Mapping the impact of crossbreeding in smallholder cattle systems in Indonesia

Tri Satya Mastuti Widi

Thesis committee

Promotor
Prof. Dr A.J. van der Zijpp
Emeritus Professor of Animal Production Systems
Wageningen University

Co-promotors
Dr H.M.J. Udo
Associate professor, Animal Production Systems Group
Wageningen University

Dr J.K. Oldenbroek
Senior Researcher, Centre for Genetic Resources
Wageningen University and Research Centre

Other members
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Dr I. Hoffmann, Food and Agriculture Organization, Rome, Italy
Dr C. Almekinders, Wageningen University

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Thesis

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Tri Satya Mastuti Widi

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In memory of my mother, Koestinah Kadarwati (1937-2005) and
my father, Soeminto Hardjo (1931-2013)
Dedicated to my dear sisters Trisna and Hetty, my beloved daughter Malya and
my loving husband, Ika

"We need to shift the focus from doing research on farmers to doing research with farmers"

(CGIAR, 2014)

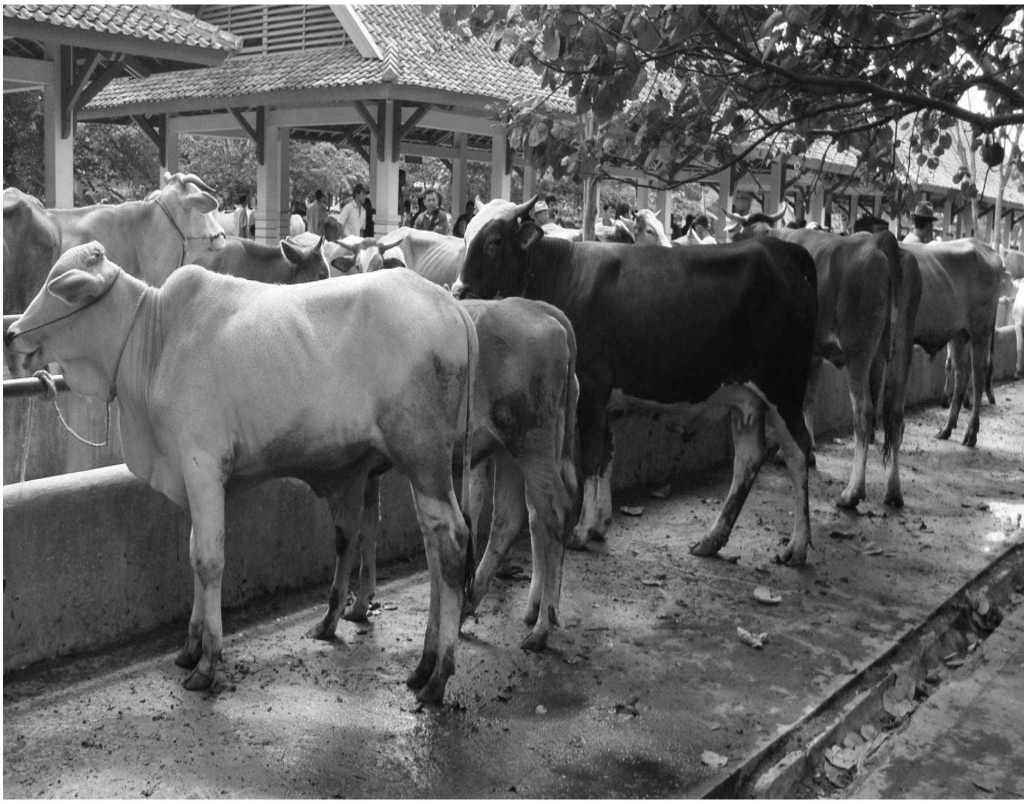
CONTENTS

ABSTRACT

In response to increasing demand for meat, Indonesia's government has been implementing crossbreeding with European beef breeds to improve the meat production of local cattle. The main objective of the present study was to evaluate the benefits and consequences of crossbreeding in smallholder cattle farming systems in Madura and Central Java. The study used participatory approaches, observations during cultural events in Madura, and measurements of cattle performances, feeding practices and farm inputs and outputs. In Madura, crossbreeding is not a threat to the two cultural events involving cattle, *sonok* (cow conformation contest) and *karapan* (bull racing), nor to the sub-populations of Madura cattle in the specific areas where these events are organised. Farmers outside the *sonok* and *karapan* areas, prefer Limousin crossbreds (*madrasin*) to conventional Madura cattle. The current breeding and conservation approaches do not distinguish between different Madura cattle types and do not consider the specific needs of the farmers in the *sonok* and *karapan* areas. In Java, farmers perceive that crossbreeding of Simmental with local Ongole cattle is beneficial for them. Crossbreeding was not accompanied with changes in the cattle farming systems. Crossbred cattle reached a higher body weight and therefore had a higher market price, but they also required more feed. This resulted in comparable Gross Margins for farms with crossbred and Ongole stock. Farmers preferred the crossbreds because of their nice appearance, high growth rate and the higher market price for progeny compared to Ongole. Crossbreeding as a tool of intensification did not reduce the carbon footprint and land use per kilogram liveweight produced. The advantage from the faster growth of crossbreds was counteracted by the higher emissions and land use from feed production for crossbreds. The dualism in crossbreeding is that policy makers promote crossbreeding to meet the increasing demand for beef, whereas farmers are concerned with their livelihoods and the multi-functionality of cattle. Crossbreeding contributes to increased meat production at the national level, however, it has limited possibilities to improve cattle production at farm level. Crossbreeding is also not reducing rural poverty. Participatory approaches should ensure that farmers' views are considered in national crossbreeding policies and practices. In Madura and Central Java, farmers identified economic benefits, feed availability, cattle management, animal performances, additional functions of cattle, and health and fertility as issues to be considered beforehand in a genetic impact assessment of crossbreeding. Other stakeholders mentioned meat production, environmental quality and diversity in farm animal genetic resources as important issues. Crossbreeding will inevitably continue in Java and Madura. Breeding strategies, have to be adjusted, however, as farmers do not want to upgrade their local cattle to Simmental or Limousin. Viable populations of local cattle are needed to ensure sustainable crossbreeding strategies.

