collected from the interviews are:

1. Breeding female

Date of birth, acquisition (date, reason, location, age), breed, age at first calving, number of calves, interval between 2 parturitions, number of abortion (if any), conception problems and current reproduction status

2. Calves

Date of birth, sex, suckling period (lactation length), survival of the calves until weaning, reasons for calf mortality and where the calves were in the time of the survey (in herd, sold, died, given away as gift, or other)

Performance measurement

Live weights of 479 cattle were measured using a shed scale (TB-1000K-TK, capacity 1000 kg x 400 g, produced by PT. Timbangan Indonesia, Jakarta, Indonesia) and recorded in measurement sheets. The measurements were done in the morning before cattle were released for grazing and in the repeated visits, the live weight of the cattle was recorded again to get the average live weight of each cattle. The time between the first and the second measurement was 3 – 5 days. Ages of the cattle, as well as physiological status of female cattle were recorded based on farmer's information. The age stages were used to classify cattle prior to live weight analysis, namely from pre-weaning to adult. The average weaning age of Bali cattle on Ceram Island was calculated based on farmer's information in the Progeny History Questionnaire and was used to group cattle into pre-weaning and post-weaning groups. The pre-weaning class started from 4 to 7 months, while the post-weaning class started from 8 to 10 months old (Table 3.7). Female cattle from one year until reaching the age of first mating were assigned to the heifer group. Cattle which reached the age of first mating until being culled were grouped into the adult class.

Forage sample collection

Samples of vegetation were taken from three grazing areas, namely road side area, pasture and river banks in every village under study. Road side refers to space of about 1 – 5 meters width between house fence and roads, asphalted or not, where grasses grow naturally. Adult cattle were normally tethered in the fence while the offspring was allowed to graze in the area. Pasture refers to the land covered by natural vegetation, consisting of grasses, legumes, shrubs and trees (Nitis, 1999). The land could be owned by the community (village-own land) as result of shifting cultivation or fallow land inside the village, or attached to the plantation area close to the beach (coconut plantation) or close to the forests (cloves, nutmeg and cocoa beans plantations). River banks refer to a space of about 2 – 20 meters width in both side of river streams, covered by natural vegetation, where animals were tethered for grazing and free access to water. In the rainy season, most of the river banks were covered by water, especially when the flood appeared. In the dry season the places were used frequently in competition among farmers. Thus, the first to come would occupy the grazing area and the last would need to find another grazing location.

Table 3.7. Definition of reproductive and productive traits used in the analysis

Traits	Definition
Fertility rate	The number of calves born per number of adult cows in the herd in one calendar year
Calf mortality	The number of calves below one year of age that died from all causes in one calendar year related to the number of calves in the same year, by farm
Adult mortality	The number of adult cattle that died from all causes in one calendar year related to the number of cattle present in the farm at the beginning of the same year
Calving interval	The interval in days between two parturitions
Weaning age	The age at which young stock was weaned
Cow age at first calving	The age at which a young cow calved for the first time
Bull age at first mating	The age at which young bulls mate for the first time
Parity	The number of calvings of a cow
Longevity	The life span of a cow from birth to death
Pre-weaning weight	The weight of a calf, male or female from 4 to 7 month-old
Post-weaning weight	The weight of a weaned calf, male or female, at 8 to 10 month-old
Yearling weight	The weight of a cattle between 12 to 24 months of age (thus heifers or young bulls); only the data of 18 to 24 month-old animals were included into the final analyses
Adult weight	The weight of adult cattle, males or females, above 24 months of age

Selection of grazing locations for sample collection was based on own observation and farmers' information on the locations they used most for grazing their animals. River banks were found only one in every village in the study area. Road sides and pastures which were used most for animal grazing were selected for sample collection. The total number of samples per village was 25, consisting of 5 samples from road side areas, 10 samples from pastures and 10 samples from river banks.

Samples from pastures, road sides and river banks were collected by randomly throwing a 100 x 100 cm wooden square backwards. The throwing of the iron square followed a diagonal of the pasture and river banks area. In the road side area, the throwing of the iron square followed the length of the road straightly after taking 2 steps left or right from the border between road and grass. All species of the vegetation inside the iron square were collected as botanical collection (herbarium) using the vegetation outside the square for species identification. Each species was sticked to a piece of paper and labelled alphabetically.

All standing vegetation including grasses, ground legumes, and lower parts of shrubs of maximum 30 cm from the ground within the boundary of the square was removed at a height of 1-2 cm from the ground using scissors, placed into a plastic bag and weighed immediately using Nagata balance (Type B-01.R, capacity 500 g x 2 g, produced by PT. Timbangan Indonesia, Jakarta, Indonesia). Samples were dried in the sunshine for 5 - 8 hours, reweighed, placed into a paper bag and labelled.

Participatory rural appraisal (PRA)

Participatory rural appraisal (PRA) techniques were employed for communal data collection using 4 tools with 5 farmers participating in each tool. The selection of farmers was based on their willingness and ability to participate. One farmer could participate in more than one tool if she/he liked to do so. The selection of farmers was made in close consultation with the village authority leader as well as the traditional leader. Female farmers were encouraged to participate in every tool resulting in 7 females out of 40 participants. The tools used were:

A. *Time line with resource maps at specific points in time*

   The time line group of farmers included five older farmers of each community. This tool was used to identify:

   a. Number of animals kept per species and breed, by age group and sex in the village during a period of at least two household generations, which included the interviewed farmers and their parents, and reasons for changes in the numbers.

   b. Main problems in husbandry at different times: discussing about the problems, e.g. pasture areas decreasing over time (e.g. drawing a map of pasture areas in the village in different times), main disease outbreaks over the years, feed shortage, social crimes, changes in animal product markets, change in level of access to veterinary and livestock husbandry services during this time (e.g. draw a horizontal timeline and identify the periods of each problem and changes).

c. Development of beef production and reasons for change in beef production over time (herd size and structure, resources used, breeds, functions, off-take, management practices).

B. Seasonal calendar

The seasonal forage calendar and preferred grazing species put into visual form the seasonal pattern of forage availability in the village and animals that are grazing. This tool explored where animals graze, at what time of the year, and which fodder or forage species they prefer. It was also meant to identify the availability in resources, including grazing and browsing resources, and crop by-products and any other supplements, labour, functions and off-take as well as seasonal problems in livestock keeping, differentiated between the species kept by using open-ended questions for discussing about the problems in one year (e.g. seasonal draught/no water to give to animals, dry ponds, seasonal disease outbreaks, seasonal feed and labour shortage due to seasonal crop harvest). It assessed the occurrence, frequency, duration, and strategies to overcome such problems. The seasonal calendar was also used to list seasonal crop production activities of all crop types grown in the village from land preparation to harvest time.

C. Bio-resource flow

Bio-resource flow diagrams were used to identify interrelationship between beef production, crop production, other livestock production (goat, chicken, duck, buffalo and pig) and land use, labour and capital. Each component was arranged on the wall, and flows between the components were recorded.

D. Ranking and scoring

The ranking and scoring matrix was used to define priorities or preferences in the farming systems. For instance, to identify the role and function of cattle and crops in the production systems, and their economic value for the household. The participants were asked to write down the functions of cattle and crops, and ranked them according to the priorities of their farming system. Problems and opportunities in their farming system at present were defined using this tools as well as economic aspects such as ranks of income generated from all sources (farm income and off-farm income).

Focus group discussion

Focus group discussions (FGD) were carried out to derive sustainability indicators from farmers and local experts. The discussions were conducted twice in each of the eight villages, selected as outlined in the previous section. In the first round in May 2009, normally one FGD was held per village, whereas two FGD were carried out at Kairatu and were attended by two different non overlapping groups of stakeholders because of miscommunication with the extension service and the village authority officer. One group was arranged by the extension service and another by the village authority officer. Each FGD was attended by 6 to 10 participants (making up a total of 71 participants in 9 groups in 8 villages). Participating stakeholders were farmers, village authority people, extension service officers, government officers (district agricultural officer) and market suppliers (Table 3.8).

Table 3.8. List of participants of the Focus Group Discussions

Participant	Village								
	L	O	Ws	K1	K2	Wh	Wm	JB	B
First FGD									
Group No.	1	2	3	4	5	6	7	8	9
Farmers	3	5	2	3	3	5	3	4	3
Village authority officer	1	1	1	1	1	1	1	2	1
Traditional leader*	1	0	1	1	1	1	0	0	1
Extension service	1	1	1	1	1	1	1	0	0
District agriculture officer	1	2	1	1	0	1	1	1	1
Market supplier	1	1	1	1*	1	1*	0	1*	1
Subtotal	8	10	7	8	7	10	6	8	7
Research team									
Principal investigator	1	1	1	1	1	1	1	1	1
Research assistant	1	0	1	1	0	1	0	0	0
Enumerator	0	1	0	0	2	0	1	1	1
Subtotal	2	2	2	2	3	2	2	2	2
Total number of participants	**10**	**12**	**9**	**10**	**10**	**12**	**8**	**10**	**9**
Second FGD									
Facilitator	1	1	1	1	0	1	1	1	1
Farmers	7	6	6	6	0	7	6	6	6
Enumerator	2	2	2	2	0	2	2	2	2
Total number of participants	**10**	**9**	**9**	**9**	**0**	**10**	**9**	**9**	**9**

L is Luhu, O is Olas, Ws is Waisamu, K is Kairatu, Wh is Waihatu, Wm is Waimital, JB is Jembatan Basah, B is Bula.
* are also farmers.

The selection of farmers was based on the ability and willingness to participate in the discussion. The village authority and district agricultural officers were invited and who finally attended the discussion depended on the instruction of the leader (village authority leader and the head of district agriculture office). Normally there was only one market supplier per village, so he/she was invited to the discussion. A brain-storming session was done to develop a joint perception about the concept of agricultural sustainability taking into account the local knowledge about how to sustain the production system. Participants were asked to list relevant factors considered to be important as indicators for sustainability of agricultural production in their villages. The lists were then ranked according to the importance of each factor by each individual participant. Factors considered as very important were ranked as 5, relatively important as 4, important as 3, less important as 2 and not important as 1. The overall group ranking for each individual indicator was defined as the median value of all ranks assigned by each individual participant in the group. Farmer participants were encouraged to share their ideas on the indicators listed directly in the discussion, or individually to research team members or by writing it on a piece of paper in some cases. The discussions were recorded and transcribed. After the FGD, the lists produced and derived from the discussion were grouped according to the similarity of the issues.

In a second step, local experts were selected to assess the indicators derived from the discussions. The selection of experts was based on the familiarity with the farming systems and cattle keeping management in Maluku province. Besides a higher educational level of at least graduation in animal sciences and willing to be included in the study served as selection criteria. These local experts consisted of provincial extension service staff (n = 4), provincial agricultural officers (n = 5) and university lecturers in animal sciences at Pattimura University, Maluku (n = 6). The local experts were contacted personally and provided with the first draft of indicators derived from the discussions. They were asked to rank each sustainability indicator according to its relevancy and sensitivity to the local situation. The ranks ranged from 5, if the indicators were considered as very relevant, 4 if the indicators were relatively relevant, 3 if the indicators were relevant, 2 if the indicators were less relevant and 1 if the indicators were not relevant.

The second round of FGD was carried out in October 2010. A total of 50 farmers participated in 8 FGD in 8 villages. Farmers who participated in the first FGD were encouraged to participate again in the second FGD. Additional farmer participants were selected according to their ability and willingness to attend the discussions. Brain-storming sessions were done prior to the ranking exercise, to remind the farmers about what was done and the results in the first FGD. The lists of indicators derived by the local experts were handed over to all participants to start the ranking excercise. Farmers were asked to rank the indicators according to their importance, and indicate the missing issues or indicators. These ranking exercises were done following the rule of ranking in the first FGD. The ranking given by farmers were then used as the weight of each indicator in the latter step to estimate the farm sustainability by summing up the single elements into an aggregated overall system value.

Pre-testing of indicators

The indicators were pre-tested in 6 villages, namely Luhu, Olas, Kairatu, Waihatu, Jembatan Basah and Bula villages. Two farmers from each village, consisting of a farmer who participated and a farmer who did not participate in the FGD, were included in the pre-testing of indicators. The farmers were asked to estimate their own farm performance by using the indicators from the ranking exercise. The ranking scale was from 1 to 3 (Table 3.9). Farmers were guided by two enumerators in this exersice. The results of this exercise were analysed by comparing the rank given by farmers with the reference value (rank = 3), described in bar graph using Microsoft Excel 2003 and interpreted before feeding them back to the farmers. Farmers' responses regarding the results were recorded, particularly in answering three major questions:

- Was the set of indicators sufficient enough to describe their farming practices?
- Were the results of the exercise matching with their own perceptions about their farming practices?
- Did they seem to be willing to improve or complement their farming practices based on the results of the exercises?

Table 3.9. Ranking scale used for qualitative indicators in estimating own farm sustainability by farmers

Rank	Description
1	If the objects to be measured were not existing, not suitable or not available in the system (worst condition)
2	If the objects to be measured were existing, suitable or available with some restriction
3	If the object to be measured were existing, suitable or available without any restriction (best condition)

In the third stage of the study, thus the second round of indicator selection, 3 facilitators and 16 enumerators were employed to conduct focus group discussions and pretesting indicators. The enumerators and the research assistant were recruited from the Faculty of Animal Sciences, Pattimura University in Ambon.

3.4 Data Analysis

Row data collected from the field work were entered in Microsoft Excel worksheets, grouped according to the issues in the interviews, such as socio-economics, crop system, livestock system, beef management, fishery and forestry, and problems, strengths and weaknesses. Data from the progeny history questionnaire, performance measurements, forage analysis, participatory rural appraisal and focus group discussions were entered in separate files. All quantitative variables were checked for normal distribution based on the criteria that the skewness and kurtosis of each variable falls within the range of -1.0 to +1.0 (Chan, 2003). Besides, histogram and Q-Q plots of the residual were also used in checking data distribution using SAS 9.1.

3.4.1 Characterisation of the production systems

Two steps were used to analyse farm systems on Ceram: (a) categorising (grouping) the farming systems (b) characterising the systems.

(a) Categorizing the farming systems

As assuming at the beginning that the production system was mainly determined by the farmer's migratory status (indigenous versus transmigrant), it was used as a dummy for the production systems when testing for differences in cattle management. However, since differences in cattle keeping between indigenous and transmigrant farms were limited, and the activity patterns and management of the two groups were not as easily distinguishable during field work as expected beforehand, there might be more groups to be differentiated. Thus, cluster analysis was used to detect structure of farming systems based on a series of variables, instead of one criterion only.

Factors selected for categorising the production systems included resource availability and agricultural and non-agricultural production patterns. Variables were defined covering those factors (Table 3.10). The variables farm size, family labour, capital source and livestock kept (chicken and goats) described the resource availability on the farm, while fishing and hunting activities as well as off-farm income generating activities covered the activities undertaken by farmers besides agricultural activities. Production patterns included both, crop and livestock production consisting of the variables cattle herd size, cattle ownership, supplement use (salt), stable use, crop types (rice, perennials, others) and crop functions. Economic variables were excluded as they were foreseen to serve as descriptors in the characterising step of the analysis.

Table 3.10. Variables selected for cluster analysis

Factor	Variable		Category	n	Percent
Resource availability	Farm size	1	≤ 0.65 ha	31	26
		2	0.66 – 4.4 ha	56	46
		3	≥ 4.5 ha	34	28
	Family labour	0	< 3 person	47	39
		1	≥ 3 person	74	61
	Capital source	0	Own capital	99	18
		1	Other[d]	22	82
	Livestock kept : - Goats	0	No goats	109	90
		1	Has goats	12	10
	- Chicken	0	No chicken	56	46
		1	Has chicken	65	54
Cattle production	Herd size	1	≤ 3 cattle	36	30
		2	4 – 7 cattle	54	45
		3	≥ 8 cattle	31	26
	Cattle ownership	0	Own cattle	101	84
		1	Other farmers' cattle	20	17
	Supplement use (salt)	0	No	33	27
		1	Yes	88	73
	Stable use	0	No	89	74
		1	Yes	32	26
	Pasture ownership	0	Communal	86	71
		1	Private	35	29
Crop production	Rice	0	No	88	73
		1	Yes	33	27
	Perennials[a]	0	No	67	55
		1	Yes	54	45
	Other crops[b]	0	No	90	74
		1	Yes	31	26
	Crops for sale	0	No	23	19
		1	Yes	98	81
	Crops for household consumption	0	No	41	34
		1	Yes	80	66
	Crops for cattle feeding	0	No	80	66
		1	Yes	41	34
Other activities	Fishing and hunting	0	No	95	79
		1	Yes	26	22
	Off-farm activities[c]	0	No	74	61
		1	Yes	47	39

[a]Perennials were coconuts, cloves, nutmeg and cocoa beans; [b]Other crops included vegetables, cassava, maize, sweet potatoes; [c]Off-farm activities were public officers, pedicab drivers, carpenters, teachers, shop owners; [d]Other capital sources included gifts, credits, family inheritances.
In the cases percentages sum up to more than 100%, this is due to rounding.

The selection of variables was done after testing for correlations between potential variables employing CORR procedure of SAS. In case of highly correlated variables such as crop type (rice) and supplement use (rice bran) the latter was discarded by taking into account that the variable crop type was providing relatively more information as it was used in parallel with other crop types (perennials and others), while the variable use of rice bran supplement did only focus on yes versus no. This was done in order to avoid their overlapping in the contribution to the measure of distance in the next step of categorising (Köbrich et al., 2003). Data was transformed into binomial categories prior to analysis, as categorical data cannot be directly processed within the clustering process. Data on herd size and farm size were categorised into quartiles (lower, middle two, upper quartile) prior to binomial transformation.

A distance matrix was computed prior to cluster analysis using Jaccard coefficient by adding single distance matrices into the matrix as the variables did not have the same weight (Siegmund-Schultze and Rischkowsky, 2001). Different algorithms were tested in the cluster analysis and finally the Ward algorithm was selected as the resulting tree provided the clearest differentiation of the data. Determination of the cluster number was based on a visual inspection of the hierarchical tree (dendrogram). Natural clusters are indicated by relatively dense branches of the dendrogram (Ketchen and Shook, 1996). The semi-partial R-squared (SPR), one of the validity indices used in cluster analysis, was used to validate the number of clusters by taking into account that the smaller the SPR the more homogenous the clusters are, preferring a cluster solution with a bigger SPR difference before (n-1 clusters) and a smaller difference after this solution (n+1 clusters) (Halkidi et al., 2001; Siegmund-Schultze and Rischkowsky, 2001; Köbrich et al., 2003).

Characterisation of the resulting clusters was carried out using frequency procedure for categorical variables such as migratory status of farmers, crop types and their function, capital source, livestock kept by farmers, fishing and hunting activities, other income generating activities, farmers' educational level, cattle ownership, supplement use, stable use and pasture ownership. Means and standard errors of the means for continuous variables such as cattle herd size, herd composition, farm size, family labour and land use were calculated using GLM and MEANS procedures of SAS.

Dependency ratios were calculated for labour and land following the formula suggested by Kitchaicharoen (2003). Labour dependency ratio was calculated by dividing the number of family member under 14 years and over 60 years of age by the number of working age members between 14 and 60 years, expressed in man-equivalent units as suggested for use in

IMPACT (Herrero et al., 2007). Land dependency ratio was computed by dividing uncultivated land by total agricultural land.

(b) Characterisation of clusters by modelling with IMPACT software

IMPACT software version 1.1 was used to capture data for mixed farming systems on a monthly basis (Herrero et al, 2005). The software organises data in 7 groups: (a) climate, (b) household, (c) land, (d) livestock, (e) labour, (f) farm input and output, (g) household dietary pattern.

Prior to entering data into IMPACT software, descriptive statistics were performed on entry variables prescribed by the software. Median values for continuous data and mode values for categorical data were entered into the software. As a result, IMPACT provides baseline analyses in three different aspects: economics, food security and labour (Herrero et al., 2005). A complete summary of the cash income, cash expenses and the balance (net income) of the farming system on a monthly basis are computed for economic analysis. Thus, the economic analysis performed here is only considering monetary items, but not home consumption or other internal farm and household uses of products and services. The monthly nutritional status (energy and protein) of the family throughout the year was estimated in the food security analysis using nutritional values for every food item given by the software. For local food items which had no data in the software, values from the nutritional survey of the SEAMEO-TROPMED RCCN – University of Indonesia (Ehrhardt and Gross, 2007) were applied. The calculated nutrient intake was compared to WHO standards (WHO, 1999).

Labour analysis comprises labour efficiency per farm sector, differentiated by gender. Man equivalent units, defined as the amount of labour carried out by a non-adult converted into the amount that an adult would do, in any time period (Herrero et al., 2005) (Table 3.11). The results were transferred to Microsoft Excel 2003 for data presentation and figures. Standard errors of the means were calculated to provide a measure of variation by using Microsoft Excel 2003 as IMPACT was so far only used for single farms where such measures are not applicable.

Table 3.11. Standard man equivalence

Member	Age	Equivalences
Man	≥ 60	0.8
Woman	≥ 60	0.8
Man	18 - 59	1.0
Woman	18 - 59	1.0
Teenager	14 - 17	1.0
Child	5 - 13	0.5

Source: IMPACT Software by Herrero et al., 2005

3.4.2 Cattle performance analysis

Data on cattle performance, collected from progeny history questionnaire, household interview and measurement, were analysed toward their reproductive and productive parameters. Parameters of reproduction used in the analysis were bull age at first mating, cow age at first calving, fertility rate, parity and age of cows, weaning age, calving interval and calf and adult mortalities. Parameters of production were live weight of the age stages pre-weaning, post-weaning, yearling and adult.

Data on bull age at first mating, cow age at first calving, weaning age and calving interval were expressed on monthly base in the time of data collection unless the farmers could give them on a daily basis. Calving interval was calculated for each breeding cow as the number of days from one parturition to the next parturition. In case monthly data was available only, the intervals were transformed into daily base by multiplying with 30.5 days/month.

Fertility rate was calculated based on calving data in the year 2008, as collected either in 2008 or 2009. The rate was calculated by dividing the number of calvings recorded per farm between January and December 2008 with the number of adult females in January 2008 in the same farm. Data on parity and age of cows were gathered from the progeny history questionnaire from 121 breeding cows, while data on the cattle longevity was derived from key person interviews (extension services in all districts studied).

Mortalities by class of animals were computed based on mortality data in the year 2008 taken either in 2008 or 2009. Calf mortality was calculated by dividing the number of calves that died between January and December 2008 with the number of calves born in one calendar year (2008) by farm (equation 2), while adult mortality was calculated by dividing the number of adult cattle that died between January and December 2008 with the total number of adult cattle in January 2008 in each farm (equation 3). Because of the non-normal distribution of the mortality data, the data were transformed using Log-transformation in SAS 9.1. The transformed variables were checked again for their normality prior to further analysis. Furthermore, data (least square means and standard deviation) were back-transformed before arranging the tables for interpretation.

$$Annual\,calf\,mortality = \frac{(\text{No. of calves that died between Jan and Dec 2008})}{(\text{No. of calves born in same period})} * 100 \text{ .... } (2)$$

$$Annual\ adult\ mortality = \frac{(\text{No. of adults that died between Jan and Dec 2008})}{(\text{No. of adults in the herd in Jan of 2008})} * 100 \text{ ..... } (3)$$

Multivariate analysis of variance was employed to analyse all reproductive parameters stated above with farmer's migratory status, district, cluster and the number of herd owned by farmers were used as main fixed effects according to the following equation:

$$y_{ijklm} = \mu + F_i + D_j + C_k + H_l + \varepsilon_{ijklm} \qquad (4)$$

Where y is bull age at first mating, cow age at first calving, fertility rate, parity, age of the cows, weaning age, calving interval and calf and adult mortalities, μ is the overall mean, F is the effect of the farmer's migratory status (two levels: indigenous, transmigrant), D is the effect of the district (three districts: West Ceram, Kairatu, Bula), C is the effect of cluster (three clusters: TVC, IPC and TRC), H is the effect of herd size (two sizes: ≤ 5 cattle and >5 cattle) and ε is the error term. Religion, even though used as a criterion in sampling, was not used as an effect as differences in religion only appeared in indigenous but not in transmigrant farmers (compare table 3.5). Moreover, religion matches with district insofar all Christian indigenous farmers were from one district (Kairatu) and no Muslim indigenous farmers were found there.

Descriptive statistics and data distribution of Bali cattle's body weights were performed using Box-and-whisker plots in SAS 9.1. The figures were also used to detect outliers in the data. Growth curves, representing the age-weight relationship, were made using the measured weight data on different age groups of cattle, namely calves, pre-weaning, post-weaning, yearling and adults, differenciated by sex and cluster. The non-linear curves of animal growth were predicted by applying the PROC NLIN of SAS 9.1, using logistic function of non-linear regression. The average daily weight gains were approximated based on the predicted data. To this end, all daily increments of each period were averaged.