Chapter 1

General introduction



Cattle market with Ongole and crossbred animals

1.1. General background

Population growth, urbanisation, economic progress and changing consumer preferences boost the demand for livestock products in developing countries (Delgado *et al.,* 2001). Indonesia is an emerging economy, where high population growth and economic progress are major driving forces for the rising demand for animal source foods. Red meat is a traditional animal source food in Indonesia (Sullivan and Diwyanto, 2007). The average meat consumption is 1.87 kg/capita per year (BPS, 2011) and is expected to increase to 3.72 kg/capita per year by 2020. The human population is expected to increase from the current 241 million to 274 million by 2020 (Agus *et al.*, 2014). The highest production and consumption of beef is in Java, the main island, where 57% of the human population live (Kementan, 2013). To satisfy the demand for meat, the government has been importing meat as well as live feeder and slaughter stock, a few breeding animals and semen. Since the 1980's, the government has been promoting artificial insemination (AI) using exotic *Bos taurus* breeds, such as Simmental, Limousin, Aberdeen Angus and Hereford, to improve the meat production of local cattle, especially in Java.

In Indonesia, cattle systems have developed for centuries in harmony with local conditions for climate, vegetation, existing farming systems and social, cultural and religious values. Smallholder cattle farms are characterised by keeping between two and four head of cattle and integrating crop and livestock production (Djajanegara and Diwyanto, 2002; Priyanti *et al.*, 2012). This is done by gathering nutrients from waste lands, roadsides, home gardens and crop residues, and using draught power for the cultivation of arable land (Beets, 1990; Devendra, 1993; Rodriguez and Preston, 1997). In Java and Madura, which have densely populated rural regions with limited grazing areas, cattle are universally kept in a barn and fed forages, which are cut-and-carried from roadsides and field margins. The cut-and-carry feeding system is labour intensive (Tanner *et al*., 2001).

The importance of livestock for smallholder livelihoods around the world is well understood. For poor households, the non-income functions of livestock keeping are particularly important (Anderson, 2003). In Indonesia, farmers do not only keep cattle to produce meat for the urban market. Cattle are also kept to support cropping with manure and draught power, and as livelihood assets (Widi, 2004). The livelihood functions or benefits include savings, buffering, insurance and cultural benefits (Anderson, 2003; Moll *et al.*, 2007). The introduction of crossbreeding in smallholder systems implies that the major objectives of keeping cattle will change from multipurpose production to market-oriented production (Udo *et al.*, 2011).

Cultural practices, in particular, are expected to require specific characteristics, which might not be fulfilled by crossbred animals. Cattle breeds in Indonesia differ substantially in their cultural values. In Bali Island, albino Bali cattle are treated as holy cattle and used in a cultural ceremony (Panjono, 2014). Bali people (mostly Hindu) are not allowed to slaughter 'white' cattle (mostly Zebu, such as Ongole and Brahman), as they believe that a 'white' bull is the mount of the god Wisnu. In mainland Java, the cultural values of cattle are much less pronounced. For a minority of Java people (usually rich farmers), Ongole bulls still have socio-cultural value as a hobby and expressing pride in keeping beautiful cattle. In Central Java, traditional cart pulling festivities with Ongole males are organized every month. Cultural values of cattle are most prominent in Madura. Crossbreeding was prohibited for a long period, in order to protect the Madura cattle breed and traditional cultural practices. However, since 2001, crossbreeding is allowed in Madura. In Bali crossbreeding is still prohibited to protect the Bali breed (*Bos banteng*).

Exotic breeds have been introduced in many developing regions for crossbreeding with local breeds. *Bos taurus* sires for beef cattle crossbreeding may result in higher growth rates and larger carcasses, at least under improved management conditions (Said *et al.*, 2003; Scholtz *et al.*, 2011). This requires more feed resources, improved marketing and a better infrastructure. Crossbreeding has often failed to yield the desired and expected results. Results from optimized testing facilities cannot be directly translated to mixed farming systems, where institutional and infrastructural constraints are prominent. Scholtz *et al*. (2011) claim that it is likely crossbreeding programs will never succeed in harsh environments unless adequate fodder availability is assured. In Indonesia, especially Java, lack of feed is a major constraint for cattle production. It is questionable whether farmers could afford to grow or buy the feed and concentrates required by crossbred cattle.

Crossbreeding in smallholder systems is never done systematically (Wollny, 2003). This is a major threat to the conservation of local genetic resources (Wollny, 2003). So, there is general concern that genetic variation is disappearing through crossbreeding and breed substitution (FAO, 2001; Köhler-Rollefson *et al.*, 2009). In addition, cultural and social aspects can be important reasons for continuing to keep certain breeds that have become economically unviable (Singh and Sansthan, 2003). The analysis of cultural values can be a tool to add economic value to local breeds, and consequently might contribute to maintaining local breeds (Gandini and Villa, 2003).

A recent pressing international issue is the emphasis on reducing the climate impact of cattle (Steinfeld *et al.*, 2006; Herrero *et al.*, 2009; Gerber *et al.*, 2013; Herrero and Thornton, 2013). Increasing productivity is generally seen as an efficient climate change mitigation strategy. In this context, local ruminant breeds are considered to be less efficient in mitigating greenhouse gasses (GHG) emissions than improved breeds (Steinfeld *et al.*, 2006). Increasing productivity to reduce environmental impact could have an additional negative effect on the future use of local farm animal genetic resources (Hoffmann, 2011).

There is often a gap between the objectives at national and global levels and the objectives of smallholder farmers. The influence from the lower level (smallholder farmers) to higher levels is very weak, whereas influences from national to regional and global levels are often stronger (Giller *et al.*, 2008). Public and private interests do not always match (Hoffmannn, 2011). In Indonesia, the government is mainly concerned with the increasing demand for meat by urban consumers, whereas smallholder farmers are mainly concerned about their livelihoods.

Crossbreeding policies are implemented throughout the world without sufficient knowledge of the positive and negative effects on food production, genetic diversity, environment, resource use and the social and economic sustainability of the majority of farming systems and rural livelihoods (Pilling, 2007; Gandini and Oldenbroek, 1999; Samdup *et al.*, 2010; Marshall, 2014). In Indonesia, crossbreeding is also applied without sufficient knowledge of its impact and without necessary changes in the institutional environment. Hence, crossbreeding may influence not only the future availability of local farm animal genetic resources but also (for better or worse) the farming systems and livelihoods of livestock keepers. The major motivation for the research in this thesis is the current lack of understanding about the consequences of the introduction of exotic breeds for crossbreeding for specific mixed farming systems in Indonesia.

1.2. Cattle keeping in Indonesia

Timeline of cattle breeds

Table 1.1. provides a timeline of the development of cattle breeds in Indonesia. The timeline shows that crossbreeding is not a new approach in cattle production systems in Indonesia. Martojo (2005) stated that in the 19th century, during the Dutch administration, local breeds were upgraded using Ongole bulls from India. The pure Ongole from India was brought to Sumba Island. This island, far from Java, was originally only a quarantine area, as India had endemic rinderpest. However, Ongole cattle developed well in Sumba (Hardjosubroto, personal communication) and became the pure Sumba-Ongole (Sudardjat and Pambudy, 2003). In Java, the Sumba Ongole was crossed with small Java cattle (Barwegen, 2004), particularly in East Java. Further importation of Indian *Bos indicus* cattle, such as Ongole, Hissar and other zebu cattle, occurred early in the 20th century. The purpose of the importations was to provide Java with strong draught cattle to pull carts for the sugar industry (Barwegen, 2004). The crossbreeding during this period resulted in Ongole-grade (in Indonesia called *Peranakan Ongole*, PO). The Dutch administration introduced Ongole-grade cattle in areas along a main concrete road, 'Daendels road', located along the south coast in Central Java. This road was made to stimulate sugarcane production on large plantations, and as a main road to connect Central Java with West Java. Ongole cattle replaced the buffalo as draught animal, as they are humped and their hooves are better suited to walking on concrete roads. From about the 1930's onwards, the Ongole became the prominent cattle breed in Java (Maule, 1990).

Starting in the 1980's, the Ongole was upgraded using exotic breeds through an AI program promoted by the Indonesian government (Sutresniwati, 2006). The government introduced artificial insemination in 1952 in AI training centres. AI was applied for the first time in the field in 1969 and since 1973 it has been widely applied in smallholder farms, using frozen semen (Sudardjat and Pambudy, 2003). Martojo (2005) stated that frozen semen from exotic cattle breeds began to be imported during the second five-year plan in the 1970's. In 1976, the government built two AI centres, in West and East Java, to fulfil the demand for frozen semen, and established local AI bureaus in almost every province. In the

Table 1.1. Historical timeline for development of non-dairy cattle breeds in Indonesia

Time line	Breed	History	Location	Population size
3,500 BC	Bali (*Bibos sondaicus*)	Bali cattle were domesticated from *Banteng* (*Bos banteng*)	Bali, Nusa Tenggara, Sulawesi, and Javas	4,789,521 (Kementan, 2013)
Unknown	Java (*Bos javanicus*)	Java cattle are presumably developed from a cross between an old mix of Indo-Chinese cross of Zebu and *Banteng* (Barwegen, 2002) or indigenous hybrids with genes from the *Bos indicus*, *Bos taurus* and *Bos (bibos) spp*. (Payne and Hodges, 1997)	Java	< 10,000 (Astuti *et al*., 2007)
Unknown	Sumatera / *Pesisir*	Sumatera cattle are a result of crossing *Bos indicus* and *Bos sondaicus*. They are of the same origin as Java cattle (Deptan, 2003).	Sumatera Island	950,000 (Deptan, 2003)
About 1,500 years ago	Madura	Crossbreeding of Banteng /Bali cattle (*Bos* (*bibos*) spp x *Bos indicus* (Ressang *et al*., 1959) or Bali cattle (*Bos* (*bibos*) spp x *Bos indicus* x *Bos Taurus* (Payne and Rollinson, 1976), resulted in Madura cattle.	Madura, Java, Sumatera, Kalimantan, Sulawesi, Nusa Tenggara Islands	1,285,690 (Kementan, 2013)
1900's	Sumba Ongole (SO)	In 1906, Ongole cattle (*Bos indicus*) were imported from Madras, India to Sumba Island (Hardjosubroto and Astuti, 1993).	Sumba Island	46,649 (Astuti *et al*., 2007)
1900's	Hissar	Hissar cattle were imported from Punjab, India, in 1900's and brought to Sumbawa Island (Astuti *et al*., 2007).	Sumbawa Island	< 10,000
1930	Ongole-grade (in Indonesia called *Peranakan Ongole*, PO)	*Peranakan* Ongole was developed around 1930 as a grading up of Java cattle and SO (Sudardjat and Pambudy, 2003; Astuti *et al*., 2007).	All around Indonesia, particularly Java, with the highest population in East and Central Java	4,281,602 (Kementan 2013)
1980's	*Bos taurus* crossbred	Crossbreeding of PO with *Bos taurus* breeds such as Simmental, Limousin, Hereford, Angus, Santa Gertrudis, Droughtmaster, Charolais, and Shorthorn started in smallholder farms through artificial insemination (AI) (Hardjosubroto, 1994). Simmental, Limousin and Angus were favoured by farmers.	All around Indonesia, particularly Java	Unknown
1990's		Crossbreeding of Bali cattle with *Bos taurus* breeds such as Simmental, Limousin, and Angus through AI. Male crossbred progeny is sterile (Hardjosubroto, personal communication).	Nusa Tenggara Island	Unknown
2000's		Crossbreeding of Madura cattle with Limousin through AI (Widi *et al*., 2014)	Madura except Sapudi (outer) Island	Unknown

1980's the government imported cattle of ten exotic breeds (Brahman, Santa Gertrudis, Droughtmaster, Sahiwal, Charolais, Simmental, Limousin, Hereford, Shorthorn and Angus) (Hardjosubroto, 1994), to provide semen. These cattle were kept on a central farm. Only information about purebred performances of the Brahman, Simmental and Limousin is available (Hardjosubroto, 1985; Baliarti, 1991). At present, the national AI organization imports exotic AI bulls from Australia and buys bulls from smallholder and large-scale farms with upgraded cattle. AI bulls of local breeds originate from government owned local breed breeding centres and private farmers.

Nowadays many different types of cattle exist in Indonesia as a result of the crossbreeding policy. Bali, Madura, Ongole, Hissar, Aceh, Pesisir and Java are local cattle breeds, which are kept both pure and crossed with exotic breeds, in particular Simmental, Limousin, Hereford and Angus. Figure 1.1. shows the trends in the number of beef-type cattle, cattle slaughtered and meat production in Indonesia since 1970. The number of beef-type cattle increased from 3.8 million in 1945 to 12.8 million in 2013. The numbers increased strongly in the 1980's, due to growth of the breeding stock population, new farmers and intensive extension support. Extension support programmes included '*Bimbingan Masal'* (Bimas), meaning intensive guidance, and '*Panca Usaha Ternak Potong'* (PUTP), meaning five pillars of support for keeping meat animals (Sudardjat and Pambudy, 2003). The second president of Indonesia, Soeharto (1965-1998), was very active in spreading breeding stock through a program named "*Bantuan Presiden*", meaning presidential support. The promotion of crossbreeding was also encouraged by President Soeharto, as he was interested in livestock production (Hardjosubroto, personal communication).