Body weights were tested for the effects farmer's migratory status, district, cluster, herd size, sex and physiological status, analysed at four different age stages of cattle classified as: pre-weaning (4-7 months old), post-weaning (10-12 months old), heifer (18-24 months old) and adult (more than 24 months old). The analysis was done using multivariate analysis of variance using the following models.

$$y_{ijklmn} = \mu + F_i + D_j + S_k + H_l + C_m + (a) + \varepsilon_{ijklmn} \qquad (5)$$

$$y_{ijklmn} = \mu + F_i + D_j + S_k + H_l + C_m + D * F + (a) + \varepsilon_{ijklmn} \qquad (6)$$

$$y_{ijklmn} = \mu + F_i + D_j + H_k + C_l + P_m + (a) + \varepsilon_{ijklmn} \qquad (7)$$

Where y is the body weight, μ is the overall mean, F is the effect of the farmer's migratory status (two levels: indigenous, transmigrant), D is the effect of the district (three districts: West Ceram, Kairatu, Bula), S is the effect of sex (two sexes: male, female), H is the effect of herd size (two sizes: ≤ 5 cattle and >5 cattle), C is the effect of Cluster (three clusters: TVC, IPC and TRC), P is the effect of physiological status (three levels: dry, pregnant, lactating), D*F is the interaction between district and farmer's migratory status, a is the age of the cattle as covariate and ε is the error term.

Model (5) was used to test the body weight of pre-weaning and post weaning animals, taking into account the effects of farmer's migratory status, district, sex, herd size and cluster. Model (6) was applied for the body weight of yearling cattle, and model (7) for adult females by employing physiological status as one of the effects. All models, including model 4, were first run as full models including the interactions. As no interaction turned out to be significant in model (5) and (7), all were dropped coming up with the above presented final models with main effects only.

3.4.3 Forage analysis

Species dominance assessment

Assessment of species dominance was conducted in the field prior to vegetation sample collection. The 4 small iron squares (50 x 50 cm) were placed inside the big iron square (100 x 100 cm). Vegetation in each wooden square was ranked according to species dominance. Rank 4 was given to the most dominant species in the square, rank 3 was given to the dominant species, rank 2 was given to less dominant species and rank 1 for the existing species considered as not dominant. The total rank of each species from the 4 small squares was calculated and an index was computed by dividing the rank of each species with the total rank of all species found.

Laboratory analysis

Laboratory analysis was performed in the laboratory of Feed Science and Technology, Faculty of Animal Science, Bogor Agriculture University, Bogor, Indonesia. Analyses included dry matter, crude protein, crude fiber and gross energy content in the native forage of Ceram Island using AOAC method, Kjeldahl method and bomb calorimetry.

AOAC method

Dry matter percentage and crude fiber were analysed using the AOAC method (1990). Samples were thoroughly mixed and placed into dishes for oven-drying at 60ºC for 24 hours before weighing. The percentage of dry matter was calculated by dividing the sample weight after drying with the fresh weight on the field and multiplying by 100. Prior to further analysis, samples were grinded to pass a sieve with circular openings of 1 mm diameter and mixed thoroughly as outlined in the AOAC method 950.02 (AOAC, 1990).

Crude fiber was analysed following the procedure 962.09 (AOAC, 1990). Two grams of fine dried samples were extracted using ether prior to transferring into a 600 ml reflux beaker. To aid in complete wetting of the sample, 0.25 grams of anti-bumping granules and 200 ml warm H_2SO_4 of a 1.25% concentration was added in a small stream directly on the sample. Beakers were then placed on the digestion apparatus in 5 minutes intervals and refluxed for 30 minutes. Before the end of the refluxing step, the filtration apparatus was sealed and adjusted into 25 mmHg. At the end of the step, a near-boiling H_2O (distilled water) was flowed through the tunnel. The residue was washed using 40 ml of the near-boiling H_2O and rewashed using 1.25% NaOH prior to the re-reflux for 30 minutes. A crucible was used to place the residue after the refluxing step and dried at 130°C for 2 hours prior to re-weight. Crude fiber (CF) was calculated using equation (8):

$$\% \text{ CF} = \frac{\text{Loss in weight after ignition (g)} \times 100}{\text{Weight of the sample (g)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(8)}$$

Kjeldahl analysis

Crude protein was analysed using the Kjeldahl method, employing three different steps namely digestion, distillation and titration. One gram of the fine, dried sample was first digested using concentrated H_2SO_4 in the presence of a catalyst (Sodium sulphate and Copper sulphate) for 45 minutes before adding 45% NaOH. Boric acid in 4% concentration was used as a receiver in distillation to separate ammonium from the digestate. The titration was done using 0.1N HCl. The amount of HCl used in the titration indicated the quantity of nitrogen contained in the sample. The percentage of crude protein was then calculated as percentage of nitrogen multiplied by 6.25 as conversion factor.

Bomb calorimetry

One gram from each sample was formed into pellets using a press machine prior to analysis. One ml of water was placed in the bomb and the bomb pressure was set to 25 atm. After filling the volumetric flask with distilled water and pour it into the oval bucket, the bomb in the bucket was submerged and the electric cable was attached. When the stirrer motor was turned on, several temperature readings at 30 second intervals were taken until the inner bath temperature was nearly constant. Titration was done to the remaining sample with NaOH after rinse (Parr Instrument Company, 2008).

Forage yield per hectare from natural grass and ground legumes taken from road sides, pastures and river banks was estimated by multiplying the average fresh matter yield of the sample (1 m^2) with 10.000. Dry matter yield was computed by multiplying the fresh matter yield per hectare with the dry matter percentage as explained above. Crude protein, crude fiber and gross energy were calculated based on dry matter.

Quantitative variables were first checked for normal distribution based on the criteria that the skewness and kurtosis of each variable falls within the range of -1.0 to +1.0 (Chan, 2003), besides checking the q-q plots of the residual. Variables which were not distributed normally were transformed. Different transformation methods were tested and finally the Log-transformation was selected as the transformed variables showed normal distribution when checking the residual prior to further analysis.

To compare forage yields according to district, the district variable was fitted as fixed effect in a general linear model using the GLM procedure of SAS. The analysis was done by performing two-factorial analysis of variance with districts and grazing locations as main effects. As the interaction was found to be non-significant ($p>0.05$), it was dropped from the final model (equation 9).

$$y_{ijk} = \mu + L_i + D_j + \varepsilon_{ijk} \quad \text{..........} (9)$$

Where y is dry matter, crude protein, crude fiber or gross energy, μ is the overall mean, D is the effect of the district (three districts: West Ceram, Kairatu, Bula), L is the effect of the grazing location (three locations: road side, pasture and river banks), and ε is the error term. As in the previous sections, the model was first run as full model with the interaction. As the interaction showed no significance ($p<0.05$), the final model was reduced to the main effects.

Data (least square means and standard deviation) were back-transformed before arranging the tables for interpretation.

3.4.4 Sustainability Indicator selection

The final selection of the sustainability indicators was realised in a stepwise procedure. The possible indicators listed during the focus group discussions were ranked by the group. The maximum rank weight an indicator could achieve was 45, if the indicator was weighted as 5 in 9 FGD and the minimum weight was 9, if the indicator was weighted as 1 in 9 FGD. An index of each indicator was calculated by dividing the total weighed value of each individual indicator with the total weight of all indicators. For all indicator rankings done by each FGD (local community), the mean rank and quartile deviation were calculated using Microsoft Office Excel 2003. The primary selection of the indicators was based on the rule given by Hugé et al. (2009) based on Chu and Hwang (2007): Indicators with a mean rank higher or equal to 3.5 and quartile deviation lower or equal to 0.5 were accepted for further selection. Indicators with a mean rank lower than 3.5 and quartile deviation higher or equal to 0.5 were rejected and not used anymore in the following steps.

The second step was the secondary selection of the indicators ranked by the local experts based on their relevance and sensitivity to the local situation. Relevant in this context means that the indicator is relevant to the issue concerned, local farm systems and local environment (ecosystem and geographic), while sensitive means that the indicator is sensitive to system stresses or its changes and it is meant to indicate and measures what is important to the local situation (Table 3.12). Here, ranks given by the local experts were also calculated to get the mean rank and quartile deviation, followed by applying the same rules as used in the primary selection.

Table 3.12. Criteria for secondary and final selection of indicators

Criteria	Description	References
Relevant	The indicator is relevant to the issue concerned, local system and local environment (ecosystem and geographic).	Bernstein,1992 Mitchell et al., 1995 Mollenhorst, 2005 Reed et al., 2006
Sensitive	The indicator is sensitive to system stresses or changes and it is meant to indicate and measure what is important to the local needs.	Zhen and Routray, 2003 Mollenhorst, 2005 Reed et al., 2006

Additional issues indicated by farmers or local experts were treated similarly, following the stepwise procedure of the primary and secondary indicator selection.

3.4.5 Estimation of the farms' sustainability

Indicators derived from the previous section were used to measure the sustainability of three different farm types identified in this study. All issues and indicators were weighted according to their contribution to the systems's sustainability as perceived by farmers with the total weight summing up to 1. The weight of each individual issue was calculated by dividing the rank weight given by farmers for each individual issue with the sum of the rank weight of all issues. Similarly, the weight of each individual indicator was calculated by dividing the rank weight of each individual indicator with the sum of all indicator rank weights within the same issue.

The reference values for the quantitative indicators were derived from the literature, describing political goal to be achieved or desired performance of indicators (Table 3.13). For the arbitrary qualitative indicators, the best rank (rank 3), was used as a baseline toward which the original values, namely the values gathered from the field work, were compared as percentage deviation and depicted graphically in bar graphs (de Boer and Cornelissen, 2002; Mollenhorst, 2005) (compare Table 3.9).

The deviation of the original values from the reference values were calculated as a proportion of the values following the equation 10, adapted from de Boer and Cornelissen (2002):

$$Dev_{ij} = \frac{OV_{ij} - RV_i}{RV_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Where : Dev_{ij} is the deviation of SI_i (i = 1,2,..) in farming system j (j = TVC, IPC, TRC)

OV_{ij} is the original value of SI_i in farming system j

RV_i is the reference value used in SI_i

By definition, all indicators contributed positively to the system sustainability. This means that the contributions of all indicators improve the sustainability when the original value of each indicator increases. There are three possibilities in interpreting the sustainability as adapted from de Boer and Cornelissen (2002) (Table 3.14). If the OV is higher than RV, it indicates that the farming system succeeds to meet the target value and the system will most probably be sustainable. If both values (OV and RV) are the same, this indicates that the farming system succeeds to meet the target value and the system will also most probably be sustained in the future. However, if the OV is lower than the RV, it indicates that the farming system failed to meet the target value, leading to unsustainability of the system. OV was represented by its relative deviation (Dev) from RV, which is a baseline with the value 0.

Table 3.13. Reference values for quantitative sustainability indicators

Indicator	Unit	Reference value	Description and source
Cattle body weight (adult male)	kg	494	Optimal body weight of adult male Bali cattle in good condition achieved in P3Bali# (Pane, 1990)
Cattle body weight (adult female)	kg	300	Optimal body weight of adult female Bali cattle in good condition achieved in P3Bali# (Pane, 1990)
High fertility	%	86	Average Bali cattle fertility rate in P3Bali# (Pane, 1990)
Farm size	ha	2.0	Standard holdings estimated by the GoI to achieve a good living standard in rural Indonesia (Holden et al., 1994)
Land ownership		2	2=owned land with certificate Standard land ownership estimated by the GoI to achieve a good living standard in rural Indonesia (Holden et al., 1994)
Family labour availability	Man equivalent	4	Standard family labour number estimated by the GoI to achieve a good living standard in Indonesia (Suryono, 2009)
Household income	IDR/capita/ year	2,395,152	Poverty line of household income in rural area of Maluku Province (CBS, 2009)
Crop yield	IDR/ha/year	24,593,137[1] 9,419,635[2] 11,750,369[3]	The national average of farmers' revenue from vegetable[1] and tuber production (Dewi and Sudiartini, 2001), perennial[2] crop production (Assagaf, 2004) and rice[3] production (Sugiarto, 2008)
Livestock yield	IDR/year	3,000,000	Average price for 1 cattle sold per year in Maluku province. The target of cattle yield in the smallholder system in Maluku is 1 adult per year (CBS, 2002)
Off-farm opportunities	%	65	The engagement rate of farmers in the rural area practiced off-farm activities for income generation (Kristensen, 2003)
Food security (Protein intake)	g/year	81,030[1,2] 64,240[3]	The household's minimum requirement of protein according to the number and age of family members in TVC[1], IPC[2] and TRC[3] (Herrero et al, 2005)
Food security (Energy intake)	MJ/year	19,245[1] 19,710[2] 16,425[3]	The household's minimum requirement of energy according to the number and age of family members in TVC[1], IPC[2] and TRC[3] (Herrero et al, 2005)
Children's education		2	2 = middle high school. Target level of children's education in Indonesia (CBS, 2009)
Forage availability	kg DM/ha	7,500	The average total dry matter produced from native pasture in the humid tropical pacific islands (Reynolds, 1978)

#P3Bali = The National Bali Cattle Breeding and Development Institute

Table 3.14. Interpretation of sustainability indicators to estimate farming system sustainability

	$Dev_{ij} < RV_i$	$Dev_{ij} = RV_i$	$Dev_{ij} > RV_i$
Interpretation	sustainable	sustainable	unsustainable

Adopted from de Boer and Cornelissen (2001)

The overall contribution of sustainability indicators to the livestock production sustainability was based on the sustainability index calculated using an equation given by de Boer and Cornelissen (2002). It takes into account the weight of each indicator (equation 11).

$$\text{Sustainability index} = \frac{\sum_{i=1}^{n} w_i . Dev_{ij}}{\sum_{i=1}^{n} w_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Where w_i is the weight of SI_i and Dev_{ij} is the relative deviation of OV.

4 RESULTS

4.1 Current Bali cattle production systems on Ceram Island, Indonesia

4.1.1 Characterisation and socio-economic analysis of Bali cattle farms in different crop-livestock production systems

Livestock production in the study area started along with the establishment of the villages. Chicken and cattle were kept traditionally in the indigenous villages. The cattle were obtained from the forest as wild animals, then tamed and raised in the villages or in the forest. In a transmigrant village, namely Olas (West Ceram district), cattle were introduced by the Dutch colonials in 1920s. Households received Bali cattle as in-kind payments for their work. In other transmigrant villages, namely Waihatu, Waimital (Kairatu district) and Jembatan Basah (Bula district), Bali cattle were provided by the government to be raised as working animals in the rice fields. The cattle herd size per household before the 1980s varied in the communities, ranging from 5 to 100 cattle in Luhu village, while several farmers in Bula mentioned that their families or other farmers in the village used to have more than thousands of cattle. Since the year 1990, the cattle number decreased. Over-selling, high cattle mortalities because of diseases, social crime and natural disasters (flood and landslide) were the reasons mentioned by the farmer groups. Apart from Bali cattle, several other breeds were introduced in the study area by the local government. Those disappeared nowadays, due to the riots in Maluku from 1999 – 2002.

Most cattle were sold before the religious festivities (Ied el Fithr, Ied el Adh and Christmas) when the prices are high and the money is needed for celebration expenses. Cattle were mainly sold at farm gate to interested buyers who visited the farms. Some farmers re-stocked their herds after crop harvesting.

Apart from livestock, crops were cultivated. Many of the indigenous farmers inherited clove, cocoa and coconut plantations from their parents. Replanting was only done when the trees died. Inputs were purchased from the other farmers in the village, or from neighbouring villages. Harvest was done once a year, in October to November. The transmigrant farmers normally cultivated rice and vegetables, although many transmigrants also owned plantations nowadays. Rice was harvested in March and September, thus fields were prepared and rice was sown twice a year, in May and in November. Vegetables, consisting of chili, spinach and tomato were cultivated in October and November for harvest in January and March. The harvested crop products were either sold in the local village market (for vegetables), or at the farm gate where the traders came directly to purchase (for rice). A small portion of the products were used for household consumption. Inputs (seeds, fertilizers and pesticides) were purchased only in the local market of Waimital and Waihatu villages.

Crop by-products and rice bran produced during the harvest period were fed to cattle in the transmigrant farms, which were rarely found to be used in the indigenous villages. However, several transmigrant farmers in Olas village (West Ceram district) used manure from cattle as fertilizer in their vegetable plots.

The majority of the farmers in the discussions agreed that crops were their main source of income, although farmers in Bula village claimed that cattle contributed more in the last two years, as compared to crops. Cattle in the study area were mainly used for asset investment, occasional cash generation and insurance for emergency cases. The often mentioned function of cattle in determining the social status of the owners was not confirmed.

Farm characteristics

Farmers' migratory status has partly differenciated the farming systems according to crop types. Indigenous farmers planted perennial crops (cloves, coconut, nutmeg and cocoa beans), while transmigrant farmers planted rice and vegetables. Nowadays, 5 out of 60 transmigrant farmers in the sample have planted cloves, and 4 out of 61 indigenous farmers in the sample have planted rice too. Other activities such as cattle keeping, fishing, hunting and off-farm activities were found to be similar between indigenous and transmigrant farmers. Religion differed among indigenous farmers. It has, however, not affected the characterization of farming systems in the study area.

Cluster analysis yielded three clusters with relatively balanced proportions of respective farm numbers (Figure 4.1, Table 4.1). The first cluster (TVC) consisted of 62% transmigrant farmers; they planted vegetables, fruits and tuber crops on a land of on average 2 ha without other income generating activities. The second cluster (IPC) grouped 71% of the indigenous farmers who planted perennial crops in a land of 3.7 ha on average. More than half of the farmers in this group were reported to have other activities to generate income for the households. The third cluster (TRC) referred to 65% of the transmigrant farmers who planted rice within 3.3 ha of the average land size. The majority of the group members had no other income generating activities. The average age of the farmers in all clusters was 47 years. Variation was found in the level of education, where illiterates were found in TVC (9.5%) and TRC (3.2%) but none in IPC (Table 4.2). Farmers, who attended elementary school, completed or not, formed the majority in all clusters, ranging from 38.1% in TVC to 45.2% and 45.8% in TRC and IPC, respectively. Middle high school was attended by 29% farmers in IPC and TRC, and in TVC 31%, while high school was attended by 21 - 2.6% farmers in all clusters. Interestingly, one farmer in IPC attended university although did not complete the degree.

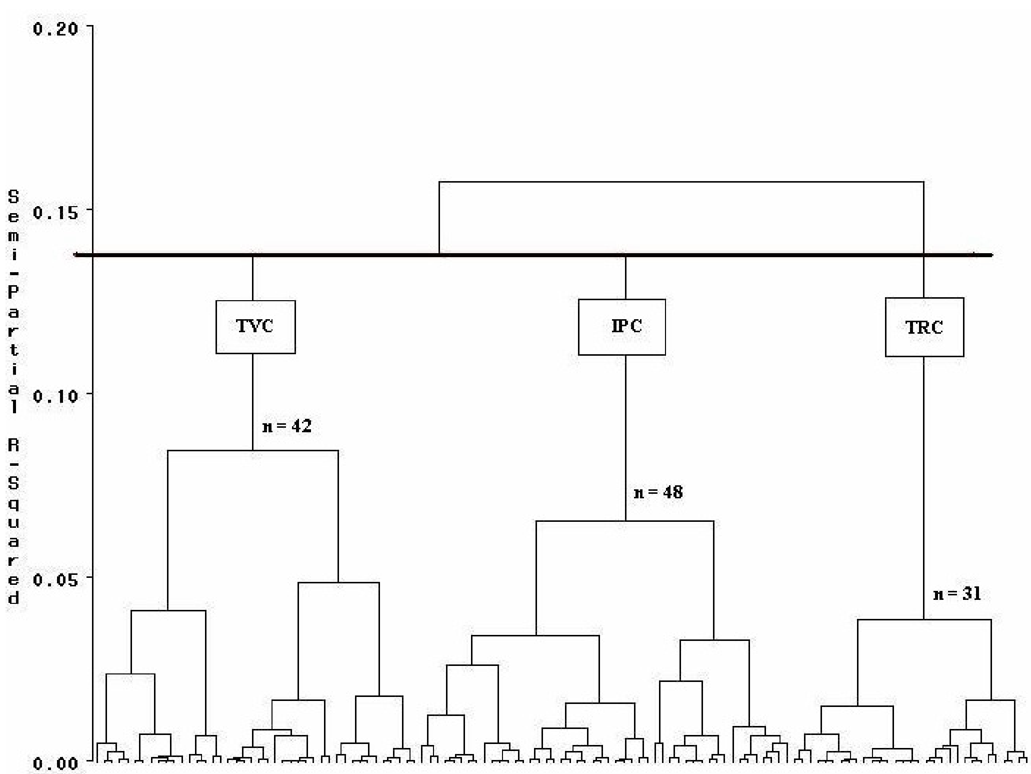


Figure 4.1. Dendrogram of 121 households grouping the farms into three clusters

TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

Table 4.1. Description of the production systems of the three clusters

Variable	Cluster					
	TVC	%	IPC	%	TRC	%
Household number	42		48		31	
Migratory status	Transmigrant	62	Indigenous	71	Transmigrant	65
Religion	Muslim	86	Muslim	71	Muslim	65
Crop type	Vegetables	74	Vegetables	4	Vegetables	7
	Perennial	19	Perennial	90	Perennial	3
	Rice	0	Rice	0	Rice	90
Crop function	For sale	81	For sale	69	For sale	100
	Consumption	71	Consumption	40	Consumption	100
	Cattle feed	21	Cattle feed	19	Cattle feed	74
Farm size (ha)	2.0 (0.5)		3.7 (0.5)		3.3 (0.6)	
Capital source	Own capital	83	Own capital	85	Own capital	74
Livestock kept	Cattle	100	Cattle	100	Cattle	100
	Chicken	50	Chicken	42	Chicken	77
	Goat	12	Goat	6	Goat	13
Fishing and hunting	None	86	None	63	None	94
Other income generating activities	None	69	Off-farm	58	None	55

Note: Numbers in parenthesis are standard errors.
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

Table 4.2. Educational level and age of farmers in each cluster

Variable	unit	Cluster			Overall
		TVC	IPC	TRC	
n		42	48	31	121
Educational level					
Illiterate	%	9.5	0	3.2	4.1
Elementary school	%	38.1	45.8	45.2	42.9
Middle High School	%	30.9	29.2	29.0	29.7
High School	%	21.4	22.9	22.6	22.3
University	%	0	2.1	0	0.8
Farmers Age					
Mean	years	47.7 (1.9)	47.2 (1.6)	46.4 (1.8)	47.2 (1.0)
Median	years	47	47	47	47

Note: Numbers in parenthesis are standard errors
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

The average herd size of Bali cattle in all clusters ranging from 8.9 cattle per household in IPC to 4.3 cattle per household in TVC (Table 4.3). This is considered to be low compared to the average herd size in 1990 in all clusters, ranging from 5 – 20 cattle per household. Regional crisis and high percentage of social crime appeared to be the main reasons for the decreasing number. Although the majority supplemented their cattle with salt, the percentage of salt given among clusters differed significantly from 55% in TVC to 90% in TRC. The majority of TRC cluster farms were reported to add rice bran and other crop by-products in cattle feeding especially during the harvest period, while TVC and IPC were not. The latter relied much on the natural pasture, which was recently reported by farmers and other stakeholders in the PRA sessions to be decreasing in all study locations because of the increasing village population. Stables for the cattle existed in 61% of the TRC farms while they were less common in TVC and IPC farms. Information and services provided by the local government through extension services for livestock production, as well as for crop production, varied between locations. Farmers in West Ceram and Bula districts mentioned that they received less information and services from the extension services, including health services for cattle and pest management for crops. The number of extension services was also limited in those districts, 1 extension service for 2 – 5 villages, compared to 1 extension service per village in Kairatu district.

Herd composition of Bali cattle on Ceram consisted of on average 3 adult females, 1 adult male and 1 calf (Table 4.4). Cluster IPC had significantly more cattle in the herd with 4 females, 2 males and 2 calves, compared to TRC with 3 females, 1 male and a calf. Cluster TVC had the least cattle with 2 females, 1 male and 1 calf on average.

Table 4.3. Cattle husbandry characteristics in each cluster

Variable	Cluster					
	TVC	%	IPC	%	TRC	%
n	42		48		31	
Herd size (mean head)	4.3 (0.9)		8.9 (0.9)		5.9 (0.9)	
Cattle ownership	Own cattle	88	Own cattle	77	Own cattle	87
Supplement use	Salt	55	Salt	77	Salt	90
	Rice bran	19	Rice bran	12	Rice bran	71
Stable use	no	88	no	83	yes	61
Pasture ownership	Communal	83	Communal	62	Communal	68

Note: Numbers in parenthesis are standard errors
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables (n=42)
IPC = farm system with mostly indigenous cattle farmers with perennials crops (n=48)
TRC = farm system with primarily transmigrant cattle farmers cultivating rice (n=31)

Table 4.4. Herd composition in each cluster

Cattle	Cluster						Overall		p-value (Kruskal-Wallis test)
	TVC		IPC		TRC				
	mean	s.e.	mean	s.e.	mean	s.e.	mean	s.e.	
Adult Female	2.3	0.2	4.2	0.6	2.6	0.3	3.1	0.3	0.0008
Adult Male	0.6	0.1	1.6	0.2	1.0	0.2	1.1	0.1	<.0001
Calves	0.7	0.1	1.8	0.3	1.0	0.2	1.2	0.1	0.0015

Note: s.e. is standard error of the mean.
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables (n=42)
IPC = farm system with mostly indigenous cattle farmers with perennials crops (n=48)
TRC = farm system with primarily transmigrant cattle farmers cultivating rice (n=31)

Economics

Annual cash revenue from the sale of crops and livestock contributed differently in each cluster. Cluster TVC and TRC received 98% and 93% cash revenue, respectively, from crop production while livestock and off-farm income contributed 2% in TVC and 7% in TRC (Figure 4.2). Farms in cluster IPC earned a higher cash revenue contribution from livestock of 9% while crop production contributed 78%. Expenditures also varied among clusters. Crop production absorbed the main part of expenditures in clusters TVC (50%) and TRC (48%) (Figure 4.3). Expenses for food consumed were more in cluster IPC (39%) than the 34% and 21% in clusters TVC and TRC, respectively. Other household expenditures such as health care, school fees, water and electricity, transportation and clothing consumed 15% of income in TVC, 30% in TRC and 38% in IPC. However expenses for livestock production consumed only 1% of the total household income in every cluster.