When AI and crossbreeding were first introduced, very few farmers were interested. Farmers did not believe that AI could make their cows pregnant and disliked the crossbred progeny. However the government promoted AI intensively, together with crossbreeding. This was supported by scientists with many on-farm research results that showed the advantages of crossbreeding in terms of high growth rates (Baliarti, personal communication). Inseminators have also been very active in promoting AI and crossbreeding. The price for exotic semen is 17 to 20 % higher than for local cattle semen.

The preference of farmers has gradually changed from local breeds to crossbreds over time. Nowadays, farmers have high expectations of crossbred cattle. However, they overlook the possibility that the benefits do not compensate for the additional costs and risks associated with the management of crossbreds. In 2006, Sutresniwati concluded that crossbreeding has become a 'hype', supported by policy makers, extension workers, inseminators, veterinarians and farmers. Only sellers of *bakso*, a local soup with meat balls, preferred meat from local cattle because of the texture of the meat and the number of meat balls that can be prepared per unit of meat (Sutresniwati, 2006).

One of the expected consequences of crossbreeding is loss of adaptability, in terms of fertility, calf mortality, and diseases. Sutresniwati's work on the performance of local and

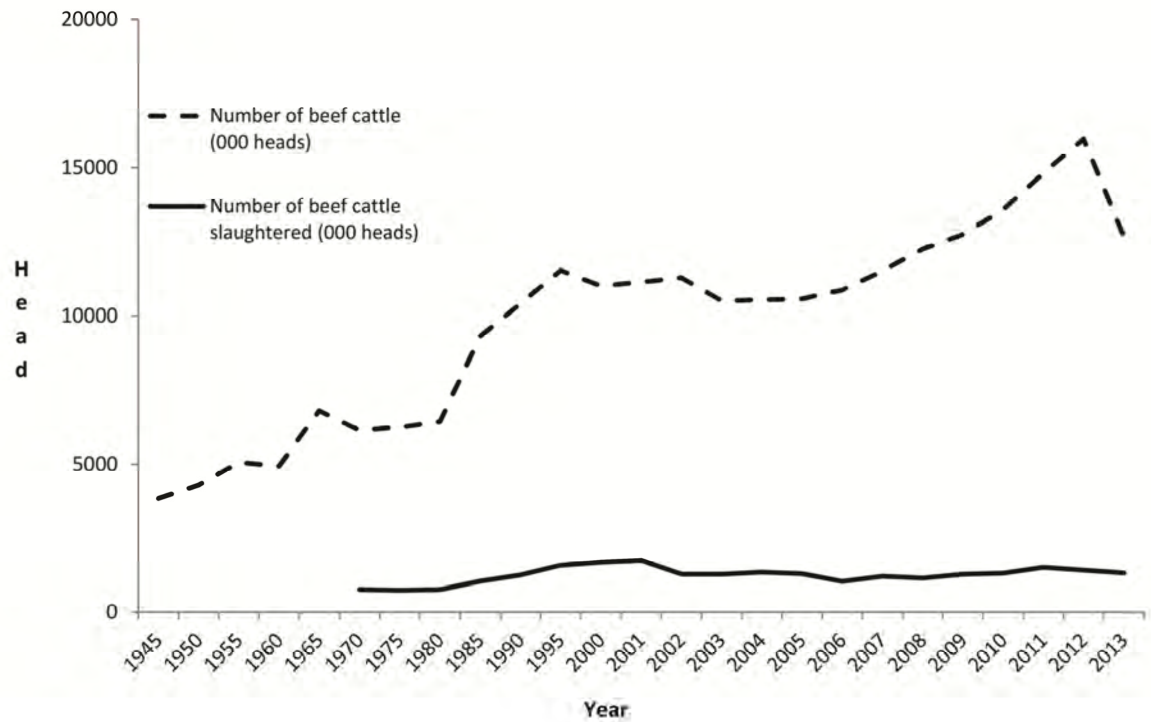


Figure 1.1. Number of beef cattle and cattle slaughtered (000 heads) since 1945 - 2013 (change in census method for 2011 and 2012)
Source : Kementan (2013) and Sudardjat and Pambudy (2003)

crossbred cattle showed that crossbred cattle in Central Java had better growth rates but lower fertility rates than local cattle (Sutresniwati, 2006). An adequate reproductive performance is crucial to the financial success of smallholder farmers with only one or two cows (Agyemang and Nkhonjera, 1990). Cunningham (1989) found that in tropical areas, calving interval was poorer when the percentage of *Bos taurus* was more than 50%. Veterinarians observe that disease resistance is better in local cattle than in crossbred cattle (Putro, personal communication). The majority of crossbred cattle suffer from Cascado disease, a disease caused by the parasite *Stephanofilaria spp*, which is spread by flies. It affects the skin around the eyes, though farmers do not consider it to be a problem (Sutresniwati, 2006). Widi and Widodo (2007) found that inadequate management (general sanitary conditions in barns and absence of fly control) is the main cause of Cascado disease.

Perspectives of local breeds

The most dangerous threat for local breeds is the euphoria of most stakeholders about crossbreeding, not only the government and cattle traders, but also farmers themselves (Sutresniwati, 2006). The international call to maintain livestock biodiversity in a country (FAO, 2001) prompted policy makers in Indonesia to contribute to the State of the World's Animal Genetic Resources process by preparing a strategic national report on animal genetic resources (Anonymous, 2003). Increased awareness about the importance of maintaining local genetic resources encouraged policy makers and scientists to support the conservation of local breeds (Astuti *et al*., 2007). The local cattle breeds defined were Aceh, Bali, Ongole-grade, Sumba-Ongole, Madura, Java, Pesisir and Grati. A number of areas have been designated as conservation areas for specific breeds, such as Sapudi in Madura for the Madura cattle and Bali for the Bali cattle. A second measure is performance testing for local breeds (Kementan, 2012). The best yearling calves are transferred to performance test stations to select the best bulls as breeding bulls for AI and cows. Performance and progeny testing in Bali cattle started earlier, around 1986. No exact data are available on the number of test stations nor on the distribution of tested animals. Furthermore, data on pedigree and on-farm performances are not collected, and therefore cannot be used for the analysis of inbreeding and the correlation of test station performance results with on-farm performance results.

Cattle value chains

In Indonesia, the marketing system for beef-type cattle from smallholders is rather diverse and long, with large numbers of different types of traders (Figure 1.2.). When farmers want to sell their cattle, they call a local trader. This trader usually lives within the village. The price of an animal is based on the live weight estimation of the local trader and the farmer. These traders are important for livestock smallholders. However, traders can also be a cause of concern as their costs contribute to lower prices for producers (Sullivan and Diwyanto, 2007). The local traders transport the cattle to inter-district traders, markets or butchers. In the market, cattle from many local traders are grouped based on age, production level and sex (cows, heifers, bulls and calves). Middle men offer the cattle to buyers, and connect buyers and sellers (local traders). Buyers generally consist of inter-district traders, inter-province traders, butchers, smallholder farmers, and medium-scale and large-scale farmers. Medium-scale or large-scale farmers are farmers with a minimum of ten cattle kept in feedlots. Some of these farmers are also the local butchers. The prices of cattle are based on the liveweight estimation of the traders and buyers. Only a few cattle markets in Java set prices based on liveweight measurements using weighing scales.

Cattle are slaughtered by local butchers in slaughter houses, which are owned by the government. Local butchers generally slaughter less than five cattle per day and sell the meat in the regularly organised local markets. *Bakso* sellers, households, small restaurants and small food processors are the buyers of meat in regular food markets or meat shops (Widi *et al*., 2008). The demand for meat from big restaurants, hotels, catering and food industries is met by local production from butchers and feedlots (65%) and frozen meat imports (35%) from Australia (Ahmadi, personal communication).

Crossbred cattle have a higher sale price because of the high demand and the perceived higher productivity (Sutreniswati, 2006). Sutresniwati (2006) concluded that prices of crossbreds are not based on the real value of saleable meat, but more on the psychological value for farmers. The risk exists that in the future, when most farmers keep

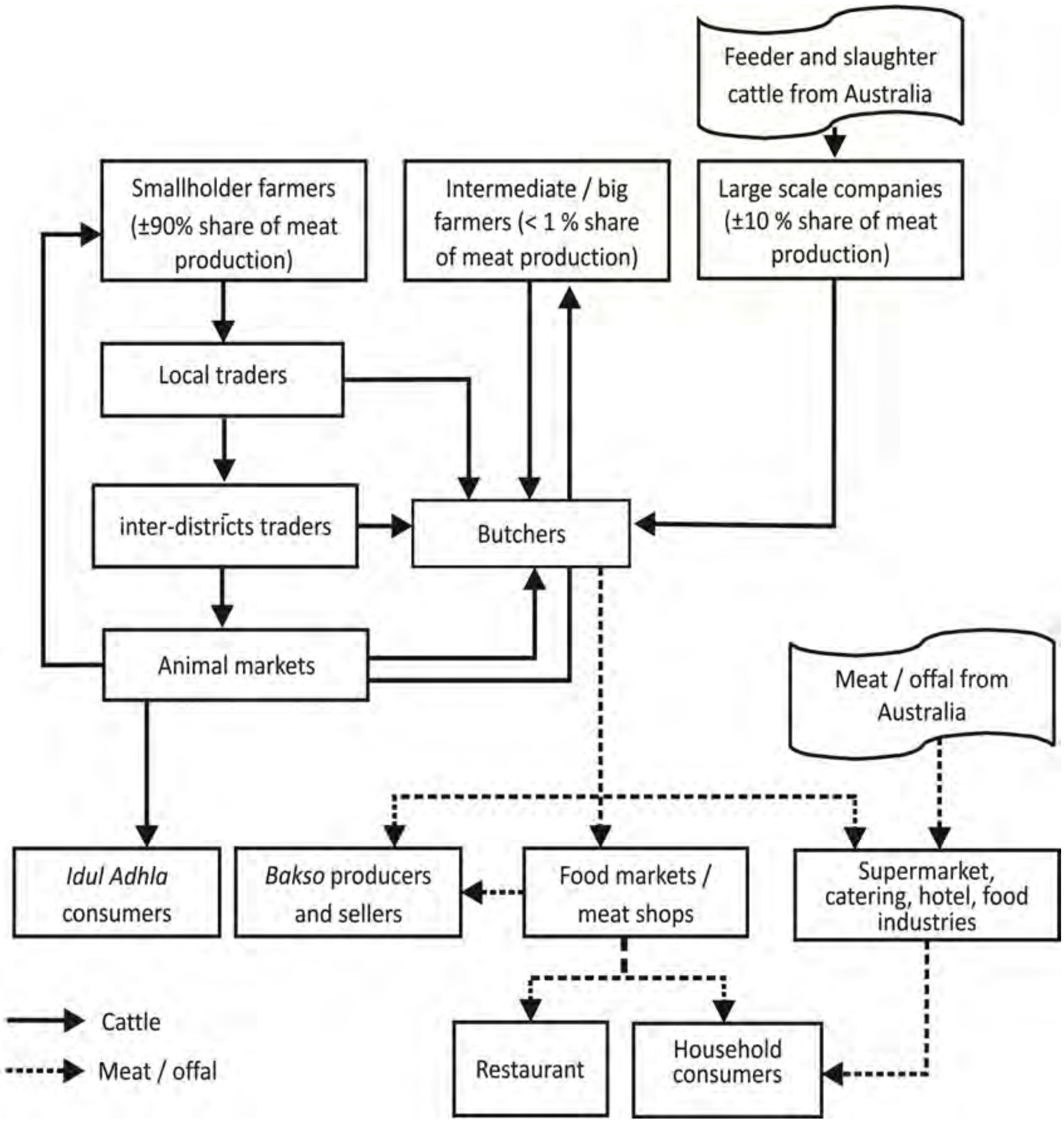


Figure 1.2. Value chain of cattle, meat and offal

crossbred cattle, the demand and prices for crossbred cattle may decline. Moreover, the price for slaughter animals has to compete with imported beef cattle from Australia (Sutresniwati, 2006).

1.3. Problem statement

Crossbreeding with breeds selected for high production has become a standard cattle intensification approach in Indonesia. As presented in Figure 1.1., census data on population number did not distinguish breeds, but it is clear that the current crossbreeding strategy has a major impact on the viability of local cattle breeds. It has been well understood that local farm animal genetic resources are important not only for their genetic contribution in terms of adaptation, but also their ability to fulfil non-income functions and socio-cultural traditions. The most prominent example of cultural values of cattle is Madura, where the social and cultural values of Madurese depend on the existence of Madura cattle. There are two traditional cultural festivities that involve Madura cattle, bull races and cow/heifer contests. These are well identified markers of the Madurese throughout Indonesia. Crossbreeding may be a threat not only to the existence of purebred Madura cattle, but also for cultural activities involving cattle.