Thus, net farm income received as total cash revenue from crop and livestock production after deducting the monetary expenses for crops and livestock, was found to vary among clusters. It ranged from IDR 40,611,250 (USD 4,366.8) per year in cluster TRC to IDR 21,590,500 (USD 2,321.6) per year in cluster TVC (Table 4.5). Hence, net farm income per family member, family labour and per hectare of land in cluster TRC were higher than in TVC and IPC.

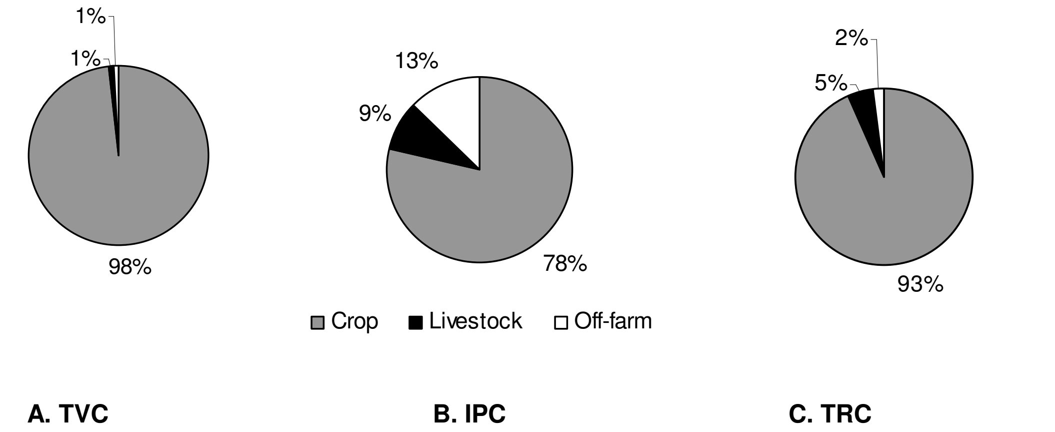


Figure 4.2. Annual cash revenue proportions from crop, livestock and other activities in the three clusters

Note: TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

IPC

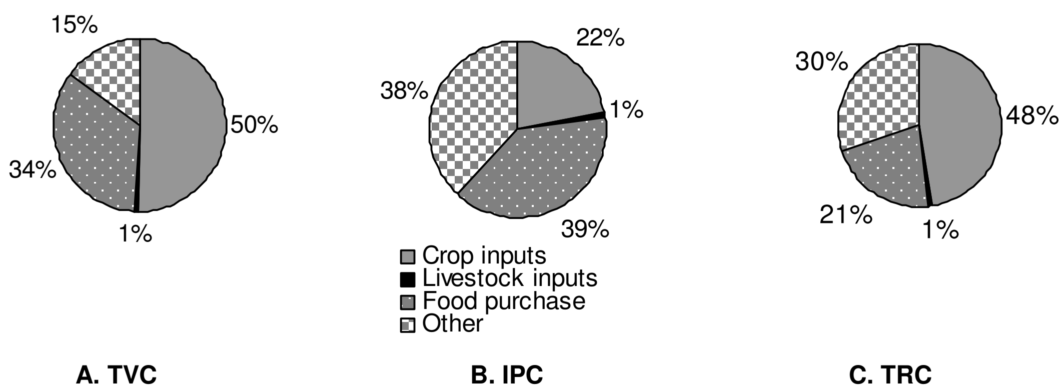


Figure 4.3. Main categories of monetary expenditures in the three clusters

Note: TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

Table 4.5. Annual net farm income, factor productivities and share of household off-farm income in the three clusters

Variable	Unit	Cluster					
		TVC		IPC		TRC	
		mean	s.e	mean	s.e	mean	s.e
Farm income	IDR	21,590,500[a]	1,432,823	26,618,000[a]	1,446,483	40,611,250[b]	3,666,223
- per family member	IDR	4,593,723	1,378,117	5,432,245	1,086,449	8,828,533	2,648,560
- per family labour	IDR	7,710,893	1,542,179	8,872,667	1,774,533	11,280,903	2,256,181
- per ha land	IDR	10,795,250	5,397,625	7,194,054	3,597,027	12,306,439	7,383,863
Off-farm income contribution to household income	%	1.2		12.7		1.9	

Note: Numbers in the same row followed by the same superscript letter do not significantly differ at p<0.05
IDR = Indonesian Rupiah (1USD = IDR 9,300)
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

Land use

Agricultural land and forest area in almost every village in the study area decreased from 76 – 90% in 1970 to 53 – 71% in 2000. The main reason mentioned by the village authority officers was the increasing rural population and the opening of new dwelling areas in the surroundings of the main villages. Dwelling area and agricultural area were located separately, ranging from 300 m to 8 km distance. The dwelling area was located in the village and occupied less than 1% of the total land owned by farmers in all clusters (Table 4.6). Land owned by farmers also decreased as a result of inheritance from parents to their children, especially when the child had married.

From the average of 2 ha agricultural land in cluster TVC, vegetables were planted on 1.5 ha on average while other crops occupied 0.25 ha. In contrast, farmers in cluster IPC planted perennial crops on 3.1 ha from their average 3.7 ha and dedicated only 0.14 ha for other crops, while TRC occupied 1.5 ha from the average 3.3 ha agricultural land for rice production, 0.8 ha for vegetables and 0.6 ha for perennials and other crops. Uncultivated land was found to be significantly higher in IPC (0.4 ha) compared to TRC and TVC of 0.3 and 0.2 ha respectively. However, all clusters showed similarity in terms of land dependency ratio, where 10 – 11% from every ha of their agriculture land were unused.

Land efficiency in terms of cash revenue accrued from crop production per ha of land invested, varied according to crop grown. Annual crops such as rice and vegetables contributed more cash revenue per ha of land (in TRC and TVC, respectively) compared to perennial crops such as cloves, coconuts, nutmegs or lemons. Consequently, land efficiency per ha of cultivated land and the overall agricultural land in IPC, where the majority of farmers planted perennial crops, was lower than in TRC and TVC (Table 4.7).

Table 4.6. Land size and use by cluster

Land size and use (ha)	Cluster						p - value (Kruskal-Wallis test)
	TVC		IPC		TRC		
	mean	s.e	mean	s.e	mean	s.e	
Total land size	2.0	0.3	3.7	0.6	3.3	0.4	0.0191
Dwelling land	0.017	0.003	0.019	0.003	0.015	0.004	0.8710
Agricultural land	2.0	0.3	3.7	0.6	3.3	0.4	0.0188
Perrenials	0.3	0.1	3.1	0.6	0.1	0.1	<.0001
Rice	0		0		1.5	0.2	<.0001
Vegetables	1.5	0.2	0.1	0.06	0.8	0.2	<.0001
Other crops	0.05	0.02	0.04	0.02	0.5	0.2	<.0001
Uncultivated, fallow, pasture land	0.2	0.1	0.4	0.1	0.3	0.2	0.0083
Land dependency ratio*	0.11		0.11		0.10		

Note: s.e= standard error of the mean
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice
*Land dependency ratio = Unculticated land in ha / agricultural land in ha

Table 4.7. Land use efficiency by cluster

Variable	Unit	Cluster					
		TVC		IPC		TRC	
		mean	s.e	mean	s.e	mean	s.e
Perennials	IDR/ha	3,026,700[a]	170,706	31,275,900[b]	4,693,043	1,008,900[c]	250,207
	USD/ha	326	18	3,363	505	108	27
Rice	IDR/ha	0[a]	0	0[a]	0	48,000,000[b]	7,604,800
	USD/ha					5,161	818
Vegetables	IDR/ha	39,232,050[a]	7,540,400	750,000[b]	34,650	16,000,000[c]	3,504,000
	USD/ha	4,219	811	81	4	1,720	377
Other crops	IDR/ha	2,039,250[a]	33,464	144,100[b]	14,420	3,277,100[c]	323,122
	USD/ha	219	4	15	2	352	35
Overall cultivated land	IDR/ha	24,075,000[a]	7,802,707	9,929,012[b]	2,099,745	23,546,897[a]	4,944,848
Overall agricultural land	IDR/ha	22,149,000[a]	6,567,178	8,694,595[b]	1,646,230	20,692,727[a]	4,345,473

Note: Numbers in the same row followed by the same superscript letter do not significantly differ at $p<0.05$
s.e = standard error of the mean
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

Food security

The families in the study region ate three to four times a day. The menu for breakfast was home-made bread or fried cassava with tea. A complete menu, consisting of rice, fish and vegetables was served at lunch and dinner. In the afternoon, tea or coffee was served, with or without snacks. Beef was eaten only in special occasions, namely religious fesivities and communal ceremonies. In Christian families, pork was served also on Christmas.

The families' annual food intake expressed in energy and protein in all clusters satisfied their nutrient requirements according to the FAO food security standards. However, the sources of nutrients varied among clusters. Own crop production contributed 44% of energy and 54% of protein to the total family intake in TRC. TVC received less than 1% energy and 3.6% protein from own crops while IPC received 1.3% energy and less than 1% protein from their crops. Livestock contributed 5 – 6 % protein but less then 1% energy in TRC and TVC. IPC was reported to consume none from their own livestock products. All clusters received a high percentage of energy and protein from purchased food ranging from 55% to 98% energy and 40% to 99% protein. Rice was the agricultural product which contributed most to the families' nutrient intake with 11,122 MJ energy and 55,875 kg protein annually in TRC. Own livestock products (chicken) provided a higher energy and protein share for TVC compared to other agricultural products produced in the clusters, while coconut was the only agricultural product that contributed directly to the families' energy and protein intake in IPC (Figure 4.4, Table 4.8).

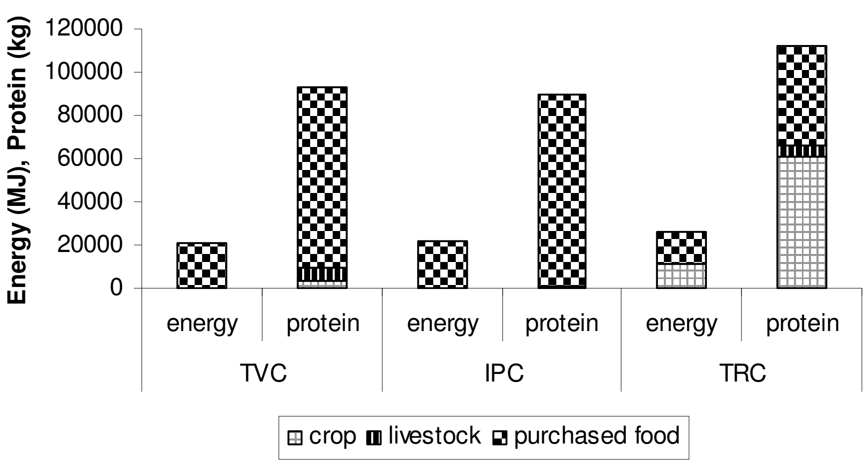


Figure 4.4. Energy and protein sources of annual food intake by farm families in the three clusters

Note: TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

Table 4.8. Energy and protein requirements and intake, farm products contributing to the farm families' nutrition, and income spent for food in each cluster

Variable	Unit	Cluster					
		TVC		IPC		TRC	
		mean	s.e.	mean	s.e.	mean	s.e.
Minimum annual family nutritional requirement							
- Energy	MJ	19,245		19,710		16,425	
- Protein	kg	81,030		81,030		64,240	
Annual family nutrient intake							
- Energy	MJ	21,245	4,249	21,403	3,852	26,056	5,732
- Protein	kg	93,094	9,123	89,379	16,714	112,242	21,326
Annual intake of farm products with highest contribution to families' nutrient intake							
- Product		Chicken		Coconut		Rice	
- Energy	MJ	125	25	270	51	11,123	1,001
- Protein	kg	5,836	1,167	760	144	55,875	5,587
Income spent for food purchased per year	IDR	15,058,000	2,710,440	15,650,000	3,130,000	13,717,000	2,743,400

Note: Data on requirements based on WHO (1999). s.e.= standard error of the mean
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

Labour analysis

The majority of the families in the region studied were living separately from their parents, formed a nuclear family, consisting of husband (farmer), wife, 2 – 4 children and one or two nephews or nieces. The average family size on Ceram Island was 4.75 man equivalents (Table 4.9), with the overall male: female ratio was 0.85 male for every female family member. Significant differences were found in family members of the age under 14 and over 60 years and the member between 14 and 60 years among clusters. TRC had the highest family labour number, namely 3.6 man equivalents per household compared to 2.8 and 3.0 in TVC and IPC, respectively. In contrast, TRC had the lowest dependency ratio with 0.28, which means that there is about 1 dependant person for every 3 or 4 family labourers. TVC and IPC had higher dependency ratios of 0.68 and 0.63, respectively, or 1 dependant for less than 2 family labourers.

When labour capacity was expressed per unit manday, TVR, IPC and TRC had capacities of on average 809, 864 and 1040 mandays per year per household. On-farm and off-farm activities occupied 96% (995.8 mandays) of the family labour in the TRC cluster, while TVC and IPC applied 93% of their family labour per year (751.8 and 800.6 mandays respectively) (Table 4.10). Crop production consumed most of the labour in every cluster ranging from 482.1 mandays in TVC to 727.8 mandays in TRC.

Table 4.9. Family size and labour availability (in man equivalents) in every cluster

Variable	Cluster						Overall
	TVC		IPC		TRC		
	mean	s.e.	mean	s.e.	mean	s.e.	mean
Family size (ME)	4.7	0.3	4.9	0.2	4.6	0.3	4.75
- Male	2.4	0.2	2.8	0.2	2.6	0.2	2.6
- Female	2.3	0.2	2.1	0.2	2.0	0.2	2.2
Family member (n) (age<14 and >60 years)	1.9[a]	0.2	1.9[a]	0.2	1.0[b]	0.3	3.1
Family member (n) (age 14 – 60 years)	2.8[a]	0.2	3.0[a]	0.2	3.6[b]	0.2	1.7
Dependency ratio	0.68		0.63		0.28		0.55

Note: Numbers in the same row followed by the same superscript letter do not significantly differ at $p<0.05$
ME is man equivalent, s.e. is standard error of the mean.
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

Livestock production received 132.6 mandays per year in cluster TVC, while cluster IPC and TRC receied 150 and 131 respectively. Other activities including household and off-farm activities consumed 18%, 16% and 14% labour in TVC, IPC and TRC, respectively. Male labour was counted as the main labour force in the household. They were engaged mainly in crop production, livestock production and off-farm work to generate family income. Off-farm works found in the study area done by farmers are carpenter, pedicab driver, school teacher and wage labour in private companies such as oil explorating or wood processing companies in the districts. Female labours were used on farm in the planting and harvesting period, where extra labour was needed. They were engaged in daily household activities such as cooking, housekeeping and buying food and grocery. In IPC and TRC clusters, female labour was also enganged in marketing crops and selling food (home industry). They contributed 29% of the total family labour applied on and off farm in TVC while in IPC and TRC it contributed 18%. Teenager and child labour were used as part of family labour ranging from 4% in TRC to 22% and 31% in TVC and IPC respectively from the total family labour used. In TVC cluster, teenager and child labour were mainly engaged in household activities such as fetching water, baby sitting, housekeeping, and helping their parents in livestock and crop production activities, while in IPC and TRC, none of the teenagers and children worked in livestock production as this was the duty of the adult male in the family.

Wage labour was used for crop production in every cluster as seasonal labour during the planting and harvesting period, namely 208.5 mandays in IPC up to 259.8 and 392.5 mandays in TRC and TVC, respectively. The main source of wage labour was from other villages or subvillages of the same district. In the peak period, where rice, vegetables and cloves were harvested together, wage labour was scarce and farmers had to search for wage labour from other districts, or sometimes other islands in the province.

Table 4.10. Average annual labour available and applied in each cluster

Variable	Mandays by cluster					
	TVC		IPC		TRC	
	mean	s.e	mean	s.e	mean	s.e
Family labour capacity	809.1	52.2	864.0	48.5	1040.5	68.9
Family labour used	93%		93%		96%	
Crop production						
- Male	282.0	28.3	209.0	14.8	594.3	62.7
- Female	165.7	14.8	121.2	20.4	129.3	8.8
- Youth and children	34.4	1.9	191.2	11.2	4.2	1.7
Total	***482.1***	41.7	***521.4***	39.2	***727.8***	62.4
Livestock Production						
- Male	75.0	3.3	150.1	7.0	120.1	6.4
- Female	10.8	2.4	0	0	10.8	0.8
- Youth and children	46.8	2.7	0	0	0	0
Total	***132.6***	5.9	***150.1***	7.0	***130.9***	6.3
Other activities						
- Male	6.0	1.9	46.8	4.1	54.2	8.1
- Female	44.3	2.1	22.8	2.4	44.3	6.4
- Youth and children	86.1	4.6	60.0	4.2	38.3	6.6
Total	***136.4***	6.1	***129.6***	9.1	***136.8***	20.4
Wage labour used	392.5	78.5	208.5	27.1	259.8	93.5

Note: s.e is standard error of means.
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice
Other activities include household activities and off-farm activities

The economic return of labour invested in crops, livestock and off-farm activities, expressed in the cash revenue obtained from each manday of labour applied varied among clusters (Table 4.11). Cluster TRC could earn IDR 390,822.3 from crop production per unit manday applied per year, including family and wage labour, IPC could earn IDR 141,060 while TVC produced only IDR 53,807.3. From livestock production, cluster TRC and IPC could earn IDR 29,136 and IDR 23,314, respectively, while cluster TVC produced no monetary cash revenue. Off-farm activities contributed more in the cluster IPC compared to what was earned in other clusters. This is because more farmers in the cluster IPC were engaged in off-farm activities than farmers in other clusters.

Table 4.11. Labour efficiency (daily revenue) of each cluster

Variable	Unit	Cluster					
		TVC		IPC		TRC	
		Mean	s.e.	Mean	s.e.	Mean	s.e.
Crop production	IDR/manday	53,807.3[a]	17,441.1	141,060.0[a]	78,300.0	390,822.3[b]	122,222.3
	USD/manday	5.8		15.2		42.0	
Livestock production	IDR/manday	0[a]	0	23,314.0[b]	11,436.2	29,136.2[b]	13,124.2
	USD/manday			2.5		3.1	
Off-farm activities	IDR/manday	1,598.9[a]	604.0	29,878.6[b]	17,441.3	6,058.5[a]	4,001.1
	USD/manday	0.2		3.2		0.7	

Note: Numbers in the same row followed by the same superscript letter do not significantly differ at p<0.05
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

4.1.2 Performance of Bali cattle

The reproductive performance of Bali cattle was assessed through household interview, key persons interview and progeny history questionnaire. Fertility rate, calving interval and the average weaning age were 48%, 384 days and 7.6 months, respectively (Table 4.12). Bull age at first mating and cow age at first calving were on average 26.6 months and 34.6 months, respectively. Number of calvings of a cow (parity) was on average 4.2, with the average cow's age of 7.5 years at the time of study. Longevity of cows was reported to range between 16 – 20 years. Mortality rate was similar between adults and calves, of on average 17% - 18% respectively.

Productive performance was considered here in terms of body weight. Pre-weaning, post-weaning and yearling average Bali cattle weights were 71.7 kg, 140.9 kg, and 222.3 kg, respectively. Adult male average body weight was 355.7 kg, while adult females were lighter with on average 337.7 kg registered.

Analysis of variance for reproductive performances showed model significance (p<0.05) only for bull age at first mating and adult mortality (Table 4.13). The effect of the district significantly influenced bull age at first mating (p<0.05). Bull age at first mating in Kairatu and Bula districts were higher than in West Ceram district (Table 4.14). In contrast adult mortality was significantly affected by the number of head kept per household. Households with more than 5 cattle showed a higher adult mortality than households owning 5 cattle or less (Table 4.15). No influence of cluster and farmer's migratory status was found in both traits.

Table 4.12. Overview of reproductive and productive performance of Bali cattle studied

Traits	Unit	LSM	s.e
Reproductive traits			
Fertility rate	Percent	48.0	7.8
Adult mortality	Percent	17.0	(9-30)
Calf mortality	Percent	17.9	(6-11)
Calving interval	Days	384.0	73.7
Cow age at first calving	Months	34.6	5.6
Weaning age	Months	7.6	1.4
Bull age at first mating	Months	26.6	5.5
Parity	Calves/cow	4.2	2.7
Cow age	Years	7.5	3.3
Longevity*	Years	16 - 20	
Productive traits			
Adult male weight	kg	355.7	61.3
Adult female weight	kg	337.7	48.6
Yearling weight	kg	222.3	38.2
Post-weaning weight	kg	140.9	21.4
Pre-weaning weight	kg	71.7	14.9

Note: Values in the same column with different superscripts are significantly different (p<0.05).
Values in the brancket are the lower and upper end points for a 95% confidence interval
n is the number of samples, LSM is the Least Square Means, s.e is standard error of LSM
* data gathered from extension services, as the range of Bali cattle longevity in the study area

Table 4.13. Analysis of variance for bull age at first mating and adult mortality

	Bull age at first mating (months)			Adult mortality (%)		
n		105			76	
Effect	DF	F-value	Pr>F	DF	F-value	Pr>F
Farmer's migratory status	1	1.32	0.2546	1	1.03	0.3141
District	2	6.64	0.0021	2	1.52	0.2250
Cluster	2	2.97	0.0568	2	0.14	0.7117
Herdsize	1	3.14	0.0801	1	28.25	<.0001
Error	83			70		
Model	21	2.13	0.0081	5	6.49	<.0001
R-square		**0.35**			**0.32**	

Table 4.14. Bull age at first mating of Bali cattle by district

Trait	unit	District								
		West Ceram			Kairatu			Bula		
		n	LSM	s.e.	n	LSM	s.e.	n	LSM	s.e.
Bull age at first mating	Months	24	22.2^{a}	1.3	53	28.9^{b}	0.9	28	26.6^{b}	1.2

Note: Values in the same row with different superscripts are significantly different (p<0.05).
n is the number of samples, LSM is the Least Square Mean, s.e is standard error of LSM

Table 4.15. Adult mortality according to herd size of Bali cattle kept by farmers

Herd size	n	Mean	Upp	Low
≤ 5 cattle	48	10.0[a]	11.4	8.8
> 5 cattle	28	22.0[b]	24.1	20.1

Note: Mean values in the same column with different superscripts are significantly different ($p<0.05$).
Upp is the upper end point for a 95% confidence interval
Low is the lower end point for a 95% confidence interval

Descriptive statistics and data distribution of Bali cattle's body weights according to age group, sex and clustered farming system were summarized in Figure 4.5. No data on female calves in the TVC cluster at the time the study was conducted. When the data were used to estimate the weight gain of Bali cattle in both farms, the weight increased sharply from 0 – 24 months in all farming systems, namely TVC, IPC and TRC. Differences according to sex can be observed after the yearling age (Figure 4.6).

Cattle average daily weight gain was approximated according to farming system, cattle sex and age group (Table 4.16). In the first three months of age, the average daily weight gain of male Bali cattle in the IPC, TVC and TRC systems were 200 g, 210 g and 220 g, respectively. In the pre-weaning, post-weaning and yearling period, cattle in the TVC system showed the lowest daily weight gain compared to the IPC and TRC systems. The lower growth of cattle in the TVC system was compensated in the adult phase, where cattle of this system turned out to be the highest in daily weight gain. Female cattle yielded lower daily weight gains compared to male until the yearling age. Then, adult females were gaining more weight than male, ranging from 220 g in the TVC system to 240 g in the IPC system, except in the TRC system were average gains of both female and male adult cattle were 140 g per day.

Farms owned by transmigrant farmers showed higher and highly significantly different post-weaning weights compared to values measured at indigenous farms (Table 4.17 and Table 4.18). When the weights were analyzed across districts, animals in Kairatu district showed significantly higher pre-weaning and yearling weights than their peers in West Ceram. Sex differed significantly ($p<0.05$) in yearling weights, where males proved to be heavier than females in this later age class. Cluster also differed significantly ($p<0.05$) in this age group. Cattle kept by farmers in the IPC cluster showed significantly higher body weight than in the TVC and TRC clusters. However, no statistically significant difference was found in these age groups according to herd size per family.