How beneficial is crossbreeding for the livelihoods of smallholders? Crossbreeding requires resources; in particular the issue of feed resources is crucial. Cattle in Indonesia are dependent on crop residues, road-side grasses and forages. In general, the quality of these feeds is not sufficient to support high production levels. The feeds available will differ in different regions due to differences in cropping patterns (Zemmelink *et al*., 2003). There is no recording of animal performances in Indonesia. Studying the impact of crossbreeding on the livelihoods of smallholders therefore requires data collection methodologies at animal and farm levels. These methodologies need to include the different motives for keeping cattle.

International literature pays ample attention to the beneficial effect for the environment of the intensification of cattle keeping (Steinfeld *et al*., 2006). However, it is unclear whether crossbreeding is an appropriate intensification strategy in smallholder farms to reduce the environment impact, in terms of GHG emissions and land use, of cattle keeping. According to Marshall (2014), it is still an assumption that the adoption of more productive breeds in smallholder farming systems will be beneficial for the environment. Intensification requires more inputs, so only more efficient use of resources will result in reduced impacts on the environment. It is unknown whether crossbreeding for beef production in smallholder farming systems, such as those in Indonesia, will result in more efficient use of resources and, if so, in less environmental impact per unit of production.

An impact assessment of the effects of the introduction of exotic cattle breeds on indigenous cattle resources, cattle farming systems and livelihoods is needed to understand the consequences of such introductions (Gandini and Oldenbroek, 2007). In literature on farm animal genetic resources, the call for genetic impact assessments (GIA) arises primarily because of concerns about the potential loss of genetic diversity through breed replacement or ill-considered crossing or upgrading (Hiemstra, 2003). However, the impact of using different breed types in developing country livestock systems requires assessments from a number of viewpoints and at different levels (Marshall, 2014). Ideally, a livestock impact assessment should be made before the introduction of exotic animals is considered. In practice, it is usually done after the introduction has already taken place. It is often not done at all.

The gap between governments' objectives and farmers' practices calls for participatory methodological approaches involving the key stakeholders, the farmers, to understand their perceptions about crossbreeding, to assess the impact of crossbreeding, and to design appropriate livestock development strategies for their farming systems.

1.4. Objectives of the study

The main objective of the study described in this thesis was to evaluate the benefits and consequences of crossbreeding in smallholder cattle farming systems, in order to develop a genetic impact assessment (GIA) of exotic cattle breeds on cattle farming systems in Indonesia. This analysis is expected to contribute to the design of feasible livestock development strategies for smallholder farming systems. The specific objectives were:

1. To analyse the cultural values of local cattle and the effect of crossbreeding on local traditions in Madura;
2. To assess the performance of local and crossbred cattle and the impact of crossbreeding in smallholder farming systems in different agro-ecological zones in Central Java;
3. To assess the environmental impact, in terms of global warming potential (GWP) and land use, of local and crossbred cattle in smallholder farming systems in different agro-ecological zones in Central Java;
4. To formulate a GIA design that shows the consequences of exotic crossbreeding.

1.5. Methodology

Research sites

Indonesia is located approximately between 6 to 11^0 north latitude and 95 to 141^0 east longitude, covering 9.82 million square kilometres and consisting of 17,508 islands with 1.92 million sq.km of land and surrounded by 7.90 million sq.km of seawater. This study took place in Central Java Province, Yogyakarta Province and Madura. Central Java and Yogyakarta Provinces are located in Java, the most populated island in Indonesia, whereas Madura is a small, densely populated island located off the northeast coast of Java. It is administered as part of East Java Province. These provinces have relatively large cattle numbers.

Madura was used to study the unique interaction between cattle and culture, and the potential impact of crossbreeding on this interaction, as Madura is famous for cultural events involving cattle (De Jonge, 1990). The study areas in Madura were determined by the use of cattle for different cultural events: *karapan* bull race, *sonok* cow contest and crossbred cattle (*madrasin*) contest.

In Central Java, the study areas represent Wet lowlands, Wet uplands, and Dry uplands. These have different topography, soil types, soil fertility and agro-climatic conditions, and consequently different cropping patterns, land use management and feed resources (Budisatria, 2006). Lowlands (less than 100 metres above sea level (m asl) are characterised by irrigated paddy mixed with maize, ground nut, soy bean and cassava growing. The main component of feed is locally grown grass (Ifar, 1996; Budisatria, 2006). Uplands are found higher than 500 m asl. Here annual crop production systems are found. The main crops are cassava, maize, groundnut and vegetables. Some perennial crops are also available, such as banana and coconut (Budisatria, 2006). Differences in the use of natural resources between areas and consequently between animal production systems might affect the type of animals that can be kept in the areas. The consequences for feed quality and quantity in different areas and ecosystems are not predictable beforehand. Farmers optimize resources around their homestead and cropping plots to feed their livestock. Cattle are the predominant type of livestock in all study areas.

Research approach

This study was approached by literature review, participatory observations and direct measurements of cattle performance, feeding practices and farm inputs and outputs. Table 1.2. provides an overview of research methods, sample categories, study areas and persons who were responsible for data collection.

Table 1.2. Methods used

Chapter	Research method	Study sample unit	Study area	Persons responsible
2	Participatory approach including semi-structured interviews; phenotypic characteristics measurement of local and crossbred cattle and gross margins analysis	97 farms (30 *karapan* farms, 37 *sonok* farms and 37 *madrasin* farms) and 184 cows.	Madura	PhD candidate and undergraduate students under PhD candidate's supervision, involving all the respondent farmers in study areas.
3	Participatory approach including semi-structured interviews; phenotypic characteristics, reproductive performances and carcass characteristics measurement of local and crossbred cattle; feeding practices and; Gross Margins analysis	252 farms (90 local farms and 162 crossbred farms), 294 female cattle (including 270 cows), 127 calves and 55 slaughtered cattle.	Central Java	
4	Recording of farmers' inputs and outputs; Life Cycle Assessment (LCA) procedures; allocation procedures; and impact assessment.	252 farms (90 local farms and 162 crossbred farms)	Central Java	
5	Literature review; expert consultation; focus group discussions (FGD) and stakeholders analysis; developing a conceptual genetic impact assessment (GIA) and testing the GIA model to own cases studies.	296 participants in Central Java and 125 participants in Madura; analyses from chapters 2, 3 and 4	Central Java and Madura	

Important issues related to the impact of crossbreeding on smallholders farming systems were gathered through focus group discussions (FGDs) among stakeholders and literature review. These issues were selected, measured and assessed using semi-structured interviews and measurements of cattle and farm performance, inputs and outputs, and costs and benefits of cattle keeping.