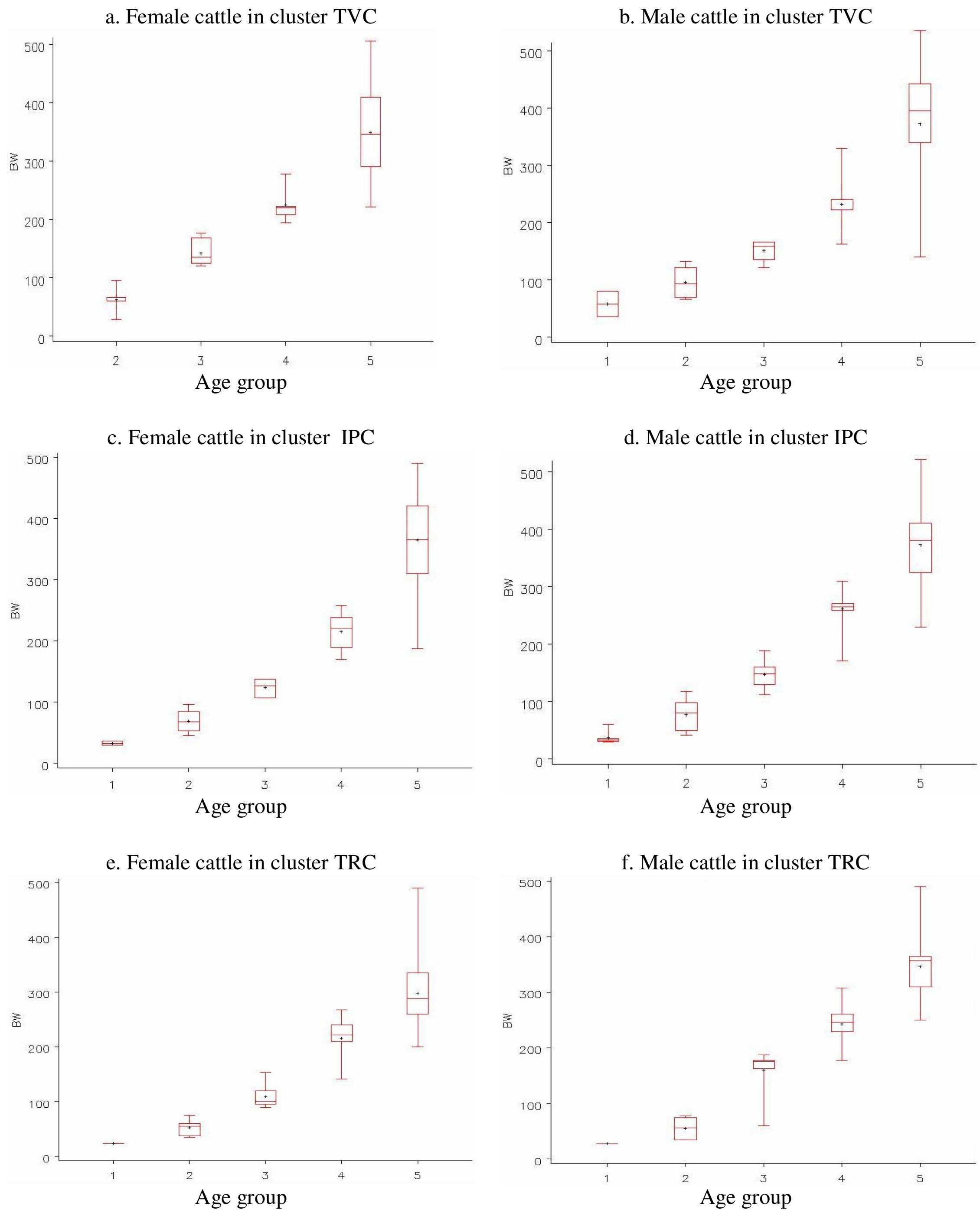


Figure 4.5. Body weight boxplots of female and male Bali cattle in the three clusters.

Note: Value in axis showed age groups: 1 is calves age of 0-3 months, 2 is pre-weaning group between 4 – 7 month-old, 3 is post-weaning group between 8 – 12 month-old, 4 is yearling group between 13 – 24 month-old, and 5 is adult cattle group with more than 24 month-old.

TVC = farm system with predominantly transmigrant cattle farmers planting vegetables; 91 female cattle and 51 male cattle measured

IPC = farm system with mostly indigenous cattle farmers with perennials crops; 114 female cattle and 53 male cattle measured

TRC = farm system with primarily transmigrant cattle farmers cultivating rice; 113 female cattle and 51 male cattle measured

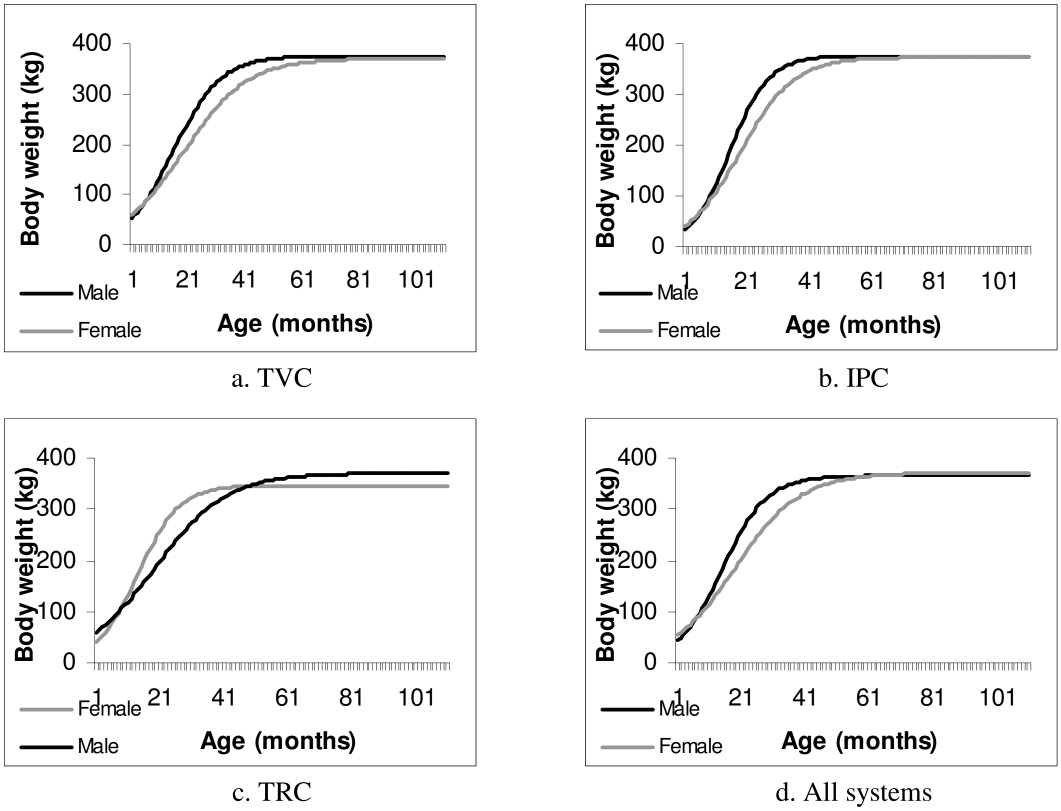


Figure 4.6. Estimated growth curves of male and female Bali cattle in indigenous and transmigrant farms.

Table 4.16. Estimated average daily weight gain (g/day) of Bali cattle in transmigrant and indigenous farms according to cattle age group and sex

Age group	TVC		IPC		TRC	
	Male	Female	Male	Female	Male	Female
Calves (0 – 3 months)	210	160	200	160	220	180
Pre-weaning (4 – 7 months)	270	190	300	220	300	240
Post-weaning (8 – 12 months)	340	230	430	290	410	310
Yearling (18 – 24 months)	350	270	430	340	370	300
Adults (25 – 35 months)	200	220	170	240	140	140

Note: TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

Table 4.17. Analysis of variance for body weight of pre-weaning, post-weaning and yearling Bali cattle

	Pre-weaning weight (kg)			Post-weaning weight (kg)			Yearling weight (kg)		
n	39			35			111		
Effect	DF	F-value	Pr>F	DF	F-value	Pr>F	DF	F-value	Pr>F
Farmer's migratory status	1	0.01	0.9525	1	10.49	0.0033	1	0.43	0.5153
District	2	3.04	0.0626	2	1.20	0.3178	2	13.63	<.0001
Sex	1	0.19	0.6685	1	2.34	0.1384	1	13.02	0.0005
Herdsize	1	0.91	0.3482	1	0.12	0.7290	1	0.21	0.6479
Cluster	2	1.61	0.2171	2	0.89	0.4239	2	9.87	0.0001
Farmer's migr stt * District							2	8.32	0.0004
Error	30			26			102		
Model	8	12.08	<.0001	8	4.94	0.0009	8	15.87	<.0001
R-square	**0.76**			**0.60**			**0.55**		

Note: Pre-weaning age is between 4 – 7 months-old, post weaning age is between 8 – 12 months-old, yearling age is between 18 – 24 months-old.

Table 4.18. Average body weight of pre-weaning, post-weaning and yearling Bali cattle

Effects	Pre-weaning weight (kg)			Post-weaning weight (kg)			Yearling weight (kg)		
	n	LSM	s.e	n	LSM	s.e	n	LSM	s.e
Farmer's migratory status									
-Indigenous	27	77.7	4.5	19	124.9[a]	7.5	47	229.7	6.8
-Transmigrant	12	80.9	6.2	16	151.3[b]	7.4	64	227.1	5.6
District									
- West Ceram	31	67.7[a]	3.0	19	134.9	5.4	51	205.5[a]	5.6
- Kairatu	6	84.6[b]	6.2	14	151.1	6.9	42	249.5[b]	7.1
- Bula	2	85.6[ab]	12.3	2	131.1	16.0	18	230.3[b]	9.5
Sex									
- Male	25	80.3	4.8	19	145.2	7.2	60	242.7[a]	5.5
- Female	14	78.3	5.7	16	132.8	7.8	51	214.1[b]	6.3
Herdsize									
- ≤ 5 cattle/household	24	82.8	5.8	25	139.9	6.1	74	224.7	5.4
- > 5 cattle/household	15	75.8	4.9	10	138.2	8.9	37	232.1	6.9
Cluster									
- TVC	13	83.7	5.8	14	143.5	10.1	34	219.3[a]	7.6
- IPC	15	78.2	5.6	8	138.8	8.1	32	249.8[b]	7.4
- TRC	11	71.6	6.7	13	132.1	10.6	45	203.0[a]	7.4

Note: Values in the same column and effect with different superscripts are significantly different ($p<0.05$).
n is the number of samples, LSM is the Least Square Mean, s.e. is standard error of LSM
Pre-weaning age is between 4 – 7 months-old, post weaning age is between 8 – 12 months-old, yearling age is between 18 – 24 months-old.
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

Heifers and young bulls in indigenous farms of Kairatu district showed significantly higher body weight than those in transmigrant farms of West Ceram and Bula districts, while cattle on the same age stage in indigenous farms of West Ceram district showed the lowest body weight (Table 4.19)

District, physiological status and cluster significantly influenced the live weight of adult female in the study area (p<0.0001) (table 4.20). Live weight of adult females in Kairatu was higher than those in Bula and West Ceram (Table 4.21). When physiological status was taken into account, all three levels (pregnant, lactating and dry) were significantly different from each other, whereas the weight of pregnant cows was highly significantly different from dry and lactating cows. However, the adult female Bali cattle raised in TVC cluster showed significantly lower body weight (313.7kg), compared to TRC cluster (369.9kg) and IPC cluster (380.4kg).

Table 4.19. Average body weight of yearling Bali cattle according to farmer's migratory status in each district

Effects		n	LSM	s.e.
District	Farmer's migratory status			
West Ceram	Indigenous	29	183.1^{a}	7.8
	Transmigrant	22	227.8^{b}	8.3
Kairatu	Indigenous	11	259.1^{c}	11.9
	Transmigrant	31	239.8^{bc}	7.4
Bula	Indigenous	7	246.9^{bc}	14.9
	Transmigrant	11	213.6^{b}	12.3

Note: Values in the same column with different superscripts are significantly different (p<0.05). n is the number of samples, LSM is the Least Square Means, s.e. is standard error of LSM

Table 4.20. Analysis of variance for body weight of adult female Bali cattle

	Adult females (kg)		
n	256		
Effect	DF	F-value	Pr>F
Farmer's migratory status	1	1.92	0.1675
District	2	16.52	<.0001
Herdsize	1	2.74	0.0990
Cluster	2	16.85	<.0001
Physiological status	2	75.83	<.0001
Error	246		
Model	9	32.30	<.0001
R-square		**0.54**	

Table 4.21. Average body weight (kg) of adult female Bali cattle

Effects	Body weight		
	n	LSM	s.e
Farmer's migratory status			
-Indigenous	138	361.5	4.8
-Transmigrant	118	368.9	5.4
District			
- West Ceram	137	349.3[a]	5.4
- Kairatu	75	388.6[b]	6.3
- Bula	49	357.7[a]	7.6
Physiological status			
- Dry	156	309.0[a]	4.8
- Pregnant	58	412.5[b]	6.9
- Lactating	42	374.2[c]	8.2
Herdsize			
- ≤ 5 cattle/household	167	365.6	4.6
- > 5 cattle/household	89	364.4	6.2
Cluster			
- TVC	74	313.7[b]	9.6
- IPC	94	380.4[a]	5.7
- TRC	88	369.9[a]	9.6

Note: Values in the same column and effect with different superscripts are significantly different ($p<0.05$). n is the number of samples, LSM is the Least Square Means, s.e. is standard error of LSM
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

In sum, the performance of Bali cattle was mainly significantly affected by district, especially for bull age at first mating, pre-weaning weight, yearling weight and adult female weight. Kairatu district showed the better performance compared to the other districts under study. Cluster (production system) significantly influenced the body weight of yearling and adult female Bali cattle, whereas cattle in IPC cluster showed higher body weights compared to TVC and TRC. However, no performance parameter tested was significantly affected by the farmers' migratory status alone, but the interaction between the farmer's migratory status and district significantly influenced the body weight of heifers and young bulls in the study area.

4.1.3 Forage availability and quality

Natural grass and legume taken from three different grazing locations (road side, pasture and river bank) on West Ceram, Kairatu and Bula districts of Ceram Island, consisted of several dominant species. Grasses were dominated by genera *Axonopus*, *Chrysopogon*, *Cyperus*, *Eleusine* and *Leersia*, while legumes were dominated by genera *Centrocoma*, *Desmodium*, *Calopogonia* and *Neunotonia* (Table 4.22 and Table 4.23). Other genera found were from the genera *Brachiaria, Cenchrus, Chloris, Digitaria, Eulelia, Eupatorium, Lepidagathis, Paspalum, Penicetum, Panicum* and *Setaria* for grasses and *Mimosa* for legumes.

The forage contained 90 – 93% dry matter (DM) in the rainy season at test day. No variation in DM percentage was found in the three grazing locations: road side area, pasture and river banks. Crude protein content in dry matter varied from 4.4% on river banks of Kairatu district to 6.6% in the road side of Kairatu and West Ceram districts. Crude fibre was contained in the range from 33.9% in the road side of Kairatu district to 38.6% in pastures of the district. Gross energy was highest in the pasture of West Ceram district (16.05 kJ/g) and lowest in the pasture of Bula district (14.81 kJ/g).

Table 4.22. Botanical composition of feed samples in West Ceram, Kairatu and Bula district

Genera (species)	West Ceram		Kairatu		Bula	
	Rank sum	Index	Rank sum	Index	Rank sum	Index
Grasses						
Acrocera	22	0.06	22	0.03	-	-
Axonopus	44	**0.12**	149	**0.18**	36	0.08
Brachiaria	18	0.05	40	0.05	9	0.02
Cenchrus	-	-	-	-	2	0
Chrysopogon	62	**0.17**	91	**0.11**	30	0.07
Cyperus	24	0.06	117	**0.14**	48	0.11
Chloris	-	-	38	0.05	-	-
Digitaria	22	0.06	46	0.05	6	0.01
Eleusine	2	0.01	3	0	53	**0.12**
Eulelia	27	0.07	5	0.01	-	-
Eupatorium	29	0.08	26	0.03	-	-
Leersia	5	0.01	129	**0.15**	78	**0.18**
Lepidagathis	-	-	-	-	39	0.09
Panicum	-	-	18	0.02	6	0.01
Paspalum	23	0.06	-	-	-	-
Pennisetum	6	0.02	40	0.05	7	0.02
Setaria	-	-	-	-	1	0
Legumes						
Calopogonia	-	-	60	**0.07**	-	-
Centrocoma	37	**0.10**	4	0	-	-
Desmodium	43	**0.11**	1	0	14	0.03
Mimosa	7	0.02	13	0.02	19	0.04
Neunotonia	3	0.01	-	-	58	**0.13**

Note: The bigger the rank the higher the dominance of the genus.
Index is the proportion of the ranking, calculated by dividing the rank of each genus with the total rank of all genera.

The average yields of fresh forage, dry matter, crude protein, crude fiber and gross energy on Ceram were 7,998.8 kg/ha, 7,305.3 kg/ha, 388.9 kg/ha, 2,672.0 kg/ha and 26,593.6 Kcal/kg/ha respectively (Table 4.24). District significantly influenced forage yields ($p<0.05$) when it fitted as fixed effect with R-square between 31 and 36%. Bula district experienced the lowest yield in fresh and dry matter per hectare as well as crude protein, fiber and gross energy content in the forage compared to Kairatu and West Ceram districts (Table 4.25).

Grazing location also significantly influenced forage yields (p<0.05) (Table 4.26). Road side areas experienced the lowest yield in fresh and dry matter per hectare as well as crude fiber and gross energy content in the forage compared to pastures and river banks. However forage taken from riverbanks contained the lowest crude protein compared to road sides and pastures.

Table 4.23. Botanical composition (dominant genera) in the three grazing locations

Genera/ species	Road side		Pasture		River bank	
	Rank sum	Index	Rank sum	Index	Rank sum	Index
Grasses						
Acrocera	-	-	11	0.02	25	0.04
Axonopus	36	**0.09**	64	**0.10**	102	**0.16**
Brachiaria	-	-	20	0.03	18	0.03
Cenchrus	-	-	-	-	2	0
Chrysopogon	18	0.05	52	**0.08**	95	**0.15**
Cyperus	108	**0.28**	104	**0.16**	35	**0.05**
Chloris	6	0.02	16	0.02	-	-
Digitaria	8	0.02	21	0.03	45	0.07
Eleusine	12	0.03	32	0.05	14	0.02
Eulelia	5	0.01	21	0.03	6	0.01
Eupatorium	7	0.02	23	0.04	24	0.04
Leersia	77	**0.20**	91	**0.14**	92	**0.14**
Lepidagathis	14	0.04	24	0.04	6	0.01
Panicum	8	0.02	10	0.02	6	0.01
Paspalum	3	0	18	0.03	5	0.01
Pennisetum	8	0.02	22	0.03	23	0.04
Setaria	4	0.01	1	0	-	-
Legumes						
Calopogonia	22	**0.06**	24	**0.04**	27	**0.04**
Centrocoma	-	-	15	0.02	26	**0.04**
Desmodium	24	**0.06**	19	0.03	28	**0.04**
Mimosa	10	0.03	4	0.01	17	0.03
Neunotonia	-	-	24	**0.04**	30	**0.05**

Note: The bigger the rank the higher the dominance of the genus.
Index is the proportion of the ranking, calculated by dividing the rank of each genus with the total rank of all genera.

Table 4.24. Analysis of variance for fresh forage, dry matter, crude protein, crude fibe and gross energy by fitting district and location as fixed effects

		FW (kg/ha)		DM (kg/ha)		CP (kg/ha)		CF (kg/ha)		GE (MJ/ton/ha)	
n			179		179		179		179		179
Mean			**7,998.8**		**7,305.3**		**388.9**		**2,672.0**		**111.3**
Min			**4,680.4**		**4,301.3**		**235.0**		**1,546.7**		**66.3**
Max			**13,670.0**		**12,407.0**		**643.5**		**4,616.2**		**187.0**
Effects	DF	Fvalue	P<F	Fvalue	P<F	Fvalue	P<F	Fvalue	P<F	Fvalue	P<F
District	**2**	35.05	<.0001	38.10	<.0001	48.55	<.0001	36.27	<.0001	43.56	<.0001
Location	**3**	3.23	0.04	3.28	0.04	2.04	0.13	5.21	0.006	3.27	0.04
Error	**174**										
Model	**4**	19.15	<.0001	20.72	<.0001	24.96	<.0001	20.77	<.0001	23.45	<.0001
R-Square		**0.31**		**0.32**		**0.36**		**0.32**		**0.35**	

FW = Fresh weight, DM = dry matter, CP = Crude protein, CF = Crude fibe, GE = Gross energy

Table 4.25. Average yields of fresh forage, dry matter, crude protein, crude fiber and gross energy in three districts

Variable	Unit	West Ceram			Kairatu			Bula		
		Mean	Low	Upp	Mean	Low	Upp	Mean	Low	Upp
FW	kg/ha	10,105.5[a]	9,270.3	11,016.0	9,239.6[a]	8,723.3	9,786.5	4,470.5[b]	4,133.4	4,835.1
DM	kg/ha	9,471.1[a]	8,699.3	10,311.3	8,408.5[a]	7,942.6	8,901.7	4,023.1[b]	3,724.9	4,345.1
CP	kg/ha	578.4[a]	533.4	627.2	444.2[b]	420.8	468.8	215.3[c]	199.9	231.8
CF	kg/ha	3,263.6[a]	2,988.7	3,563.9	3,125.0[a]	2,951.9	3,308.3	1,444.2[b]	1,333.2	1,564.4
GE	MJ/ ton/ha	146.6[a]	136.7	161.4	128.3[a]	121.3	135.7	59.9[b]	55.5	64.6

Note: Mean values in the same row with different superscripts are significantly different ($p<0.05$).
Low is the lower end point for a 95% confidence interval
Upp is the upper end point for a 95% confidence interval
FW = Fresh weight, DM = dry matter, CP = Crude protein, CF = Crude fiber, GE = Gross energy

Table 4.26. Average yields of fresh forage, dry matter, crude protein, crude fiber and gross energy according to grazing location

Variable	Unit	Road side			Pasture			Riverbank		
		Mean	Low	Upp	Mean	Low	Upp	Mean	Low	Upp
FW	kg/ha	6,401.6[a]	4,887.8	8,384.2	8,459,9[b]	6,508.1	10,997.2	7,715,6[ab]	5,936.6	10,027.6
DM	kg/ha	5,859.9[a]	4,435.1	7,742.7	7,735.7[b]	5,896.4	10,148.7	7,072.7[ab]	5,392.2	9,277.1
CP	kg/ha	375.8[ab]	277.2	509.3	417.3[a]	309.7	562.3	352.6[b]	261.7	475.1
CF	kg/ha	1,994.0[a]	1,512.0	2,629.6	2,858.6[b]	2,184.2	3,741.3	2,588.2[b]	1,977.9	3,386.7
GE	MJ/ ton/ha	89.8[a]	67.1	120.1	117.8[b]	88.6	156.6	108.0[ab]	81.2	143.6

Mean values in the same row with different superscripts are significantly different ($p<0.05$).
Low is the lower end point of the 95% confidence interval
Upp is the upper end points of the 95% confidence Interval
FW = Fresh weight, DM = dry matter, CP = Crude protein, CF = Crude fiber, GE = Gross energy

4.2 Estimation of production systems' sustainability

4.2.1 Sustainability indicator selection

In the first round of indicator selection, farmers and other stakeholders on Ceram Island suggested several issues to be considered in the sustainability assessment. The issues were defined as indicators meant to assess the level of sustainability of their agricultural enterprises. The issues were cattle production, crop production, resource availability, economic, social, environment and supporting facilities (Table 4.27). Cattle body weight, fertility rate and health condition gained higher ranks and indices for importance within the cattle production issue. Absence of crop weeds and information and service availability were ranked higher among crop production categories. All indicators related to resources, social items, economics and environment were highly important as shown by rank weights only oscillating between 32 and 45. In the supporting facilities issue, high price, market infrastructure and transportation, market accessibility, post harvest management and credit availability were considered to be more important (rank weights 32 and higher). Eight indicators yielded a low mean rank of ≤3.5 and or quartile deviation higher than or equal to 0.5, leading to the rejection of the indicators. Those are herd size, and technology used in cattle as well as in crop production, availability of agricultural machinery, crop diversity, continuous cropping, farmers' organisation and government supervision and support.

When the indicators were analysed towards their relevance and sensitivity to the local situation by the local experts, three indicators, namely cattle ownership, income diversity and post harvest management yielded a low mean rank of ≤3.5 and quartile deviation higher or equal 0.5, leading to the rejection of the indicators. Several indicators were eliminated from the selection because the data were not available or not covered by the study. Those were animal pedigree, soil quality, favourable weather and climate conditions, and water quality. A total of 26 indicators were selected.

In the second round of the selection of sustainability indicators, where farmers were asked to rank those 26 indicators for the final selection, one issue and several indicators were added. The new issue was defined as cultural aspects, including cohesion of rural life meaning here the multiple interactions among people, cultural acceptance and a traditional custom of helping each other with on-farm and off-farm works for private or cummunity benefit, called *masohi* (in local language). Other additional indicators were cattle safety, especially from social crime, cattle coat colour, suitability of crops considering the quality of soils, manure availability for fertilizer, seed and seedling availability, availability of commercial soil fertilizers and suitability of crops considering the skills and specific knowledge of farmers. Further indicators added were livestock yields, having a farm successor, a feeling of safety from social crisis and natural disasters, and absence of seasonal floods. However, two indicators were eliminated, namely coat colour and manure availability, because the ranks given by farmers varied considerably for these indicator, leading to a higher quartile deviation. The total indicators selected by farmers and considered to be relevant and sensitive to the local situation, according to the local experts, were 37 with the rank weights oscillating between 28 and 40. The indicators which received the highest ranks were household income, food security, cohesion of rural life and good market price.

Three issues, namely cattle production, crop production and environment were considered to be less important (mean rank = 33.2 – 33.3), compared to support facilities, social and economic issues, which were ranked 35.5, 35.7 and 36, respectively. Interestingly, the cultural issue was ranked higher than other issues, namely 37.3 (Table 4.28). Consequently, each issue contributed differently in estimating the level of farm sustainability, oscillating between 0.12 and 0.13.

Cattle safety was weighted higher than other indicators in the cattle production issue (0.21), while absence of crop pests was higher among the crop production issue (0.19). In the resource availability issue, several indicators weighted 0.18, considered as the highest weight in this issue. Those indicators are area size, enough capital and land ownership. In the economic and social aspects issues, household income and food security were believed to contribute more to the system sustainability, namely 0.28 and 0.20, respectively. Forage availability was considered the most important indicator for the environment issue, weighted as 0.36. In the issue of supporting facilities, a good market price was considered as the most important indicator (weight = 0.28), while *masohi* or helping each other was weighted higher (0.34) in the cultural issue.

When farmers were asked to use those indicators, 7 out of 12 farmers mentioned that the indicators were sufficient enough to describe their farming system, and the results from the exercises matched with their own perception about their farming system. However, only 5 farmers agreed to use the indicators frequently to assess their farms in order to improve the system. The reason was too much time consumed to deal with the indicators.

Table 4.27. Results of indicator ranking by local communities and local experts in a three-step approach

Issue	Indicator	Primary selection					Secondary selection					Third / final selection				
		Rank weight	Mean rank	Median rank	QD	Result	Rank weight	Mean rank	Median rank	QD	Result	Rank weight	Mean rank	Median rank	QD	Result
Cattle production	Cattle body weight	45	5.0	5	0.0	√	69	4.6	5	0.25	√	34	4.3	4	0.5	√
	High fertility	45	5.0	5	0.0	√	75	5	5	0	√	34	4.3	4	0.1	√
	Health condition	45	5.0	5	0.0	√	75	5	5	0	√	32	4.0	4	0	√
	Cattle safety (from social crime)*						64	4.3	4	0.5	√	35	4.4	4.5	0.5	√
	Coat colour*											34	4.3	4	0.6	Rejected
	Pedigree**															
	Information and services availability	35	3.9	4	0.0	√	62	4.1	4	0.5	√	31	3.9	4	0.1	√
	Cattle ownership	34	3.8	4	0.5	√	47	3.1	4	2	Rejected					
	Herd size	28	3.1	3	0.5	Rejected										
	Technology used (AI)	11	1.2	1	0.0	Rejected										
Crop production	Crop-soil suitability*						65	4.3	4	0.5	√	35	4.4	4	0.5	√
	Manure availability *											33	4.1	4	0.6	Rejected
	Seed availability*						63	4.2	4	0.5	√	36	4.5	4.5	0.5	√
	Absence of crop pests	38	4.2	4	0.5	√	70	4.7	5	0.5	√	38	4.8	5	0.1	√
	Fertilizer (chemical) availability*						63	4.2	4	0.5	√	32	4.0	4	0.3	√
	Crop-skill suitability*						63	4.2	4	0.5	√	30	3.8	4	0.5	√
	Information and services availability	33	3.7	4	0.0	√	67	4.5	5	0.5	√	29	3.6	4	0.5	√
	Availability of agricultural machinery	32	3.6	4	1	Rejected										
	Crop diversity	30	3.3	4	0.5	Rejected										
	Technology used	26	2.9	3	1.0	Rejected										
	Continuously planting	25	2.8	3	1.5	Rejected										
Resource availability	Area size	45	5.0	5	0.0	√	69	4.6	5	0.5	√	38	4.8	5	0.1	√
	Water availability	45	5.0	5	0.0	√	75	5	5	0	√	28	3.5	3	0.5	√
	Enough capital	45	5.0	5	0.0	√	70	4.7	5	0.5	√	38	4.8	5	0.1	√
	Family labor availability	40	4.4	4	0.5	√	70	4.7	5	0.5	√	30	3.8	4	0.5	√
	Land ownership	38	4.2	4	0.5	√	66	4.4	5	0.3	√	37	4.6	5	0.5	√
	Availability of cheap hired labour	38	4.2	4	0.5	√	58	3.9	4	0	√	35	4.4	4.5	0.5	√
Economic aspects	Household income	45	5.0	5	0.0	√	73	4.9	5	0	√	40	5	5	0	√
	Crop yield	44	4.9	5	0.0	√	74	4.9	5	0	√	35	4.4	4	0.5	√
	Income diversity	35	3.9	4	0.5	√	50	3.5	4	0.8	Rejected					
	Livestock yield*						58	3.9	4	0.5	√	35	4.4	4	0.5	√
	Off farm opportunities	32	3.6	4	0.5	√	54	3.6	4	0.3	√	34	4.3	4	0.5	√

Table 4.27 (Cont.)

Social aspects	Food security	45	5.0	5	0.0	√	74	4.9	5	0	√	40	5	5	0.5	√
	Farm successor*						70	4.7	5	0.5	√	39	4.9	5	0	√
	Feeling of safety (from social crime and natural disaster)*						63	4.2	4	0.5	√	33	4.1	4	0	√
	Motivation and willingness of farmers to work on their farm	41	4.6	5	0.5	√	75	5	5	0	√	33	4.1	4	0	√
	Knowledge and skills of farmers	38	4.2	4	0.5	√	73	4.9	5	0	√	33	4.1	4	0	√
	Children's education	38	4.2	4	0.5	√	70	4.7	5	0.5	√	36	4.5	5.5	0.5	√
Environment	Forage availability	45	5.0	5	0.0	√	75	5	5	0	√	36	4.5	4.5	0.5	√
	Soil quality **															
	Absence of seasonal flood*						56	3.7	4	0.5	√	33	4.1	4	0.1	√
	No land erosion	35	3.9	4	0.0	√	67	4.5	4	0.5	√	31	3.9	4	0.1	√
	Water quality**															
Supporting facilities	Good market price	45	5.0	5	0.0	√	74	4.9	5	0	√	40	5	5	0	√
	Good infrastructure and transportation	36	4.0	4	0.0	√	67	4.5	5	0.5	√	34	4.3	4	0.1	√
	Market accessibility	33	4.0	3	0.5	√	62	4.1	4	0.5	√	34	4.3	4	0.5	√
	Post harvest management (availability of storages, processing technology, etc)	33	3.7	4	0.5	√	51	3.4	3	0.8	Rejected					
	Farmers organisation	32	3.6	3	1.0	Rejected										
	Credit support from government	32	3.6	4	0.5	√	61	4.1	4	0.3	√	34	4.3	4	0.1	√
	Government supervision and support	23	2.6	3	1.0	Rejected										
Cultural aspects	Cohesion of rural life*						66	4	4	0.5	√	40	5	5	0	√
	Cultural acceptance*						67	4	4	0.5	√	35	5	3.9	0.5	√
	Masohi (helping each other)*						58	4	4	0.3	√	35	5	3.9	0.1	√

Note: QD is quartile deviation
* are indicators added in the second round of focus group discussions by farmers
** are indicators eliminated from the selection as data was not available or not covered in the study
The maximal rank weight for the first, second and the third selection are 45, 75 and 40 respectively
The minimal rank weight for the first, second and the third selection are 9, 15 and 8 respectively
The primary selection was based on the local communities' perceptions about sustainability indicators, revealed by ranking
The second selection was based on the local experts' judgement regarding relevancy and sensitivity to the local situation
The third selection was based on the local communities' perceptions about sustainability after considering the judgement of local experts and additional missing issues

Table 4.28. Issue and indicator ranks and weights as perceived by farmers

Issue	Rank	Weight	SI code	Indicator	Rank	Weight
Cattle production	33.2	0.12	SI-1	Cattle safety (from social crime)	35	0.21
			SI-2	Cattle body weight	34	0.20
			SI-3	High fertility	34	0.20
			SI-4	Health condition	32	0.20
			SI-5	Information and services availability	31	0.19
Crop production	33.3	0.12	SI-1	Absence of crop pests	38	0.19
			SI-2	Seed availability	36	0.18
			SI-3	Crop-soil suitability	35	0.17
			SI-4	Fertilizer (chemical) availability	32	0.16
			SI-5	Crop-skill suitability	30	0.15
			SI-6	Information and services availability	29	0.15
Resource availability	34.3	0.12	SI-1	Area size	38	0.18
			SI-2	Enough capital	38	0.18
			SI-3	Land ownership	37	0.18
			SI-4	Availability of cheap hired labour	35	0.17
			SI-5	Family labor availability	30	0.15
			SI-6	Water availability	28	0.14
Economic aspects	36.0	0.13	SI-1	Household income	40	0.28
			SI-2	Crop yield	35	0.24
			SI-3	Livestock yield	35	0.24
			SI-4	Off-farm opportunities	34	0.24
Social aspects	35.7	0.13	SI-1	Food security	40	0.20
			SI-2	Farm successor	39	0.18
			SI-3	Children's education	36	0.17
			SI-4	Feeling of savety (from social crime and disaster)	33	0.15
			SI-5	Motivation and willingness of farmers to work on their farm	33	0.15
			SI-6	Knowledge and skills of farmers	33	0.15
Environment	33.3	0.12	SI-1	Forage availability	36	0.36
			SI-2	Absence of seasonal flood	33	0.33
			SI-3	No land erosion	31	0.31
Supporting facilities	35.5	0.13	SI-1	Good market price	40	0.28
			SI-2	Good infrastructure and transportation	34	0.24
			SI-3	Market accessibility	34	0.24
			SI-4	Credit support from government	34	0.24
Cultural aspects	37.3	0.13	SI-1	Masohi (helping each other)	38	0.34
			SI-2	Cultural acceptance	37	0.33
			SI-3	Cohesion of rural life	37	0.33

4.2.2 Estimation of sustainability

The relative deviations of the original values gathered from the field works from the reference values of each indicator for TVC, IPC and TRC farming systems on Ceram are given in Table 4.29 and Figure 4.7. In the cattle production issue, adult female body weight in all farming systems assessed (TVC, IPC and TRC) showed a positive contribution to the system's sustainability, with the deviation from the reference value ranging from 0.02 in TRC, to 0.14 in IPC. Cattle safety indicator showed positive contribution only in the TRC system (Dev=0). Other indicators distributed negatively. Among those indicators, fertility indicator deviated very much from the reference value of 86% fertility rate, ranging from -0.52 in TVC to -0.41 and -0.40 in IPC and TRC, respectively.

The crop production issue turned out to be most favourable in the TRC system, where only 1 out of 6 indicators deviated negatively from the reference value. The negative deviation was found in the indicator absence of crop pest, which still appeared to be cumbersome in TRC as well as in TVC (Dev=-0.33). All systems agreed that crops cultivated by farmers were suitable with the soil type in the majority of the farms, while only farmers in TVC system mentioned that their skills were less suitable for the crops cultivated by them.

Two indicators deviated negatively in the resource availability issue among the farming systems, namely enough capital and the availability of cheap hired labour. The majority of farmers in TVC, IPC and TRC systems complained that cash capital and hired labour were scarce in their farms, thus deviated negatively from the reference value. Other resources such as land, water and family labour contributed positively in all systems. In the TVC system, land ownership was another limiting factor contributing negatively to the system sustainability (Dev=-0.50), because many farmers in this system have no land certificate for their holding, as traditionally, their areas belong to indigenous villages.

In the economic issue, household income, derived from farm and off-farm income, was above the poverty line in rural areas of Maluku province in all systems tested. Crop and livestock yield contributed positively in IPC and TRC, while in TVC, both indicators deviated negatively from the reference value, namely -0.02 and -0.83, respectively. Off-farm opportunity also contributed negatively in all systems, ranging from -0.11 in IPC to -0.52 in TVC.

In TRC system, only knowledge and skills of farmers deviated negatively in the social issue, whereas other indicators contributed positively. Food security, consisting of the household protein and energy intake and children education were also meeting the target values in TVC and IPC systems. Regarding this issue, many farmers in the TVC system were feeling unsafe, especially from social crisis and natural disasters in their locations.

Table 4.29. Contribution of the sustainability indicators for the sustainability of the three farming systems

Issue	Indicator	Ind. Code	TVC		IPC		TRC	
			Dev.	Sust.Ind	Dev.	Sust.Ind	Dev.	Sust.Ind
Cattle production	Cattle safety	SI-1	-0.33	-0.070	-0.33	-0.070	0.00	0.000
	Adult male body weight	SI-2a	-0.30	-0.030	-0.25	-0.025	-0.25	-0.025
	Adult female body weigh	SI-2b	0.10	0.010	0.14	0.014	0.02	0.002
	Fertility rate	SI-3	-0.52	-0.107	-0.41	-0.083	-0.40	-0.082
	Health	SI-4	-0.33	-0.064	-0.33	-0.064	-0.33	-0.064
	Information and services	SI-5	-0.33	-0.062	-0.33	-0.062	-0.33	-0.062
Crop production	Crop pests	SI-1	-0.33	-0.063	0.00	0.000	-0.33	-0.063
	Seed availability	SI-2	-0.33	-0.060	-0.33	-0.060	0.00	0.000
	Crop-soil suitability	SI-3	0.00	0.000	0.00	0.000	0.00	0.000
	Fertilizer availability	SI-4	-0.33	-0.053	-0.33	-0.053	0.00	0.000
	Crop-skill suitability	SI-5	-0.33	-0.050	0.00	0.000	0.00	0.000
	Information and services	SI-6	-0.33	-0.048	-0.33	-0.048	0.00	0.000
Resource availability	Area size	SI-1	0.00	0.000	0.85	0.157	0.65	0.120
	Enough capital	SI-2	-0.33	-0.061	-0.33	-0.061	-0.33	-0.061
	Land ownership	SI-3	-0.50	-0.090	0.00	0.000	0.00	0.000
	Cheap hired labour	SI-4	-0.33	-0.057	-0.33	-0.057	-0.33	-0.057
	Family labor	SI-5	0.18	0.025	0.23	0.033	0.15	0.022
	Water availability	SI-6	0.00	0.000	0.00	0.000	0.00	0.000
Economic aspects	Household income	SI-1	0.95	0.265	1.71	0.475	2.81	0.779
	Crop yield	SI-2	-0.02	-0.005	0.05	0.013	1.00	0.244
	Livestock yield	SI-3	-0.83	-0.203	0.00	0.000	0.00	0.000
	Off-farm opportunities	SI-4	-0.52	-0.124	-0.11	-0.025	-0.31	-0.073
Social aspects	Food security (energy req.)	SI-1a	0.15	0.012	0.10	0.008	0.75	0.060
	Food security (protein req.)	SI-1b	0.10	0.008	0.09	0.007	0.59	0.047
	Farm successor	SI-2	-0.33	-0.061	-0.33	-0.061	0.00	0.000
	Children's education	SI-3	0.00	0.000	0.50	0.084	0.50	0.084
	Feeling of safety	SI-4	-0.33	-0.051	0.00	0.000	0.00	0.000
	Motivation and willingness of farmers	SI-5	-0.33	-0.051	-0.33	-0.051	0.00	0.000
	Farmers Knowledge and skills	SI-6	-0.33	-0.051	-0.33	-0.051	-0.33	-0.051
Environment	Forage availability	SI-1	-0.08	-0.029	-0.08	-0.029	-0.08	-0.029
	Absence of seasonal flood	SI-2	-0.33	-0.110	0.00	0.000	-0.33	-0.110
	Land erosion	SI-3	-0.33	-0.103	0.00	0.000	-0.33	-0.103
Supporting facilities	Market price	SI-1	-0.33	-0.094	-0.33	-0.094	-0.33	-0.094
	Infrastructure and transportation	SI-2	-0.33	-0.080	-0.33	-0.080	0.00	0.000
	Market accessibility	SI-3	-0.33	-0.080	-0.33	-0.080	0.00	0.000
	Credit support	SI-4	-0.67	-0.160	-0.67	-0.160	-0.33	-0.080
Cultural aspects	Masohi	SI-1	-0.33	-0.113	-0.33	-0.113	-0.67	-0.226
	Cultural acceptance	SI-2	0.00	0.000	0.00	0.000	0.00	0.000
	Cohesion of rural life	SI-3	0.00	0.000	0.00	0.000	0.00	0.000

Note:
TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice
OV = original value (compare table 3.9 for ranking explanation)
RV = reference value (compare table 3.9 for ranking explanation)
Dev = deviation of original value from the reference value
Sust. Ind.= sustainability index (Dev multiplied by the specific weight, compare table 4.28 for the weights applied)

In measuring the environmental issue, the IPC system showed positive responses to the absence of seasonal flood and land erosion, while other systems did not. Forage availability in all systems deviated negatively from the reference value (Dev= -0.08).

All indicators measuring the supporting facilities issue contributed negatively in TVC and IPC systems (Dev=-0.33). Among those indicators, credit availability was the major problem in both systems (Dev=-0.67) while in TRC, the deviation was less (Dev=-0.33). The latter system has a better infrastructure and transportation in their locations, thus the market became accessible (Dev=0).

Cohesion of rural life and cultural acceptance among systems were contributing positively when the cultural issue was measured. However, the traditional custom of helping each other on the farms and in off-farm activities, for private or communal benefit (*masohi*) decresed in the last 5 years, especially in the TRC system, thus, it contributed negatively in all systems, with the deviation ranging from -0.33 in TVC and IPC to -0.67 in TRC system.

From the 37 indicators used in estimating the farms' sustainability in the study, 5 indicators deviated very much from their target values in TVC. Those are livestock yield (Dev=-0.83), Credit support (Dev=-0.67), off-farm opportunities (Dev=-0.52), cattle fertility (Dev=-0.52) and land ownership (Dev=-0.50). In the IPC and TRC systems, two indicators deviated most, namely credit support (Dev=-0.67) in IPC system and *masohi* (Dev=-0.67) in TRC system.

The overall contribution of the issues to the sustainability of the systems was summaried in Table 4.30 and Figure 4.8. With positive contributions of economic, social and resource availability issues of 0.452, 0.192 and 0.016, respectively, the TRC system showed the highest and the only positive aggregated sustainability index (0.203), followed by the already slightly negative aggregated value of IPC (sustainability index = -0.342) and finally TVC (sustainability index of -1.066).

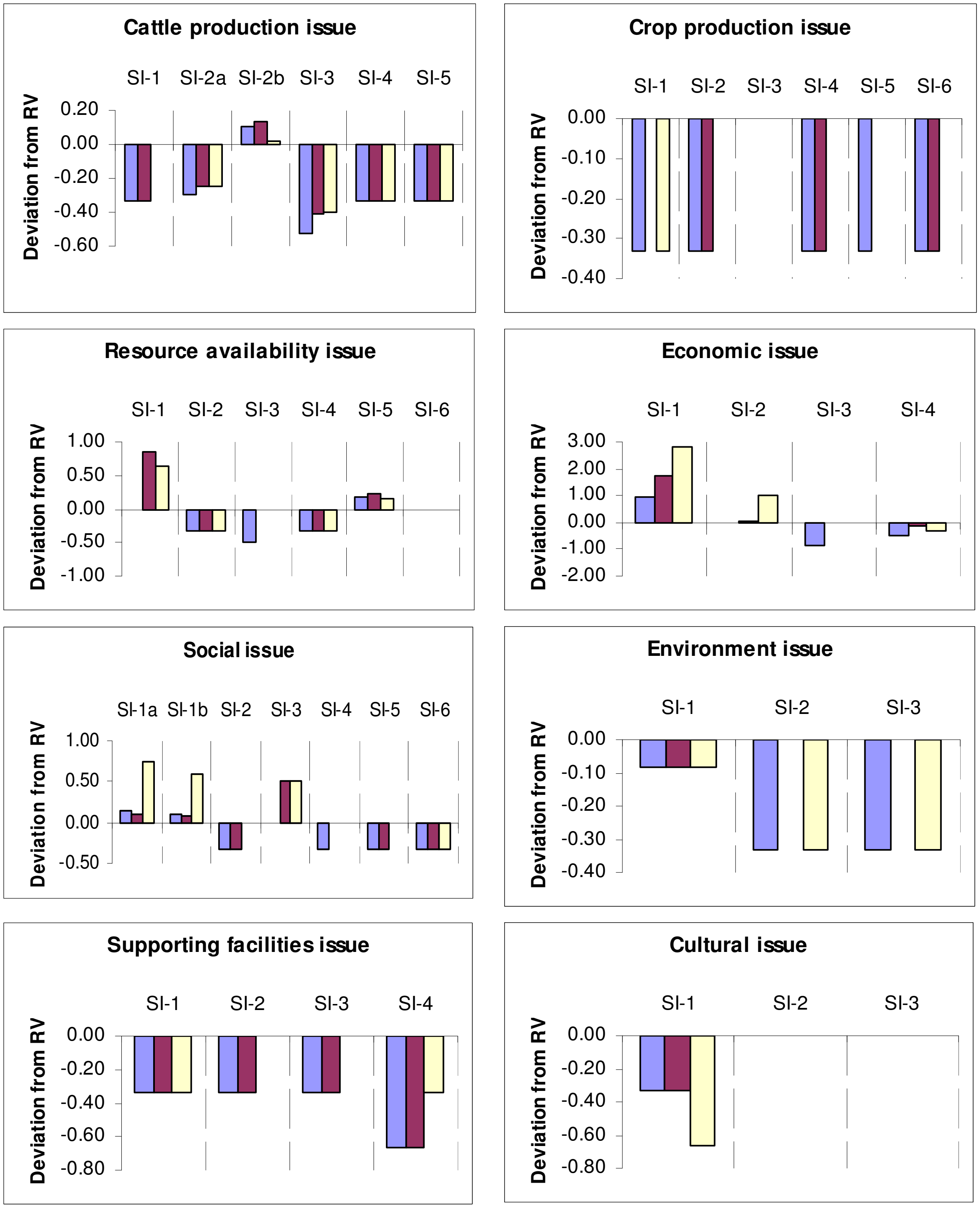


Figure 4.7.Relative deviation of the sustainability indicators from the baseline (reverence values) of the three farm systems on Ceram, according to the sustainability issues.

TVC, IPC, TRC

TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice
Compare table 4.29 for the explanation of SI (=sustainability indicator) codes.

Table 4.30. Contribution of issues to the sustainability of the three farming systems

Issue	TVC	IPC	TRC
Cattle production	-0.205	-0.180	-0.154
Crop production	-0.199	-0.120	-0.040
Resource availability	-0.122	0.050	0.016
Economic aspect	-0.055	0.214	0.452
Social aspect	-0.138	-0.040	0.192
Environment	-0.089	-0.010	-0.089
Supporting facilities	-0.212	-0.212	-0.085
Cultural aspect	-0.045	-0.045	-0.089
Overall Susainability Index	-1.066	-0.342	0.203

Note : TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice

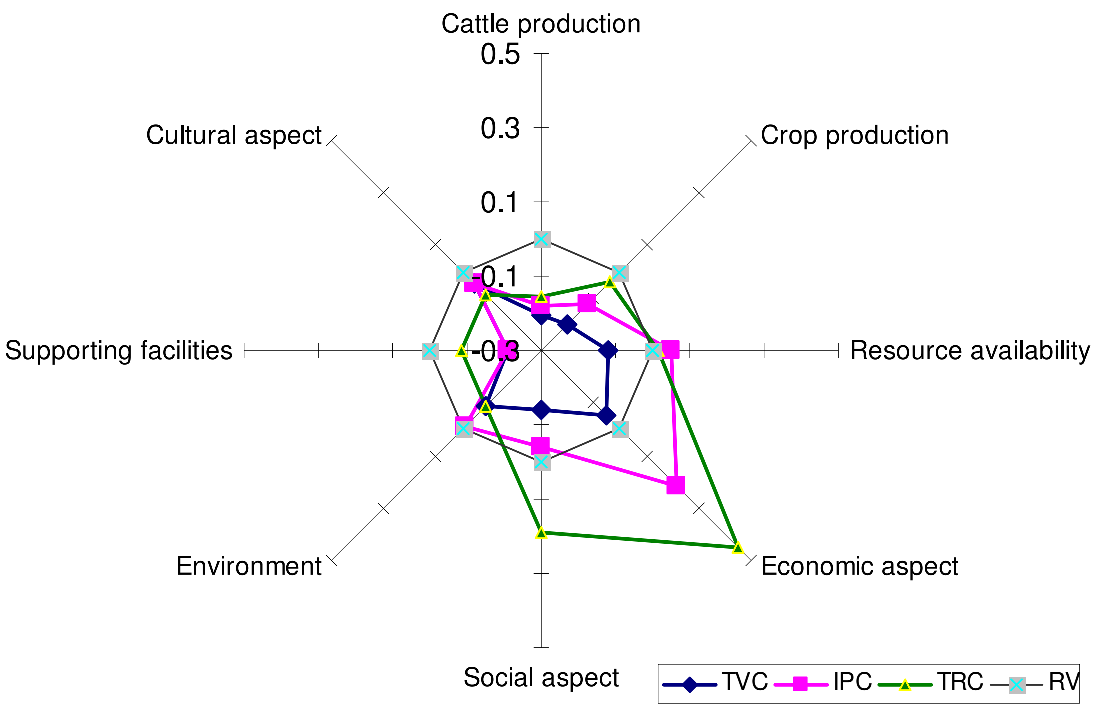


Figure 4.8. Radar graph of sustainability estimation in three farming systems on Ceram

TVC = farm system with predominantly transmigrant cattle farmers planting vegetables
IPC = farm system with mostly indigenous cattle farmers with perennials crops
TRC = farm system with primarily transmigrant cattle farmers cultivating rice
RV = reference values used as baseline (=0).