1.6. Layout of the thesis

This thesis consists of six chapters (Figure 1.3.), and starts with a general background to this study (Chapter 1). Chapters 2, 3, 4 and 5 provide information about the impact of crossbreeding on local systems.

Chapter 2 addresses the cultural value analysis of Madura cattle and the effect of crossbreeding on local traditions.

In Chapter 3, performances of Ongole and crossbred cattle were studied. Two questions were addressed. Is crossbreeding an appropriate livestock development strategy in the different agro-ecological zones? And, is this strategy economically viable for the smallholder farmer?

In Chapter 4, life cycle assessment (LCA) methodology was used to assess the environmental impact of local and crossbred beef cattle production systems in different agro-ecological zones.

Using the information in Chapter 2, 3 and 4, Chapter 5 presents a design for a GIA

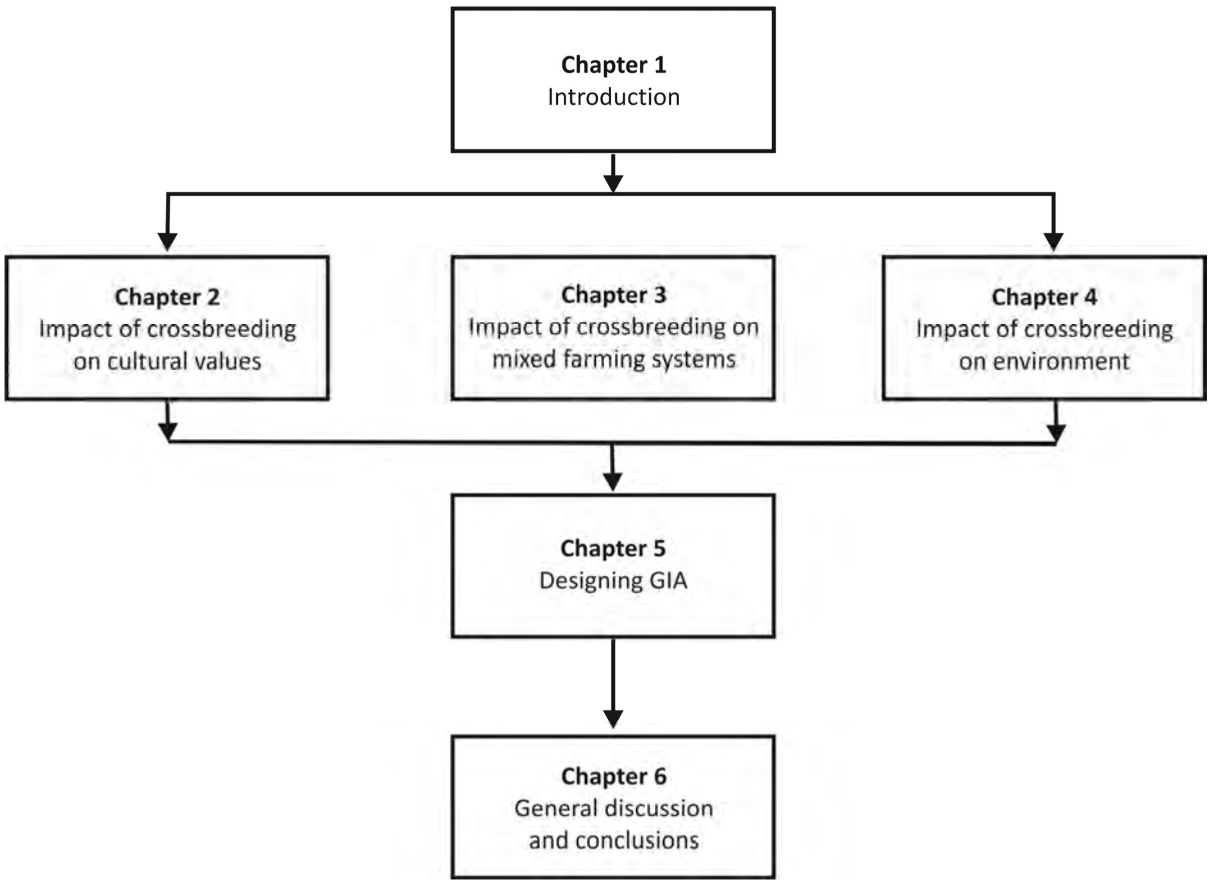


Figure 1.3. Overview of the thesis structure

and uses the results of the crossbreeding practices in Central Java and Madura to test the robustness of the design for future applications. Finally, Chapter 6 integrates the results in a general discussion on developing a GIA and sustainable development strategies for beef cattle in smallholder farming systems in Indonesia.

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Chapter 2

Unique cultural values of Madura cattle: is crossbreeding a threat?

Karapan race, children used as jockey

T.S.M. Widi [1,3], H.M.J.Udo[1], K. Oldenbroek[2], I.G.S. Budisatria[3], E. Baliarti[3], A.J. van der Zijpp[1]
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[1]Animal Production Systems Group, Department of Animal Sciences, Wageningen University, the Netherlands
[2] Centre for Genetic Resources, Wageningen, the Netherlands
[3]Department of Animal Production, Faculty of Animal Science, Universitas Gadjah Mada, Indonesia

ABSTRACT

In Indonesia, crossbreeding local cattle with European beef breeds is widely promoted to stimulate beef production. This crossbreeding is threatening local breeds which have often different functions, including cultural roles. This study analysed the cultural values of Madura cattle and the impact of crossbreeding on local traditions in Madura. Bull racing *(karapan)* and cow conformation contests (*sonok*) are traditional cultural events on Madura. Since 2001, crossbreeding with Limousin is allowed. The local government promotes also a conformation contest for crossbred (*madrasin*) cattle. Quantitative and qualitative information was collected through participatory approaches involving farmers (n=97), government officials, community groups, key informants, and through direct observation of *sonok*, *karapan* and *madrasin* events. Phenotypic characteristics were collected from 184 cows. The Madura cattle population and production systems are not homogeneous. Four cattle types could be distinguished: *karapan*, *sonok, madrasin* and conventional Madura cattle. These cattle were found in three discrete areas, differing in land sizes, cropping, and cattle keeping in terms of management practices and importance of specific cultural practices. *Sonok* and *madrasin* cows were significantly bigger and had higher body condition scores than *karapan* cows and the conventional Madura cows in the *madrasin* area. Madura cattle participating in cultural events were valued at prices that were 2-3.5 times higher than Madura cattle not participating in cultural events. Crossbreeding will not directly influence the cultural events or the management practices of Madura cattle in the *karapan* and *sonok* areas, however, outside the *karapan* and *sonok* areas, crossbreds are rapidly replacing conventional Madura cattle. The present top-down approach towards conservation and breeding strategies has to be turned into bottom-up approaches that consider the needs of the *sonok* and *karapan* Madura cattle sub-populations. Monitoring and characterization studies have to collect information at different aggregation levels and have to be aware of sub-populations. The Madura example shows that cultural values of livestock can be a main driver for maintaining relatively small populations of local breeds.