5 DISCUSSION

Assessing the current production systems of indigenous and transmigrant farmers is a prerequisite for the design of sustainable beef production systems on Ceram Island. The study met its specific objectives by (a) a comparative characterisation of current Bali cattle performance and respective farming systems, (b) developing a set of sustainability indicators based on locally identified issues and (c) evaluating the sustainability of current beef production with Bali cattle in indigenous and transmigrant farms on Ceram Island, Indonesia. It was hypothesised that farm resources, and productive and reproductive performance of beef production in the studied mixed farming systems differ according to the migratory status of the farmers, leading to different economic efficiencies and thus, different points of departure for optimising the systems in regard to sustainability. The study showed however that the differentiation of the systems is not as clear-cut. Although people of different migratory status generally live apart, their systems do show some similarities. Transitions between groups could be depicted.

5.1 Bali cattle keeping in mixed farming systems

5.1.1 Production systems of smallholder cattle keepers

Farm type

Smallholder cattle production systems were differently classified by many authors in the literature. Schiere et al. (2002) draw a matrix of crop-livestock systems to classify the systems based on relative access to three farm resources, namely land, labour and capital. Bebe et al. (2003) focused on the level of intensification in classifying smallholder cattle production systems in Kenya. Paris (2002), Dewi and Mendoza (2006) and Siegmund-Schultze et al. (2007) classified cattle production in relation to the crops grown in the mixed farming systems by using different diversification schemes, such as annual crop and cattle, perennial crops and cattle, and annual and perennial crops and cattle. In the present study, smallholder cattle production was classified according to agricultural and non-agricultural production patterns and resource availability on farm.

In the region studied, crop type was the main variable to distinguish one cattle production system from another. It determined the socio-cultural setting, potential options and interventions aiming at optimizing the systems. Farmers in the IPC system pursued dry land agricultural production with spice trees, such as cloves and nutmeg, since centuries, and as learned from their ancestors. This production type was reported also in other islands of Maluku, known as *dusun* system which refers to agroforestry systems (Kaya et al., 2002). On the other hand, farmers in the TVC and TRC systems with the majority are transmigrant farmers, established new systems in their current settlement areas, by planting annual crops. In this group, farmers in the TRC system were growing rice in the rice fields provided to them by the government, or were planting vegetables in the plots given to them. Farmers in the TVC system were mostly planting vegetables and tuber crops, such as cassava and sweet potato.

Resource availability and on-farm resource use also varied among the cattle keepers of the farming systems. Farmers in the IPC system, with the majority are indigenous people, were confirmed to have a bigger land size than in other systems, because they inherited their land from their ancestors who were known as the landlords (Syuryadi, 2008). For transmigrant farmers in TVC and TRC systems, land ownership and size varied according to their specific migratory status. Those who were beneficiaries from the national transmigration programme received their land as a gift from the government, whereas those who moved on their own were not (Holden et al., 1995; Leinbach, 2003). All systems are reported to have a small family size and using family labour to more than 93%.

Cattle management

While the cattle management showed no significant differences between indigenous and transmigrant farmers when considered as two groups, the three clusters, however, showed high differences among those variables. Herd size, defined as the total population of cattle raised in each farm (Carstensen and Christensen, 1998), of 4.3 – 6.2 in TVC and TRC clusters confirmed the finding of Dinas Pertanian Provinsi Maluku (2007) of 4 – 6 cattle per household. However the numbers were higher than the average herd size in West Timor of 2.4 cattle (Bamualim and Wirdahayati, 2003) and 3.25 cattle per household reported by Santoso et al (1991) in transmigration villages in Riau province of western Indonesia, but lower than 7.9 cattle per household in transmigration villages of East Kalimantan Province (Bosma et al., 2001). The herd size of 8.9 cattle per household in the IPC cluster however exceeded the average herd size in Maluku reported by Dinas Pertanian Provinsi Maluku (2007). Herd size is indeed varying among agro-ecological zones and countries, especially in Southeast Asia, although with a tendency to small herds. Mentioned were 1 – 8 cattle per household in Indonesia (Santoso et al., 1991; Hadi et al., 1999; Bosma et al., 2001; Bamualim and Wirdahayati, 2003), 3 – 10 cattle per household in Laos, 4 – 7 cattle per household in Cambodia (Harding et al., 2007) and 1 – 5 cattle per household in northern Vietnam (Huyen, 2010). The present study indicated that the crop types grown by farmers were associated with the realised herd size. Indigenous farmers, who planted perennial crops, tent to have more cattle, while their counterparts, who were growing annual crops, owned fewer cattle.

Herd composition also varied among farm types, but depended highly on the purposes of keeping the animals and resources available and used on-farm. The present study showed a lower sex ratio in all clusters of 1 male for every 3 females, compared to the study conducted on Timor Island, Nusa Tenggara Province of 1 male for every 5 – 6 females (Wirdahayati and Bamualim, 1990), what is still a very narrow ratio. The differences could be attributed to the function of male Bali cattle as working animals in crop production, particularly in the rice fields in the study area, where more bulls were raised, compared to the situation on Timor Island. However, the results for TVC and TRC can only partly be compared with other data as they represent specific sub-groups of transmigrant farmers not reported elsewhere.

Even though the supplementation with rice bran in the cattle feeding was highly correlated with crop type grown, namely rice, not all rice farmers gave bran to their cattle and some non-rice growers however did so. The TRC cluster accommodated the higher percentage of rice bran given to cattle simply because farmers in this cluster predominantly planted rice, while TVR and IPC did not. On the other hand, salt was used commonly in all clusters either by using purchased salts or, in 6 cases in West Ceram district, using salty water collected from the sea.

Economic assessment

Economic analyses of smallholder livestock production systems are generally focusing on the production traits in terms of cash income received, as cash revenues minus costs. By using this approach, livestock, particularly cattle production, was often seen to contribute relatively little to the household cash income compared to crop production in smallholder mixed production system. This study, for instance, recorded the contribution of cattle of only 1 – 9%

to the total household cash income, which was comparable to many other farm situations as reported in the literature (for instance, Huyen, 2010).

This study confirmed that agricultural production, particularly crops, contributed most in every cluster to household gross income. Gross income received by all clusters was above the poverty line estimated by the national government for the rural area in Maluku province of IDR 2,395,152/capita/year (equal to USD 257.5) (CBS, 2010). Income from off-farm activities particularly from the oil exploration companies contributed little in the farm households due to the limited number of farms included in the study which were engaged in the oil company (n=3). The contribution of the oil company to those three households was accounted for 31% of the total household's income. The net agricultural income in every cluster varied mostly according to the crop type grown by the farmers. The higher income registered in clusters TRC and IPC reflect the high-value crops grown in both clusters such as rice, the national staple food, and cloves, the provincial first export commodity, a sector which received more attention and priority from the government in terms of provision of services, market and inputs subsidies, besides the bigger farm size that allows more production to be obtained. Farm size of TRC was, however, not statistically significantly bigger than that of TVC. The situation in the present study was comparable with the high income obtained in Kandy, Sri Lanka, because of the high-value crops planted by the farmers and the relatively big farm size (Herrero et al., 2007). In contrast, TVC received a lower agricultural net income compared to TRC and IPC. This can be explained by smaller farm sizes and little contribution from the small cattle herds. Change in herd inventory via births or animal growth was not considered here as the software used only the revenue to calculate the income. However, when the incomes were compared per hectare of land owned, cluster IPC received the lowest income compared to TVC and TRC. A higher share of uncultivated land can have led to the lower income per land unit in the IPC cluster. Besides, harvest frequency of once a year in perennial crops could not compete with 2 times harvest per year of rice and 2 – 4 times harvest per year of vegetables planted by farmers in TRC and TVC. Farmers in both, TVC and TRC clusters, invested their income to a higher percentage in crop production reflecting the more intensive crop production systems practiced by both groups using high inputs (land and labour) in order to produce relatively high outputs. However, in general, no difference in household income received from agricultural production according to farmer's migratory status has been recorded. This is because, as mentioned above, high revenue received from perennial crops cultivated by indigenous farmers was comparable with revenue from annual crops planted by transmigrant farmers.

Cluster IPC farmers spent more income for purchasing food compared to other farmers because the main crops grown by the farmers in the cluster were non-food crops such as cloves and cocoa beans. In contrast, TRC purchased less food as they produced staple food (rice) and several vegetables and fruit crops that were used in daily food consumption. Lower food purchases are also related to the availability of improved storage for rice in almost every farm to keep the portion for the household's consumption until the next harvest. Probably because of the higher dependency level of IPC farmers on purchased food, they tried to generate more income from off-farm activities to buffer the expenditure for the purchased foods as this was economically reasonable to do. Among all three clusters, and on average, families consumed more than the minimum energy and protein requirements established by WHO. Hence, no nutritional status difference was encountered between indigenous and transmigrant households in the study area.

Labour was used to a high percentage in all clusters with more than 90%, hence unemployment was almost nil. Involved were men, women, youth and children as family labour force to achieve the current income. This reflects the high work load on the farm forcing the farmers as farm managers and decision makers to employ their family labour to almost the upper limit. Although it is often assumed that there is a constant supply of abundant farm wage labour in the tropical rural area (Waithaka et al., 2006), it appeared to be a high-cost input for farms and was applied only in seasonal needs such as for land preparation and during the harvest period. On Ceram, unlike in other tropical rural areas where wage labour can be paid with in-kind payment (Waithaka et al., 2006), wage labour was paid in cash per working day in the field. The efficiency of labour used in crop production however varied among crop types, where perennial crops were more efficient in producing income per manday compared to annual crops. The high market price for perennial crops (1 kg cloves = IDR 50,000 with an average yield of 800 kg per ha and 1 kg rice = IDR 6,000 at about 6000 kg/ha), compared to daily wages of IDR 30,000 – 45,000 per person, is one reason explaining the differences. Besides, perennial crops compared here were in the stage of maturity and no land preparation or planting activities, which would consume more labour, were included. On the other hand, annual crops were single harvest crops with complete activities needed from land preparation until harvest in their lifespan of more than one time per year.

Livestock production was very efficient in using labour. It could generate 1 USD (IDR 9,300) per manday labour applied in all clusters, however, this was not sustainable, since destocking was commonly practiced. However, the value was three times higher than the 0.3 USD (IDR 3,000) per day reported by Bosma et al. (2001) in East Kalimantan as an average Bali cattle contribution to the household's income. Higher labour applied for cattle, particularly in planting improved forages for cattle feeding in East Kalimantan compared to a minimum use of labour for cattle rearing and destocking or overextraction practice on Ceram Island, could be attributed to the higher labour efficiency per kilogram livestock production on Ceram during the study period.

This study confirmed only partly the typology of farms on Ceram as derived from their background of origin (indigenous and transmigrant). The transmigrant group was split into two by cluster analysis, showing that the transmigrant farmers had diverse strategies. Moreover, the formed groups were not homogenous regarding the migratory status, indicating that integration between indigenous and transmigrant farmers already took place in terms of knowledge exchange in farming practices. Thus, several indigenous farmers were grouped together with transmigrants in the transmigrant majority-clusters and vice versa. Despite the controversial opinion on the use of cluster analysis, that the analysis may lack an underlying theoretical rationale where groups are formed on random numerical variation only (Thomas and Venkatraman, 1988; Reger and Huff, 1993) without ability to run any statistical test (such as F-test) to identify factors causing variation (Ketchen and Shook, 1996), the analysis proved more useful for categorizing the farms according to the series of entered variables rather than grouping the farmers based only on their background of origin alone. Although it was confirmed that differences exist regarding this factor, it was not an overruling factor to distinguish farms on the Island. Therefore, cluster analysis was used as a means to categorize farm households in a quantitative manner based on resource availability on the farm, production pattern and household activities. This method has been widely used in classifying farming systems (Hardiman et al., 1990; Weigel and Rekaya, 2000; Siegmund-Schultze and Rischkowsky, 2001; Köbrich et al., 2003; Iraizoz et al., 2007).

5.1.2 Performance of Bali cattle

Bali cattle are responsible for most of the beef production in some provinces of Indonesia, while accounting for more than 27% of the total cattle population of the country (Ditjenak, 2009). Aiming at increasing the production volume requires the evaluation of the current performance and the cattle keeping management. The performance can be measured by productive and reproductive parameters, which are closely related to the genetic and environmental conditions (Legesse, 2008).

The age of the males at first mating of 22.5 months in West Ceram district was comparable to what was reported by Pane (1991) of 22 months in West and East Nusa Tenggara provinces, and 27 to 28 months as in Kairatu and Bula district was also found in South Sulawesi and Bali (Pane, 1991). The use of bulls for ploughing in crop production in Kairatu and Bula districts, similarly reported for Bali and South Sulawesi, could have affected the bulls' physical condition that in turn affected the age of the first mating in bulls. Weaning age of 7.5 to 7.8 months was only slightly older than 6.8 months reported by Pane (1990). The cow age at first calving of 34 months was slightly older than 32 months reported in West and East Nusa Tenggara (Pane, 1990) and Bali (Talib et al., 2003) but shorter than 36 months in South Sulawesi (Talib et al., 2003). Fertility rate reported on Ceram of on average 47% was lower than 75 - 86% reported in the East and West Nusa Tenggara provinces (Wirdahayati and Bamualim, 1990) and Bali (Pane, 1991). Calving interval of 383.5 days on Ceram was comparable with 388 days reported by Sumbung et al. (1978) in Sulawesi and 384 days in Sabah, East Malaysia (McCool, 1992), but shorter than 430 days in Bali and 510-520 days in Nusa Tenggara provinces (Pane, 1990). Assuming gestation length on Ceram was 288 days as reported for Bali (Oka, 2003), the days open were 111 days agreeing with Wirdahayati and Bamualim (1990).

Bhatti et al. (2007) argued that one of the reasons for delayed age at first calving in heifers was low growth rate, due to limited amounts of protein and energy in the feeds. The deficiencies in protein and energy were also affecting calving interval and cattle fertility rate besides other factors such as genetics, season of calving and diseases. Despite the higher fertility rates reported by many authors (Payne and Rollinson, 1973; Wirdahayati and Bamualim, 1990; Talib et al., 2003), Bali cattle on Ceram Island by the time of the study showed very low fertility rates. This range was even lower than the lowest percentage found in literature of 69% in Bali in the year 1990 (Pane, 1990). The author argued that the intensive use of Bali cattle for draught power as a traditional farming practice was the reason for the low fertility rate registered. However, fertility is generally closely related to herd management and the environmental factors (Weigel, 2004). Thus, the low fertility rate reported for Bali cows on Ceram could be attributed to several factors. Nutritional deficiencies in available forages, which were not balanced by feed supplementation, could have resulted in delayed return to oestrus. Lactating cows may have allocated available nutrients to production at the expense of improving body condition necessary to stimulate ovulation. On the other hand, the calving intervals reported in this study could only be based on 41% of the total adult females sampled, from which data of at least two calvings were available. This implies that most of the females had either not given birth at all, or had just calved once so far. In a natural mating system, conception rate depends on the bull to cow ratio, influencing the probability of bulls coming into contact with the breeding cows. Some farmers in the study area grazed their cows in the common grazing ground inside the forests where they were not necessarily exposed to any breeding bull. Other farmers tethered their cows on a tree or a fence, while the bulls were moved freely, again not neceassarily meeting the cows in time. In addition, most farmers were not keeping breeding bulls individually to service their cows, only relying on chance that their cows will encounter a bull during grazing. Most of the bulls kept were used for ploughing. Thus, bulls ready for breeding were scarce or not encountered when cows were in heat. It is therefore likely that many cows were just not mated because of limited contact to breeding bulls.

The predicted average daily weight gain of Bali cattle on Ceram of on average 200 – 230 g/day from 0 – 6 months of age, was also lower than 230 – 270 g/day reported in traditional Bali cattle production systems in western Bali (Nitis and Mandrem, 1978) and 280 – 370 g/day in Australia (Kirby, 1979). In fact, in an intensive production system, the average daily gain can reach 870 g/day (Moran, 1978). This indicates that cattle production on Ceram remained considerably beneath their growth potential. However, the average daily weight gain in the present study was predicted from the weight development of certain age stages, thus some room for errors. The values may only give a very rough idea and a more detailed study designed for it may give more reliable insight.

Calf mortality of 17.9% was similar with what reported by Jelantik et al. (2008) in Nusa Tenggara Provinces, only slightly better than 20% in Malaysia (Devendra et al., 1973), but better than the range given by Wirdahayati and Bamualim (1990) in Timor Island of 20-50% annually, 40% in Australia (Kirby, 1979) and 48% in East Nusa Tenggara (Talib et al., 2003). Relatively stable climatic conditions with regular numbers of dry and wet months on Ceram Island, resulting in the availability of palatable grasses and legumes year round, may be attributed to the lower average calf mortality registered. Adult mortality of 17% is higher than 4% in Lampung province (Siregar, 1983). The difference could be attributed to higher social crime, such as cattle poisoning and injuring adult cattle reared in road sides or communal pastures as reported by extension services, which affected cattle population on Ceram at the time the study was conducted.

An average pre-weaning weight of 71.7kg was also found in Grati, East Java province (Santosa and Harmadji, 1990), which was lower than the average pre-weaning weight in South Sulawesi, Nusa Tenggara and Bali provinces (Pane, 1990). Post-weaning weight was higher than in other provinces, while yearling weight was similar to West Nusa Tenggara province (Pane, 1990) but higher than the range reported by Talib et al. (2003) of 99.2 to 129.7kg in South Sulawesi and Bali. Adult male and female live weight matched with the range reported by Sumbung et al. (1978) from 250 – 350kg in adult females and 350 – 400kg in males.

The average live weight of cattle kept by transmigrant farmers was slightly higher than cattle kept by indigenous farmers although statistical differences appeared only in post-weaning weights. This may be related to feeding management practiced by transmigrant farmers, especially those who are living in Kairatu district. They supplemented their cattle with rice bran and crop by-products in the harvest period while the indigenous farmers in other districts did not. In Kairatu district, differences according to religion and farmers' migratory status were not confirmed. However, when comparing cattle body weight across districts, significant differences were found especially between West Ceram and Kairatu districts. The use of rice bran and crop-by products as feed supplement that was common practice in Kairatu district by transmigrant farmers and some of the indigenous farmers who lived close to transmigration villages could be attributed to the differences of cattle live weight among districts. Number of cattle managed by household seems to have no effect on the cattle body weight, except for the adult male Bali cattle, where the bigger the cattle number, the higher the body weight. This is probably related to the marketing objectives of farmers, where adult males were raised mostly for selling, and farms with higher cattle number had a higher tendency to sell animals every year (regular harvest) while farms with smaller herd size had not. Among indigenous farmers, differences can be observed in terms of body weight of heifers and young bulls, whereas heifers and young bulls in Indigenous-Christian villages in Kairatu district showed significantly higher then in indigenous-Muslim village in West Ceram, but not in Bula districts. Small number of heifers and young bull in indigenous-Christian villages (n=11) could be one of the reason for the difference. Hence, the effect should be considered in further research to confirm its influence in the yearling body weight. Results also confirmed the differences according to sex in the Bali breed, after the yearling age. The male Bali cattle were heavier than the females as also reported by Mansjoer et al. (1978).

However, the performance of Bali cattle reported by several authors was below the performance potential of the Banteng in their original habitat (Pane, 1990). The major problem faced by the smallholder cattle production in the mixed system was the low quantity and quality of forage production, either in the form of native pasture or supplements (crop by-products and concentrates) to feed the animals, as indicated in the present study (chapter 4.1.2). This problem caused under-nourishment, leading to low productive and reproductive performance (Sultan et al., 2007). In fact, farmers in Indonesia and other South East Asian countries are relying on the native forages and crop by-products to feed their animals, as planting grasses for livestock is uncommon in the region (Rachmat et al., 1992).

The results of the present study regarding the productive performance of Bali cattle on Ceram Island are comparable with the reports on Bali cattle performance in other parts of Indonesia as well as in other countries such as Malaysia, Australia and the Philippines. Variation among locations may be attributed to differences in management practiced and environmental conditions, particularly feed availability and quality, playing a role on the performance level.

5.1.3 Forage availability and quality

Dominant vegetation found in the forage on Ceram Island contained several genera with high tolerance to shading such as *Axonopus, Calopogonia* and *Desmodium,* which are good to be planted under perennial trees such as coconut and cloves plantation areas (Reynold, 1978) and produce relatively high dry matter yield (Mullen et al., 1997), mixed with low yield genera such as *Neunotonia*, and *Centrocoma* (Kaligis and Sumolang, 1991). The botanical composition confirmed the finding of Kaligis and Sumolang (1991), Rika et al. (1991), Mullen et al. (1997) and Nitis (1999) who reported the native tropical grasses included *Axonopus, chrysopogon, Cyperus, Eleusine* and *Leersia,* whereas legumes included *Centrocoma, Desmodium, Calopogonia* and *Neunotonia.*

In the rainy season, dry matter yield of forage containing these natural grasses and legumes on Ceram was 6.9 ton/ha. This yield was remarkably higher compared to dry matter yield in the wetland and dryland farming areas of Bali from 0.48 to 1.89 ton/ha in wet and dry season, respectively (Nitis et al., 1980; Nitis, 1999) or 1.9 to 2.3 ton in Mozambique (Muir et al., 1995). An overestimation of dry matter yield in this study through a methodological bias of not standardizing the growth period of grasses and legumes could be attributed to the higher dry matter yield registered on Ceram. Nevertheless, there are climatic differences between the locations. The long rainy season of 6 months and 4 months dry season on Ceram (with 2 months transition between seasons) with 1000 – 4500 mm annual rainfall cannot fully be compared to 4 months rainy season and 6 months dry season in Bali or 650 mm rainfall in Mozambique. However, in West Samoa, where the rainy season appeared for 6 months with the average annual rainfall of 2929 mm, dry matter yield from the natural grass was slightly higher, of about 7.5 ton/ha (Reynold, 1978).

Crude protein of 4 – 6% on Ceram was lower than 8.4 – 8.7% average crude protein from natural pasture in western Indonesia and Pakistan (Sutardi, 1991; Sultan et al., 2007) or the range of 8.19 – 10.50% in Western Samoa (Reynold, 1978) and 13% during the rainy season of North Sumatra (Evitayani et al., 2005) but is comparable with 5% in Nusa Tenggara Provinces (Kuswandi, 1990). Buxton (1996) recommended an average of 10% of crude protein for tropical pastures while Sultan et al. (2007) suggested that at least 13.5% crude protein should be in natural pasture. The National Research Center (1985) gives crude protein requirements of at least 7% for mature beef cow. The low percentage of crude protein contained in dry matter basis on Ceram was compared to the requirements of cattle. Yet it is to be taken into account that the measurements undertaken in this study did not account for any selection by cattle. The whole samples were analysed, thus not separating the different plants neither their parts. Moreover, crude protein is highly related to the growth stage of grasses and soil fertility (Kilcher, 1981; Buxton, 1996; Hakyemez et al., 2008, Hussain and Durrani, 2009). The samples were however taken at one specific point in time only. Thus the average diet intaken by cattle could also be slightly richer (due to cattle selection and earlier growth stage of grasses) or even be lower in protein (grass at a very late growth stage).

Crude fiber content of 34 -38% was similar to 38% reported by Sutardi (1991) in the western part of the country, but higher than the 23.9% - 26.9% in Pakistan (Hussain and Durrani, 2009). A later growth stage of the naturally grown grasses on Ceram compared to planted natural grasses at a more valuable growth stage in Pakistan could be the reason for the higher crude fibre percentage registered on Ceram. The gross energy content in the forage on Ceram was 13.2 MJ/ton DM/ha, and this was lower than the most commonly accepted value of 18.4MJ/kg DM for ruminant diets (Kadzere, 1995), although several locations such as road sides and river bank areas in West Ceram district exceeded the value. The variation of gross energy, as also in crude fiber, was mainly attributed to variation of herbage composition and the growth stage of grasses.

When comparing forage yield across districts, significant differences were found between West Ceram and Kairatu with Bula. Higher population density in Bula districts as compared to West Ceram and Kairatu could explain the lower availability of forage in the district. The increased economic activities in Bula, by the establishing of two international oil exploration companies and as a result of being the capital city of East Ceram Regency since 2005, pushed the district to a transition from small villages to towns creating pressure on the land. This may lead to lower forage yields in the district. River erosion was observed to a higher degree in Bula (Dinas Pertanian Provinsi Maluku, 2005), leading to loss of vegetation and thus lower dry matter yields in river bank areas in Bula district. Results suggested that pastures and river banks were more favourable for cattle grazing compared to road side areas as the latter produced less quantity and lower quality of forage.

Some farmers used rice bran and crop by-products to supplement their cattle during the harvest period where those feeds were available. By simply calculating the total rice production on Ceram of 12,731 ton/year (CBS, 2010) and containing 7 – 8.5% rice bran (Anon., 2010) the total rice bran yield per year on Ceram would be 891.2 – 1082.1 ton with 88.5% dry matter, 9.45% crude protein and 16% crude fiber (Jelantik et al., 2008). The amount looks promising to increase the feed availability for livestock nutrient requirements on the Island when using it to supplement the mere use of natural grasses and legumes. The availability and applicability of this by-product should be further studied regarding transport and labour costs, timing, restricting wastage and potential alternative uses.

Hence, further research on forage availability and quality on a seasonal basis is needed to understand the year-round forage availability and quality on Ceram. Associating this with climatic conditions, particularly solar radiation and rainfall patterns, and soil type and its quality is useful in order to better understand the availability of dry matter and nutritive value per hectare land by districts and grazing locations.

5.2 Sustainability of beef keeping in the mixed farming systems

5.2.1 Developing sustainability indicators

Sustainability indicators as measurement tools in assessing sustainability were developed and used in almost every discipline, organisation, country and region since the term sustainability earned broad attention in the Rio Earth Summit in 1992. Heink and Kowarik (2010) provided a variety of definitions, using various points of view, including indicators as descriptive, normative and hybrid measurements or components, indicator as parameter values, measurements or measurement results in hybrid concepts. A simple understanding of an indicator provided by Rigby et al. (2001) was the indicator as a proxy of something in which one has an interest but which is difficult or impossible to monitor itself. There are two common points of the authors regarding an indicator: first, an indicator is a proxy to measure a complex system, second, the interpretation and validation of the indicator depends on how it fits with our understanding about the system, which consists of interactions between three sustainability dimensions, namely economic, environmental and societal. The theoretical basis used to develop the indicators was that sustainability is site- and system-specific and the involvement of local communities was essential, since all indicators were raised in accordance with the availability of resources and the relevance to the particular farming system (Campbell and Heck, 1997).

Locally derived indicators for sustainable farming systems on Ceram Island, Maluku, focused in the present study on the common issues that were cited frequently in sustainability indicator selection by many researchers in the world (Andreoli and Tellarini, 2000; Campbell et al., 2001; Giourga and Loumou, 2006; Dantsis et al., 2010). This similarity confirmed the statement given by Dougill and Reed (2004) and Subedi et al. (2009) that farmers and researchers shared a common understanding of the term sustainability although the groups used different words to refer to sustainability. Farmers and stakeholders in the study area formulated indicators according to their objectives regarding the production system. Cattle production, for instance, was defined using specific indicators such as cattle body weight and cattle ownership, representing the objectives of farmers in keeping cattle to afford high body weights at sale and owning cattle rather than raising cattle of other farmers as it is common in almost every part of Indonesia. Health and forage availability were among the common indicators used in sustainability assessment of livestock production (for instance Mollenhorst, 2005, in assessing sustainability of egg production systems) besides high fertility, pedigree of the animals, animal safety and information and services available to support the production. Cattle body weight and fertility were indicators used in the cattle production issue suggested also by pastoralists in Kalahari district, South West Botswana, to measure livestock production sustainability (Dougill and Reed, 2004). These indicators, as mentioned above, besides representing the objectives of farmers in keeping cattle, could also serve as a "warning" to inform the decision makers about the real condition in recent years on declining body weight and fertility of cattle (Doughill and Reed, 2004). By comparing the cattle body weight according to the age groups and sex, and the fertility with the reference values, these indicators can be used easily to estimate the sustainability of cattle production, taking into account the definition of sustainability of livestock production given by Vavra (1996), stating that sustainability is the ability to produce the same quantity of meat or fiber from a given land and input indefinitely. This time horizon is, however, rather long and therewith impossible to be observed.

The absence of crop pests was an indicator proposed to ensure a stable yield from crop production. The yield of crops itself was classified into economic indicators as also done by other authors (Zheng and Routray, 2003; Mollenhorst, 2005; Zhen et al., 2005; Subedi et al., 2009) because of its direct impact on income generation. The indicator of seed, fertilizer and information and services availability were meant to potentially improve the current state of the production systems. Additionally, the interaction between the production and the environmental as well as internal support were captured in two indicators, namely crop-soil suitability and crop-skills suitability. Both indicators were useful to evaluate the decision of farmers to cultivate certain crops based on the soil and farmers skills supporting this type of cultivation. Crop-market suitability, measuring the suitability of crops cultivated by farmers based on the market demand, seems not being important in the study area, since the majority of farmers inherited the crops from their parents, and rarely changed the crop type. This behaviour may be enhanced through the unavailability of information and services for new species or varieties of crops. However, the indicator may be important in other areas.

Local community and key persons in Maluku, as well as researchers agreed that environmental indicators were the key indicators to measure agricultural sustainability in terms of forage availability to support livestock production (Vavra, 1996; Dougill and Reed, 2004), soil and water quality, and specifically, absence of land erosion (Rigby et al., 2001; Yuan et al., 2003; Hugé et al., 2009) and seasonal floods. The study indicated 5 more indicators regarding the environmental support in farm sustainability besides those indicators mentioned above. These indicators were cattle safety from theft and social crime (being poisoned and injured by other people), cattle health condition, crops free from pests, cohesion of rural life and cultural acceptance. The support from government was also described in at least 8 indicators, namely information and services for cattle and crops, seeds and fertilizer availability, good market price, infrastructures and transportation availability, market accessibility and credit. It could be considered a bias of the present study that no negative environmental externalities from cattle keeping were included. For instance, the trampling of cattle in combination with heavy floods could contribute to soil losses by erosion. Using by-products for cattle feeding will remove nutrients from the crop fields if manure is not brought back. Methane emissions from cattle production could be higher than emissions accruing from the production of other animal-source products including fish as an apparently locally adapted protein source.

Resource availability, social aspects, economics and environment .as well as supporting facilities issues confirmed the findings of OECD (2001), Zhen et al. (2005) and Subedi et al. (2009). Generally, the indicators were proposed based on the needs to improve the production and acknowledging the pressure on the environment that could cause a change (Crabtree and Bayfield, 1998) which in turn affected the system's sustainability positively or negatively (Wattenbach and Friedrich, 1997). The pressure on the environment was however less stressed here as explained above.

Farm successor, defined as the availability of persons in the family who have the ability and are willing to take over the farm in the future, was the indicator proposed by the local communities, which is rarely found in the literature. The indicator was directly measured as the existence of the farms in a future time, and strongly indicated the time dimension, at least at medium term, of sustainability which many researchers did not include explicitly.

The cultural issue was strongly representing the site-specific issue in the sustainability, as the indicators may change according to location, but also with time. The cohesion of rural life indicator, representing the socio-cultural interactions among farmers and other stakeholders in the village, and cultural acceptance indicators, evaluated the cultural acceptability of any production system, including the type of livestock raised and crops cultivated by farmers. The *masohi* indicator evaluated the intensity of farmers being currently engaged in the traditional custom of helping each other in the village. It is connected to the farmers' migratory status, as the custom originated from indigenous communities, though several transmigrant communities have adopted the tradition. Those indicators may most probably change in the future if an economic orientation becomes mainstream in the community, where farmers may use hired labour rather than depend on other farmers to help with farm activities, and prefer to work in their own farm rather than help other farmers. In fact, the custom of *masohi* was already less meaningful nowadays compared to 10 or 20 years ago, according to farmers in the focus group discussions.

Several indicators proposed by farmers were eliminated from the list. Cattle pedigree was eliminated because there was no data available in the study area regarding pedigree of the animals. Soil and water quality were also eliminated because the study limitations regarding logistic and time did not allow for measurement. This may bias the final assessment of the systems. However Huffman et al. (2000) confirmed the high correlation between soil quality and forage availability. The more the soil was covered by forage plants, the less land erosion could happen, resulting in increased levels of soil organic carbon, which provides a better habitat and nutritional benefits to a variety of soil organisms leading to a better soil quality. Hence, the use of forage availability indicators could also represent the soil quality.

Twelve indicators were eliminated in the further analysis that could be useful in specific circumstances. In the cattle production issue, herd size and technology used indicators were omitted due to their low importance in the studied communities. The number of head in the herds was not determining the subsistence role of cattle in the present study as it was reported for East Africa (Schneider, 1957), although it is indeed representing at least a part o the wealth of the owners. Technology used in livestock production, such as artificial insemination (AI) and planting improved forages was also not common in the region as mentioned by farmers, confirming the finding of Rachmat et al. (1992). The coat colour was also eliminated from the indicator list because it has no direct economic impact or commonly reported socio-cultural value in the study area. However, this indicator could be an important indicator for farmers in Madura Island, East Java province as price determination, because in a traditional Madura cattle exhibition, where farmers sell the best cattle with very high prices, the coat colour was one of the criteria for indicating the best phenotype of Madura cattle (Widi et al., 2010).

In the crop production issue, manure availability was considered less important because it is not commonly applied in agricultural production in the study area. Manure was normally just left in the grazing locations and other places where the herds past through. This could affect the environment negatively, thus an externality that may negatively influence sustainability. However, in situations where manure is applied in the farm as fertilizer or being sold for cash income, the indicator should be used.

In the economic and supporting facilities issues, income diversity, farmers' organisation and post harvest management were eliminated due to certain debate among the local communities regarding the importance of those indicators in the study area at present. Farmers argued that income diversity was less important, because in fact many farmers in the study area can live from only one source of income, namely crop production. Similarly, post harvest management, which is useful to measure the availability of storage and processing technology, was also found to be less important of the majority of farmers and local experts. In addition, farmers' organisation was found to be less important, as the culture of tolerance and togetherness among farmers and other stakeholders in the same village, described in the cultural issue, were more representative than a more formal organisation.

The method applied in selecting indicators provided a big opportunity for farmers and stakeholders to contribute for the final list of sustainability indicators, which are relevant and sensitive to their local conditions. However, the procedure could also create biases, as many qualified indicators were eliminated due to debate among farmers in the ranking activities, leading to high quartile deviations of the indicators in the analysis. Moreover, correlation between indicators should also be considered in the future, to avoid overlapping in measuring similar objects.

Furthermore, the selection of final indicators has to be developed further as the conclusion regarding the level of farm sustainability is highly determined by the final set of indicators used. Frequently updating the indicators is highly recommended to capture the continuous change of the systems. Thus, the set of "final" indicators should be validated to make sure that the chosen indicators matched their purposes. In validating the sustainability indicators, there are two aspects that served as benchmark criteria namely accuracy and credibility. The first relates to the degree to which it is consistent with its intended application, while the later refers to the degree of confidence potential end-users have in the indicators and thus the willingness to use them in practice (Bockstaller and Girardin, 2003; Meul et al., 2009). By incorporating local key persons to evaluate the relevance and sensitivity of individual indicators, the first validation procedure has been done as suggested by Meul et al. (2009). Further qualitative research should be done with more participants from the area where the indicators were derived and areas which were not included in the current study. The local government, as a further stakeholder, should also be included in testing the indicators as the indicators are also regarding them, namely in taking decision for providing support for rural farmers in the study region.

The method of selecting indicators has its shortcomings, however, as sustainability itself cannot be measured and hence, results cannot be truly validated. The indicators of this study reflect the current understanding of sustainability and its driving factors from the perspective of farmers and other local experts. The chosen indicators were more focussing on positive contributions to livelihoods and to a lower degree including factors that may threaten sustainability such as unintended negative outcomes of agricultural activities and cattle farming in particular. Hence, merging an outside perspective with the local ones could address such externalities. Being then widely outside the perception of local stakeholders, the weighing exercise of these additional indicators would need to be redesigned.

Another challenge is the time scale of a sustainability analysis. The systems are not expected or desired to be static. The concern raised by farmers in this study regarding their successors represents a medium term worry. On a longer time horizon systems may look very different from those of today but are expected to still be able to produce sufficient products by making use of sufficiently available resources. The direction of changes in the socio-cultural setting and values are similarly hard to forsee, a general benchmark would be the satisfaction of people. By now, sustainability indicators are only able to consider current values, which can be translated sufficiently into measurements. A recurrent critical review of these indicators is recommended. A combination seems to be adequate of more general indicators allowing wider comparison and a set of more site and context specific indicators in order to capture local necessities.

The main indicators for sustainable livestock production suggested by authors in the literature (compare chapter 2.1.2) were covered in the 8 issues employed in the present study. The animal production element includes animal health, fertility and productivity (body weight and yield), determined in the animal production issue of the study. The ethical element, consisting of human attitudes to support the production, was explicitly covered in the indicators regarding farmers' attitudes. Socio-cultural and socio-economic elements were covered in at least three issues in the study, namely social, economic and cultural issues. Although the impact of livestock on the environment was not covered in the study (for instance unregulated disposal of manure, methane emission from livestock or land use changes for pasture establishment that could affect the environment negatively), environmental support for livestock production was included by forage availability, absence of seasonal flood and land erosion. However, contribution of livestock to food security on a higher scale than at household level, and animal health related to consumer safety and food quality were poorly addressed in the study.

5.2.2 Estimating the sustainability of the three farming systems

Estimating the sustainability of farming systems on Ceram Island revealed several strong points contributing to the systems' sustainability, while only few threatening elements were identified. In the economic issue, household income in all farming systems tested was higher than the poverty line estimated by the government for rural areas in Maluku province used as the target value in the exercise. Likewise, crop yield in the TRC farming system was two times higher than the target value. Government support in terms of irrigation systems, fertilizer subsidies, transportation and market availability on the one hand, and skills of farmers and their eagerness to use all resources efficiently on the other hand could be attributed to the relatively high yields. The bigger land sizes in the IPC system, in the form of clan owned land (*tanah dati*), heritage land (*tanah pusaka*) and private land, as well as gifts from the government for TRC farmers as the beneficiaries of the national transmigration programme and acquisition of land from other transmigrant and indigenous landlords close to the settlement areas, contributed to the systems' estimated sustainability. Food intake in terms of protein and energy in all farm types satisfied the need of all family members according to the international requirements considering sex and age of each member of the family (WHO, 1999). In line with it, children's education in all farm types was better than the average level of rural childrens' education in the country (CBS, 2010). Both indicators form a baseline toward which the poverty is being assessed in Indonesia (ADB, 2006). However, the level of children's education mentioned above was not satisfying the farmers in the TVC and IPC systems. The reason was related to the availability of the farm successors. Many children who received a better education (high school level) preferred to work in other fields, such as business, as a private employee, or government officer. In pursuing higher education, children in the study area tended to choose study areas other than agriculture. Hence, only few children preferred to be farmers and prepared to take over the farms in the future.

The study confirmed that farmers in TVC and IPC systems received only a minimum support from the government. The amount and availability of agriculture inputs, in terms of seeds, subsidized fertilizer, and infrastructure, including transportation and market facilities, were unfavourable for those systems. Information and services provided through extension services were other limiting factors affecting the systems' sustainability. This situation contributed negatively to the farmers' attitude, especially those in TVC system, where farmers admitted to have limited skills and knowledge towards crops cultivated by themselves.

In an attempt to develop cattle production systems on Ceram towards sustainability, the cattle fertility rate should be improved as this indicator contributed negatively to the sustainability indices of all three systems studied. The situation, together with destocking practice in the local communities may put the cattle production onto the path toward unsustainability. Thus, without any improvements on the fertility rate and continuation of current destocking rate will harm the current population of Bali cattle in the study region.

The environmental indicator represented by forage availability on Ceram depicted another limiting factor to achieve sustainability. As mentioned earlier in section 5.1.2, even in the rainy season, the quality of native pasture on the Island, expressed in dry matter, crude protein and gross energy, was reported to be low. The quality was even below the average yield of low productive pastures in the humid tropics (Reynolds, 1978). To improve the quality and quantity of the forage is rather difficult because it requires the replanting with improved forage species or the fertilization of the current forage (Nitis, 1999). This would in turn require special treatments and efforts in preparing the land, fertilizing and watering among others. However, farmers in those systems were limited in labour and capital (section 5.1.3) which explains why improved forage technologies introduced to farmers in eastern Indonesia yielded a low adoption rate (Rachmat et al., 1992; Pengelly and Lisson, 2003). Other environmental and social factors such as cattle diseases, losses by theft and killing cattle by people on one hand, and crop pests on the other hand contributed negatively to the system sustainability. Interestingly, the negative contribution of almost all environmental factors did not affect the economic issue of all systems studied. Cattle production produced the same amount, while crop production produced more than what was required in the reference values, especially in TRC systems. The government support of providing the subsidized seeds and fertilizers in this system could be the reason for this opposite relationship among those issues.

The study suggested that the smallholder mixed farming systems were strongly influenced by internal factors such as farmers' attitude and resource availability, and external factors such as governmental and environmental support. Thus, the farm type with predominantly transmigrant farmers with on average 6 cattle per household and cultivating rice on 3.3 ha of land (TRC) was the better farm type when compared to the other types as it showed a positive contribution to the estimated sustainability. This farm type performed better in the socio-economic dimension (household income, crop yield, land size, household's food security and children's educational level), and received more support from the government through provision of subsidized inputs and infrastructure, although it performed worst in the cattle production (body weight and fertility) and environmental support. Likewise, a study conducted in transmigration settlements in West Kalimantan confirmed that, compared to other diversification schemes existing in the area, such as annual crops and perennial crops, perennials and animals, or annual or perennials alone, diversification schemes involving rice and cattle were found to be more sustainable, as the system performed better in crop yield, land use efficiency, household income and labour use efficiency (Dewi and Mendoza, 2006). It should be further studied, however, whether the government subsidizing this system is the decisive factor for this system's sustainability. If so, then also subsidizing the other systems should be considered as a means to support sustainability according to the declared aim given by the government. Likewise, the three systems' sustainability should be compared in a scenario without subsidies, or reduced subsidies, in order to better understand self-sustained sustainability, although this would be rather difficult, since in practice, many collateral effects occur.

The results of the present study could serve as a guide in making adjustments to herd management policies for sustainable smallholder Bali cattle farming systems in Indonesia. Lower fertility rates, slower growth rates, higher adult mortality and higher destocking rates were reported for the studied Bali cattle on Ceram Island compared to what was previously reported under similar production conditions. All these factors lower the productivity of the Bali cattle, compromising the sustainability of the cattle production systems in the study locations. Bali cattle keepers may need to alter their herd management strategies so as to overcome the aforementioned constraints. This should include deliberate efforts to increase the probability of cows coming into contact with breeding bulls, based on the close monitoring of the cows for any heat signs and investing in rearing a breeding bull, either individually or by a group of neighbouring farmers. Moreover, strategic feeding could improve the herd performance and increase the fertility rate of females, ultimately enhancing the productivity of their herds. Advances in the cattle management should go along with improving cattle safety from social crime in order to reduce the currently high adult mortality rate.

The results also can serve as baseline for policy makers to plan strategies and interventions to develop the performance of smallholder cattle keepers and their rural livelihoods, especially to enhance the performance of Bali cattle on the Island. In order to increase the level of sustainability of the farming systems studied, the challenge for the local as well as the national governments will be to reinvigorate their support and equally distribute them among farmers. Information and services provided through a better quality and quantity of extension service staff, input subsidies and improving rural infrastructures, as well as providing better market opportunities and prices for agricultural products produced by farmers in the region could be the foundation for long run sustainability of the farming systems in the region.

5.3 Potentials and limitations of the methodological approach

To characterise the farming systems in the present study, elements of Farming System Research (FSR) were adopted. This methodological approach is meant to elicit a better understanding of farm households through a participatory approach (Collinson, 2000). The farming system was referred to as the household, its resources and the complex interaction within those resources (Dixon et al., 2001), including cattle production and other agricultural and non-agricultural activities.

Although the interaction between cattle production and other agricultural and non-agricultural activities was considered in the study, there could be more factors, outside the scope of the present study that might have affected the farming systems. For instance, the rapid increase of the rural population and transition processes from rural to urban settlements and options for income generating activities in several districts, such as Bula, and some villages in Kairatu, could affect the farming characteristics and functioning, as well as the concept of sustainability. Therefore further research should include more external factors, which were not considered in the present study, to capture a clearer picture of the farming systems and their evolving production conditions.

IMPACT software, which provides a structured step by step assessment of mixed farming systems, is a rather time consuming tool. Its worth will become more visible if more and more studies would use the structured data collection and analysis suggested by IMPACT. Results of the single studies could then be easily compared with other systems worldwide. This is true for any standardization of parameters, and will specifically be helpful in comparable and comparative sustainability analyses. The IMPACT results could also serve as baseline information to further system analysis when linking the software with other analytical tools such as models for climatic and soil analyses to simulate a range of development scenarios from an agro-ecological perspective (Herrero et al., 2007).

According to literature (Herrero et al., 2005 and 2007; Ng'ang'a, et al., 2008; Zingore et al., 2009), IMPACT was so far only used in order to characterize single, typical farms. The present study is the first to employ it for farm groups using median values. For the future development of the software, it would be useful if IMPACT would further be used for an "average farm" or a series of farms entered together rather than only considering one model farm. This, assuming that no individual farm can be fitted on behalf of other farms but the group of farms can be used to perform average values serving as the average characteristics of the group. Moreover, it would be preferential if the software could accept arrays of data from individual farms rather than means or medians only, facilitating the calculation of measures of variation.

To estimate the sustainability of Bali cattle keeping in mixed farming systems in the study area, sustainability analysis was used by employing sustainable indicators as measuring tools. Three dimensions of sustainability were considered, namely economic, environmental and societal. However, several elements in those dimensions could not be included, because some indicators were not raised in the discussion with the local communities (for instance, energy used and farmers age), or were omitted from the final indicator list due to low ranks perceived by the local communities (for instance, manure availability, farmers' organisation, technology used on farm, income diversity and post harvest management). This limitation could be addressed by modifying the data collection procedure, namely a second data collection after the final definition of indicators. Several indicators were also beyond the scope of the study (for instance, soil and water quality and favourable climate and weather). Working in a multi-disciplinary team could address these points. Besides, few studies in Indonesia are so far dedicated to sustainability analysis, and the existing statistical data, in most cases, was insufficient. Therefore, more comprehensive and multidisciplinary studies are needed to estimate the sustainability of the farming system as a whole. As sustainability can only be estimated but not consistently be tested, a monitoring system is needed which is able to capture the impact of the changing frame conditions, which may change the assessment of sustainability over time.

6 SUMMARY

6.1 Summary

A beef boom in Indonesia triggered the over-proportional selling of productive animals on Ceram Island, a centre of agricultural production in Maluku province, as chosen by the government, threatening the sustainability of beef production on the island. Mainly two farmer groups are affected, namely indigenous farmers who live as crop farmers, livestock keepers and fishermen and transmigrant farmers who came from other provinces in Indonesia, settled on the Island and live as food crop farmers, mainly producing rice and later becoming cattle keepers. The aim of the study was to contribute to the knowledge base needed for the design of sustainable beef production systems by analysing the sustainability of farms on Ceram Island, Indonesia. The general hypothesis of this study was: farm resources, productive and reproductive performance of beef production in the mixed farming systems on Ceram Island differ according to the migratory status of farmers, leading to different level of sustainability, productivity of beef production and economic efficiencies. Therefore, different strategies and interventions are needed to improve the systems. The study focused on districts with agriculture as the main economic activity, namely West Ceram and Kairatu districts in the west, and Bula district in the east.

The study was carried out in three stages. A preliminary study was done to identify the production patterns and key features of farms in a diagnostic survey (33 households and 154 cattle) between June and September 2008. A comprehensive data collection was realised in a second stage, covering the areas of cattle distribution and performance, forage availability and quality, farm characteristics, production pattern, household socio-economic conditions and indicators used for sustainability analysis (88 households and 325 cattle). A final data collection was performed with 8 farmer groups in October 2010 in order to present, discuss and re-rank indicators in the sustainability analysis. The data was collected using household interviews, key person interviews, a progeny history questionnaire, systematic observation, cattle measurements, forage sampling and laboratory analysis, time line history of both farms and external condition, seasonal calendar for crops and cattle, internal bio-resource flow, ranking and scoring of the role and function of households member, as well as for cattle, crops and contribution of them for the household, and focus group discussion. After performing descriptive statistics, analytical analysis included general linear models and cluster analysis, IMPACT software was employed for annual economic balances, the households' food security status and labour allocation.

Results of the study showed that performance of Bali cattle in farms managed by indigenous (Muslim and Christian) versus transmigrant farmers were not significantly different in terms of fertility rate, mortalities, calving interval, weaning age, cow age at first calving and bull age at first mating. The fertility rate of Bali cattle was very low compared to other areas in Indonesia and other countries. The body weights showed a tendency towards heavier cattle in transmigrant farms. The growth performance of Bali cattle on Ceram Island was lower than in previous studies conducted in other parts of Indonesia and in other countries such as Malaysia, Australia and the Philippines. Forage production in the rainy season was 6.9 ton dry matter per ha, with 4 to 6% crude protein, 34 to 38% crude fiber, and 13.1 MJ per ton dry matter, which is relatively low compared to the western part of Indonesia and other islands in the Pacific like Samoa.

As the two ethnic groups showed little difference in cattle performance, cluster analysis was employed to identify groups based on farm resources, agricultural production patterns and non-agricultural household activities. This resulted in three different farm types in the study area: TVC (predominantly transmigrant farmers with on average 4 head of cattle and planting about 2 ha of vegetables), IPC (mostly indigenous farmers with on average 9 head of cattle with perennials on about 3.7 ha land) and TRC (primarily transmigrant farmers with on average 6 head of cattle, cultivating rice on 3.3 ha land). The TRC system generated the highest net agricultural income per labour applied and per ha of land, while IPC received the least. Even though IPC produced cash crops (spices), their production systems were found to be rather extensive with low input – low output, while TRC farmers were the ones most intensively using their resources and therewith realising higher outputs. In the studied period, TVC farmers had realised almost no income from cattle. The available family labour in each system was employed to at least 93%. The study confirmed differences of farming conditions to a certain degree according to farmers' origin (transmigrant and indigenous), although integration in terms of knowledge exchange in farming practice had already taken place, indicated by non-homogenous clusters. Any development programme aimed at increasing farm income in the study area, and cattle production in particular, should consider the availability of farm resources and the current farm priorities towards crops in the different farm types.

To estimate the sustainability of the three farm types, indicators were developed with the local communities, covering the issues of cattle production, crop production, resource availability on farm, economics, social conditions, supporting facilities, environment and cultures. These issues partly matched with the ones proposed in the literature, indicating that farmers and researchers shared a common understanding of the term sustainability. Interestingly, cultural aspects appeared as the most site-specific issue, describing the cohesion of rural life, cultural acceptance of the system, and *masohi*, the traditional custom of helping each other on- and off- farm among farmers and other rural inhabitants. The farm successor indicator represented the time dimension of sustainability which was included by the local community; an indicator rarely found in the literature.

The selected sustainability indicators captured strengths and weaknesses of different farm types. TRC, the farm type with predominantly transmigrant rice-cattle farmers, was the most successful farm type in comparison to the other types, as shown by the positive contribution to sustainability (sust. index = 0.203). This farm type disposed of a large enough land size and performed relatively well in the socio-economic dimension (crop yields, households' food security and children's educational level), although indicators were less promising in cattle production (body weight and fertility). However, this system received more support from the government in terms of input supplies, information and services provided, and favourable rural infrastructure. The results depicted the constraints of Bali cattle production systems on Ceram Island, particularly the low fertility rate, contradicting what was reported elsewhere, and the destocking practice that could put the farming system onto the path towards unsustainability. The results could serve as a baseline for farmers to adjust their management, and for policy makers to plan their strategies and interventions to develop the performance of cattle in smallholder systems along with improving rural livelihoods, where system sustainability seems promising.

6.2 Zusammenfassung

Die verstärkte Nachfrage nach Rindern in Indonesien verursachte einen überproportionalen Ausverkauf produktiver Rinder auf der Insel von Ceram, einem von der Provinzregierung bestimmten Zentrum der landwirtschaftlichen Produktion der Molukken, was die Nachhaltigkeit der Rinderproduktion zu bedrohen scheint. Hiervon sind zwei Landwirtsgruppen auf der Insel betroffen. Einerseits sind dies die einheimischen Landwirte, welche Ackerbau mit Tierhaltung und Fischerei verbinden. Andererseits handelt es sich um die von anderen indonesischen Gebieten nach Ceram umgesiedelten Landwirte, welche vor

allem Ackerbau betreiben, insbesondere Reis, und später in die Rinderhaltung einstiegen. Das Ziel der vorliegenden Arbeit war es, nötige Kenntnisse für den Entwurf einer nachhaltigen Rindfleischproduktion auf Ceram zu erarbeiten, und zwar durch die Untersuchung der Nachhaltigkeit der vorhandenen Betriebssysteme. Die zugrundeliegende Hypothese war: Die Farmressourcen, sowie produktive und reproduktive Leistung der Rinderhaltung in den gemischten Systemen von Ceram variieren mit dem Migrationsstatus der Landwirte, was zu unterschiedlicher ökonomischer Effizienz führt. Folglich werden unterschiedliche Strategien und Innovationen benötigt, um diese Betriebssysteme zu fördern. Die Studie wurde in solchen Distrikten vorgenommen, in welchen die Landwirtschaft die hauptsächliche ökonomische Aktivität darstellt, nämlich in West Ceram und Kairatu im Westen und im Distrikt von Bula im Osten.

Die Studie wurde in drei Abschnitten durchgeführt. Eine Pilotstudie identifizierte die Produktionsmuster und Schlüsselfaktoren von Landwirtschaft mittels einer Erhebung in 33 Haushalten mit 154 Kühen (Juni bis September 2008). Eine vervollständigende Datenerhebung wurde in der zweiten Feldphase realisiert. Hierbei wurden die Tierleistungen, Futterverfügbarkeit und –qualität, generelle Merkmale der Betriebe, Produktionsmuster, sozio-ökonomische Haushaltsdaten und weitere Indikatoren für die Nachhaltigkeitsuntersuchung in 88 Haushalten mit 325 Kühen erhoben. Eine abschließende Datenerhebung fand im Oktober 2010 mit 8 Landwirtsgruppen statt, wobei die Indikatoren der Nachhaltigkeitsanalyse den Landwirten erneut vorgestellt und mit ihnen diskutiert und ein weiteres Mal gewichtet wurden. Erhebungsmethoden waren Haushaltsinterviews, Interviews mit Schlüsselpersonen, Fragebogen zum Verbleib der Nachzucht, systematische Beobachtung, Messungen an Rindern, Futterprobennahme und Laboruntersuchung, Entwicklung der Betriebe und Rahmenbedingungen auf der Zeitachse, saisonaler Kalender der Landwirtschaft, Flussdiagramm der Farmressourcen, Bewertung und Rangierung und Fokusgruppendiskussion. Nach anfänglicher deskriptiver Statistik, wurden analytische Methoden benutzt, und zwar allgemeine lineare Modelle und Clusteranalyse. Die IMPACT Software wurde für die wirtschaftliche Auswertung, und die Ermittlung der Nahrungssicherheit und der Arbeitskraftnutzung eingesetzt.

Die Ergebnisse der Studie zeigten, dass die Leistung der Bali Rinder in den zwei untersuchten Gruppen, Einheimische und Umgesiedelte, sich nicht signifikant voneinander unterschieden in den Parametern Fruchtbarkeitsrate, Mortalitäten, Zwischenkalbezeit, Absetzalter, Erstkalbealter und Zulassungsalter der Bullen. Die Fruchtbarkeitsrate der Balirinder war sehr

niedrig im Vergleich zu anderen Regionen in Indonesien, sowie anderen Ländern. Eine Tendenz zu schwereren Rindern in den Betrieben der umgesiedelten Landwirte wurde verzeichnet. Die Wachstumsleistung der Balirinder auf Ceram Insel war niedriger als die anderer Studien aus Indonesien, Malaysia, Australien und den Philippinen. Die Futterproduktion in der Regenzeit betrug 6.9 t Trockenmasse mit 4 bis 6% Rohprotein, 34 bis 38% Rohfaser und 31.94 kcal pro t Trockenmasse, was relativ wenig im Vergleich zu westlicheren Gebieten von Indonesien und anderen Inseln des Pazifiks, z.B. Samoa, ist.

Da die Tierleistungen in den zwei Gruppen bezogen auf den Migrationsstatus wenige Unterschiede aufwiesen, wurde eine Clusteranalyse anhand von Farmressourcen, Mustern landwirtschaftlicher Produktion und nicht-landwirtschaftlicher Aktivitäten der Betriebe durchgeführt. Dies führte zur Definition dreier Betriebstypen: TVC (vor allem umgesiedelte Bauern mit 4 Rindern und ca. 2 ha Gemüseanbau), IPC (vor allem einheimische Landwirte mit ca. 9 Rindern und Anbau von Dauerkulturen auf ungefähr 3.7 ha Land), und TRC (insbesondere umgesiedelte Landwirte mit ca. 6 Rindern und 3.3 ha Reisanbau). Das TRC System erwirtschaftete das höchste Nettoeinkommen pro eingesetzter Arbeitskraft und pro ha Fläche, wohingegen IPC das geringste Einkommen erzielte. Obwohl IPC Marktfrüchte (Gewürze) produzierte, wurde hier extensiv gewirtschaftet unter Einsatz weniger Betriebsmittel und einer geringen Erzielung von Erträgen. TRC hingegen wirtschaftete am intensivsten und erzielte höhere Erträge. Im Untersuchungszeitraum erzielte TVC keinerlei Einkommen von der Rinderhaltung. Die vorhandene Familienarbeitskraft wurde in allen Systemen zu mindestens 93% eingesetzt. Die Studie bestätigte Unterschiede der Betriebsumstände je nach Migrationsstatus, jedoch hat bereits ein gewisser Austausch zwischen diesen Gruppen stattgefunden, was sich durch die nicht-homogenen Gruppen gezeigt hat. Entwicklungsprogramme zur Erhöhung der Einkommen von Bauern, insbesondere von der Rinderhaltung, in der Untersuchungsregion sollten die unterschiedlichen Verfügbarkeiten von Ressourcen und die aktuell vorhandenen Schwerpunktsetzungen in der Pflanzenproduktion in den verschiedenen Betriebstypen beachten.

Um die Nachhaltigkeit der drei Betriebstypen abzuschätzen wurden Indikatoren zusammen mit den Landwirten und lokalen Experten entwickelt. Diese deckten die Bereiche Rinderproduktion, Pflanzenproduktion, betriebliche Ressourcenaussstattung, Wirtschaftlichkeit, soziale Umstände, unterstützende Strukturen und Umwelt ab. Diese Bereiche ähnelten denjenigen beschrieben in der Literatur, was bedeutet, dass Landwirte und Wissenschaftler ein vergleichbares Verständnis von Nachhaltigkeit zu haben scheinen.

Zusätzlich wurde ein kultureller Bereich definiert, welcher besonders lokalspezifisch ist und durch den Zusammenhalt in den Dörfern, die kulturelle Akzeptanz von Produktionssystemen und eine lokale Form der Nachbarschaftshilfe beschrieben wurde. Der Indikator der Betriebsnachfolge, vorgeschlagen durch Landwirte, führte die Zeitdimension ein, und ist in der Literatur kaum zu finden.

Die ausgewählten Nachhaltigkeitsindikatoren deckten Stärken und Schwächen der Betriebstypen auf. TRC, der Betriebstyp mit vor allem umgesiedelten Landwirten, welche Reis anbauen und Rinder halten, war am erfolgreichsten und wies als einziger Typ einen positiven Beitrag zur Nachhaltigkeit auf (sust. index = 0.203). Dieser Betriebstyp wies eine genügend große Landfläche auf und erwies sich auch als positiv im sozio-ökonomischen Bereich (Erträge der Pflanzenproduktion, Nahrungssicherheit der Haushalte und Schulbildung der Kinder), jedoch waren die Indikatoren der Rinderhaltung weniger vorteilhaft (Körpergewichte and Fruchtbarkeit). Allerdings erhielt dieses System auch die größte Unterstützung seitens der Regierung, und zwar bezüglich der Betriebsmittel, Informationen und Dienstleistungen und einer förderlichen ländlichen Infrastruktur. Die Ergebnisse zeigten die Begrenzungen der Balirindhaltung in Ceram auf. Diese sind insbesondere die niedrige Fruchtbarkeitsrate, im Widerspruch zur vorhandenen Literatur, und der Herdenabbau, welcher kontraproduktiv bezüglich Nachhaltigkeit der Betriebe wirken kann. Die Ergebnisse der Studie können den Landwirten dienen, und die Politikgestaltung kann sich daran orientieren, um Strategien und Maßnahmen zur Förderung der Leistung von Rindern in Kleinbetrieben so zu planen, dass diese kompatibel mit und förderlich für die ländlichen Lebensumstände sind, und zwar dort, wo die Nachhaltigkeit der Systeme vielversprechend zu sein scheint.

6.3 Ringkasan

Meningkatnya permintaan akan daging sapi di Indonesia memicu terjadinya penjualan sapi produktif secara besar-besaran di Pulau Seram, daerah yang ditetapkan oleh pemerintah sebagai pusat produksi pertanian di Provinsi Maluku, dan mengancam kesinambungan produksi daging sapi di pulau tersebut. Hal ini mempengaruhi 2 kelompok petani, yaitu petani pribumi yang hidup sebagai petani tanaman perkebunan, peternak dan nelayan dan petani transmigran yang datang dari provinsi/pulau lain di Indonesia, menetap di pulau Seram dan hidup sebagai petani tanaman pangan, terutama memproduksi beras dan kemudian menjadi peternak . Tujuan penelitian ini adalah untuk memberikan kontribusi pada ilmu pengetahuan untuk mendesain suatu sistem produksi daging sapi yang berkelanjutan, dengan terlebih dahulu menganalisa tingkat sustainabilitas dari sistem pertanian yang terdapat di Pulau Seram,

Indonesia. Hipotesis umum dari penelitian ini adalah: sumber daya pertanian, performans produktif dan reproduktif dari kegiatan produksi daging sapi pada sistem pertanian campuran di Pulau Seram berbeda menurut status migrasi petani, yang selanjutnya membedakan tingkat sustainabilitas, produktifitas dan efisiensi ekonomi. Oleh karena itu, diperlukan strategi dan intervensi yang berbeda pula untuk meningkatkan performans sistem. Studi ini difokuskan di beberapa kecamatan dimana pertanian merupakan kegiatan ekonomi utama, yaitu kecamatan Seram Barat dan kecamatan Kairatu di bagian barat, dan kecamatan Bula di bagian timur. Penelitian ini dilaksanakan dalam tiga tahap. Tahap awal digunakan untuk mengidentifikasi pola-pola produksi dan fitur kunci peternakan dalam suatu survei diagnostik (33 rumah tangga dan 154 ekor sapi) antara bulan Juni dan September 2008. Pengumpulan data yang lebih komprehensif dilaksanakan dalam tahap kedua, meliputi bidang distribusi and performans hewan ternak, ketersediaan pakan dan kualitasnya, karakteristik dari sistem pertanian yang ada, pola produksi, kondisi sosial-ekonomi rumah tangga dan pengembangan seperangkat indikator yang akan digunakan dalam menganalisa tingkat sustainabilitas (88 rumah tangga dan 325 ekor sapi). Pengumpulan data akhir dilaksanakan dengan 8 kelompok tani pada bulan Oktober 2010 untuk mempresentasikan, mendiskusikan dan menyusun kembali peringkat indikator sesuai dengan prioritas petani. Data dikumpulkan melalui wawancara dengan rumah tangga petani dan stakeholder lainnya, Progeny History Questionnaire, observasi sistematis, pengukuran ternak, sampling hijauan dan analisa laboratorium, Participatory Rural Appraisal (PRA) yang meliputi sejarah pertanian dari kedua grup petani serta kondisi eksternal di luar pertanian, kalender musiman untuk tanaman dan ternak, aliran sumberdaya biologi (bio-resource flow), peringkat dan penilaian tentang peran dan fungsi anggota rumah tangga, ternak, tanaman dan kontribusinya untuk rumah tangga, serta fokus grup diskusi. Selain melakukan analisa statistik deskriptif, analisa analitis juga dilakukan dengan menggunakan model linier umum (GLM) dan analisa cluster. Software IMPACT juga digunakan dalam menganalisa status ekonomi rumah tangga tahunan, ketahanan pangan rumah tangga dan sistem alokasi tenaga kerja dalam rumah tangga.

Hasil penelitian menunjukkan bahwa performans sapi Bali yang dipelihara oleh petani pribumi (Muslim dan Kristen) versus petani transmigran tidak berbeda nyata dalam hal tingkat kesuburan, kematian, interval beranak, umur sapih, umur sapi pada saat pertama kali beranak, dan umur sapi jantan pada saat pertama kali kawin. Tingkat kesuburan sapi Bali sangat rendah dibandingkan dengan daerah lain di Indonesia dan di negara-negara lain. Berdasarkan berat badan, terdapat kecenderungan bahwa ternak di daerah transmigrasi lebih berat daripada di daerah non-transmigrasi. Pertumbuhan sapi Bali di Pulau Seram juga lebih rendah dari pada studi sebelumnya yang dilakukan di daerah lain di Indonesia dan di negara-negara lain seperti Malaysia, Australia dan Filipina. Produksi pakan hijauan pada musim hujan adalah 6,9 ton berat kering per ha, dengan 4 - 6% protein kasar, 34 - 38% serat kasar, dan 13,1 MJ per ton bahan kering, yang relatif rendah dibandingkan dengan di bagian barat Indonesia dan di kepulauan Pasifik lainnya seperti Samoa.

Karena kedua kelompok etnis ini hanya menunjukkan sedikit perbedaan dalam hal performans ternak, analisa clusterpun digunakan untuk mengungkapkan perbedaan kelompok berdasarkan sumber daya pertanian, pola produksi pertanian dan kegiatan rumah tangga non-pertanian. Hal ini menghasilkan tiga jenis sistem pertanian/peternakan yang berbeda di wilayah studi: TVC (terdiri dari sebagian besar petani transmigran dengan rata-rata 4 ekor sapi, menanam sayuran dan memiliki lahan seluar 2 ha), IPC (terdiri dari sebagian besar petani pribumi dengan rata-rata 9 ekor sapi, melakukan sistem pertanian tanaman keras, dan memiliki lahan seluas 3,7 ha) dan TRC (mayoritas petani transmigran dengan rata-rata 6 ekor sapi, melakukan budidaya padi, dengan luas lahan sekitar 3,3 ha). Sistem TRC menghasilkan pendapatan bersih dari pertanian tertinggi, dihitung per tenaga kerja dan per ha lahan, sedangkan IPC menerima pendapatan tersedikit. Meskipun IPC memproduksi tanaman rempah-rempah, sistem produksi mereka terbilang ekstensif dengan input dan output yang rendah. Petani TRC adalah yang paling intensif dalam menggunakan sumber daya mereka sehingga menghasilkan output yang lebih tinggi. Dalam periode penelitian, rata – rata petani pada sistem pertanian TVC tidak menghasilkan pendapatan dari ternak mereka. Tenaga kerja keluarga yang dikaryakan pada setiap sistem mencapai 93%. Penelitian ini menegaskan adanya perbedaan kondisi pertanian menurut asal petani (transmigran dan pribumi), meskipun integrasi dalam hal pertukaran pengetahuan dalam praktek pertanian sudah terjadi, ditandai dengan pengelompokan petani yang non-homogen berdasarkan analisa cluster. Untuk itu setiap program pembangunan yang bertujuan meningkatkan pendapatan pertanian di daerah penelitian, dan produksi ternak khususnya, harus mempertimbangkan ketersediaan sumber daya pertanian dan peternakan serta jenis tanaman yang diusahakan petani dalam setiap sistem pertanian yang ada.

Untuk memperkirakan tingkat sustainabilitas dari tiga jenis pertanian tersebut diatas, seperangkat indikator dikembangkan bersama masyarakat setempat, yang mencakup isu produksi ternak, produksi tanaman, ketersediaan sumber daya, kondisi ekonomi, sosial, fasilitas pendukung, lingkungan dan budaya. Isu-isu tersebut ternyata sesuai dengan yang diusulkan dalam literatur, menunjukkan bahwa petani dan peneliti berbagi pemahaman yang sama tentang pengertian sustainabilitas. Menariknya, aspek budaya muncul sebagai isu yang paling spesifik terhadap lokasi, menggambarkan kohesi kehidupan pedesaan, penerimaan akan suatu sistem dari segi budaya (adat istiadat), dan *Masohi*, yaitu kebiasaan tradisional saling tolong menolong di kalangan petani dan penduduk pedesaan lainnya. Indikator penerus pertanian (farm succesor) dapat mewakili dimensi waktu dalam pengertian sustainabilitas, yang dimasukan sebagai salah satu indikator sustainabilitas oleh masyarakat setempat; suatu indikator yang jarang ditemukan dalam literatur.

Indikator sustainabilitas yang terseleksi dapat menangkap kekuatan dan kelemahan dari jenis pertanian yang berbeda. TRC, jenis pertanian/peternakan dengan sebagian besar petani padi-sapi transmigran, adalah tipe pertanian paling sukses dibandingkan dengan jenis lainnya, ditunjukkan oleh kontribusi positif dalam analisa sustainabilitas (indeks sust = 0,203). Sistem pertanian ini memiliki lahan yang cukup luas, dan menunjukan performans yang baik dalam dimensi sosio-ekonomi (hasil panen, ketahanan pangan rumah tangga dan tingkat pendidikan anak-anak), walaupun indikator menunjukan segi negatifnya dalam produksi ternak (berat badan dan kesuburan). Sistem ini menerima lebih banyak dukungan dari pemerintah dalam hal pasokan input, informasi dan layanan yang diberikan, serta infrastruktur pedesaan yang menguntungkan. Hasil penelitian ini juga menggambarkan kendala pada sistem produksi sapi Bali di Pulau Seram, khususnya tingkat kesuburan yang sangat rendah, bertolakbelakang dengan apa yang dilaporkan di daerah lain, ditambah praktek destocking yang umum dikalangan petani, dapat mengakibatkan sistem pertanian disini tidak berkelanjutan. Hasil penelitian ini juga dapat berfungsi sebagai dasar bagi petani untuk menyesuaikan manajemen mereka, dan bagi para pembuat kebijakan untuk merencanakan strategi dan intervensi dalam mengembangkan performans produksi ternak dan meningkatkan mata pencaharian pedesaan, di mana tingkat sustainabilitas dari setiap sistem dapat lebih menjanjikan.

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8 Curriculum Vitae

Personal data

Name	Faradilla ATTAMIMI
Date and place of birth	August 5th, 1974 in Ambon, Indonesia
Address	Egilolfstrasse 48, 70599 Stuttgart, Germany
	Hohenheim University (480a), Garbenstr. 17, 70599 Stuttgart, Germany
Nationality	Indonesian
Marital Status	Married
Languages	Indonesian (mother tongue), English (fluent), German (school knowledge equivalent), Japanese (school knowledge equivalent)

Professional experience

2008 – 2009	Selected lectures at the Institute of Animal Production in the Tropics and Subtropics, Hohenheim University, Germany.
2006 – present	Head of Animal Health and Production Laboratory Type B, Department of Agriculture, Maluku Province, Indonesia
1999 – 2006	Staff of Livestock Services Division, Department of Agriculture, Maluku Province, Indonesia
2004 - 2006	Lecturing “Physiological Reproduction” and “Livestock Production” at the Faculty of Animal Science, Pattimura University, Ambon, Indonesia
1999 – 2002	Veterinary Practitioner, CK PET CARE, Jl. Cikatomas I No. 27 Kebayoran Baru, Jakarta Selatan, Indonesia.
1993 – 1998	Journalist at Infovet magazine (national magazine for animal health and therapy)

Education

10/ 2007 till present	PhD thesis on “Sustainability analysis of beef production with Bali cattle in smallholder farms on Ceram Island, Indonesia” at the Institute of Animal Production in the Tropics and Subtropics, Hohenheim University, Germany. Supervisor: Prof. Dr. Anne Valle Zárate
2002 - 2003	Master thesis on “Assessment of the government policies with emphasis on cattle distribution programme for small scale beef production system in Ceram Island, Indonesia” at the Larenstein University of Professional Education, The Netherlands. Supervisor : G. den Hertog.
1992 – 1999	Bachelor study at the Faculty of Veterinary Medicine, Bogor Agriculture University, Bogor, Indonesia. Supervisors: 1. Prof. Dr. Y. Horii, MSc, DVM. Miyazaki University, 889-2192, 1-1,Gakuen Kibana-dai Nishi, Miyazaki-shi, Japan 2. Dr. Risa Tiuria, MSc, DVM.

	Bogor Agriculture University (IPB), Jl. Taman Kencana No. 3 Bogor 16151, Bogor, Indonesia
1989 – 1992	High School at SMA Negeri 3 Ambon, Indonesia
1986 – 1989	Yunior High School at SMP Angkasa Lanud Pattimura, Ambon, Indonesia
1980 - 1986	Elementary School at SD Negeri 1 Tawiri, Ambon, Indonesia

Additional Educational Experience

2006	Refresher course on “PRA and PLA: a space of intercultural learning on AIDS and rural development” in Tanzania.
2003	Workshop on project cycle management at the Larenstein University, The Netherlands
1996 - 1997	Student research exchange to Miyazaki University, Japan. Research topic: *Strongyloides venezuelensis* infection in cotton rats, *Sigmodon hispidus*.

Stuttgart, ………………………….. Faradilla Attamimi

9 Erklärung

Hiermit erkläre ich, daß ich die vorliegende Dissertation selbständig angefertigt habe in Übereinstimmung mit den Vorgaben der Promotionsordnung. Alle verwendeten Quellen und Hilfsmittel sowie wörtlich oder inhaltlich übernommene Stellen sind als solche gekennzeichnet.
Die vorliegende Arbeit wurde bei keiner anderen Prüfungskommission als Dissertation zur Eröffnung eines Promotionsverfahrens eingereicht, weder in Teilen noch als ganze Arbeit.

Stuttgart, ………………………….. Faradilla Attamimi