Keywords: Madura; Bull racing; Cattle contests; Conservation; Cultural values

2.1. Introduction

In Indonesia population increase is a major driving force for the rising demand for animal products. To satisfy the demand for red meat, the government has been implementing a policy to import meat and live exotic livestock. From the 1980’s the government has also promoted an Artificial Insemination (AI) program using beef breeds from temperate regions, such as Simmental, Limousin and Angus, to improve the beef performances of local cattle. At present, the AI organisation uses almost exclusively exotic semen. So crossbreeding is rapidly progressing.

Many publications state that crossbreeding leads to a loss of indigenous breeds and loss of adaptation of livestock to local environments (Anderson, 2003; FAO, 2007). On Indonesia’s Madura, until 2001, crossbreeding was not allowed to protect the local Madura cattle breed. Madura cattle developed approximately 1500 years ago from crossing wild banteng or Bali cattle and zebu (Payne and Rollinson, 1976). Continuous selection by the farmers in Madura created a uniform breed population (Deptan, 2003). Its coat is reddish-brown with a non-specific white pattern on the rump and legs (Deptan, 2003), see Figure 2.1. Madura cattle are extremely well adapted to the local conditions and traditional management. They are reported to be one of the best draught animals in the world relative to their size (Barwegen, 2004). Since the removal of import restrictions, the local government has allowed crossing with the Limousin breed (which is also preferred by Madura farmers) because of its red colour, similar to the Madura cattle. As a result the crossbreeding through AI is threatening the survival of the Madura breed (Barwegen, 2004).

Currently, the number of cattle in Madura is about 600,000. It is not possible to obtain accurate data about the population of pure Madura cattle as not all regional government offices separate the data in terms of genetic group.

Understanding and assessing cultural values of livestock are important in the implementation of interventions aiming at conservation and utilization of animal genetic resources (FAO, 2012). Madurese people have strong cultural ties to their animals, caring for their cattle as if they are their family members (De Jonge, 1990). The significance of cattle within the culture is also evident from the appearance of bulls in local folk-tales, proverbs, and wood carvings depicting bulls, and from the horns on traditional houses. Bull racing *(karapan)* and cow conformation contests (*sonok*), are important cultural events on the island (De Jonge, 1990).

Crossbred cattle are kept primarily for meat production. So crossbreeding may be a threat not only to the existence of purebred Madura cattle, but also for cultural activities involving cattle in Madura. In Indonesia, Madura cattle offer a unique opportunity to study cultural practices involving cattle and the impact of crossbreeding. This paper aims to analyse the cultural values of Madura cattle and the impact of crossbreeding on these local traditions.

2.2. Materials and methods

Study areas

Madura (Figure 2.2.) is a small, densely populated Indonesian island located off the northeast coast of Java. It is administered as part of East Java Province and consists of four districts: Bangkalan, Sampang, Pamekasan and Sumenep. Besides the mainland, Madura has some small outer islands. The climate is tropical exhibiting defined wet (September to February) and dry (March to August) seasons, with an average annual rainfall of 1500 – 2000 mm.

Two districts were used in this study (Figure 2.2.). One was Sumenep, within which is Sapudi, an isolated island, that is demarcated by the national government as a conservation area for Madura cattle, particularly as a source of *karapan* cattle. For the study, Nong Gunong, one of two sub-districts, was used. This study area will be described as the '*karapan*' area. The second district was Pamekasan; Waru, Pasean, Larangan and Pegantenan sub-districts were used in this study. Waru and Pasean sub-districts are famous as the source of *sonok* cattle and are well-known as areas where the *sonok* contest started. This study area will be described as the '*sonok*' area. Larangan and Pegantenan sub-districts were selected by local government as crossbreeding areas due to the abundance of crop by-products. Crossbred cattle are expected to have larger body sizes than Madura cattle and, consequently, require more feed. Crossbred cattle are not used for draught purposes. All crossbreds resulted from Madura cows being inseminated with semen of Limousin bulls. The farmers named the crossbred cattle *madrasin*. This study area will be described as '*madrasin*' area. From 2007 the local government promoted a conformation contest for *madrasin* cattle. Madura cattle in the *madrasin* area will be described as conventional Madura cattle.

The three study areas do not only differ in cattle keeping practices, they also differ in cropping practices. In the *karapan* area, cropping conditions are difficult due to small farm sizes and poor fertility of the soil. In the *sonok* area, tobacco is the main crop, which results in a relatively good income (Smith, 2011). In the *madrasin* area more crop by-products are available mainly due to the large paddy growing areas in this lowland area.

Data collection

Secondary data collection

Secondary data were collected from the Agricultural Department of Indonesia, the Animal Husbandry Office of East Java Province, Pamekasan and Sumenep District offices, government websites, publications and institutional reports. These provided insights into the local situation and policies.

Specific white pattern on the rump and legs of Bali cattle

Non-specific white pattern on the rump and legs of Madura cattle

Figure 2.1. Colour pattern of the rump and legs of Bali vs Madura cattle

Figure 2.2. Map of Indonesia and Madura with the three study areas

Participatory observations

Quantitative and qualitative information was collected through participatory approaches involving farmers (cattle-keepers), government officials, community groups and other key informants, and through direct observation of *sonok*, *karapan* and *madrasin* events. A historic overview of the cultural events was based on the secondary data and open interviews with key informants, comprising of persons well-versed in cattle keeping and cultural events, such as heads of cultural event groups, experienced farmers or village elders (three persons per study area).

Semi-structured interviews were carried out with three categories of cattle-keepers: 30 *karapan* farmers, 37 *sonok* farmers, and 30 *madrasin* farmers. Farmers were interviewed about their background and motivation, technical aspects such as cattle management, and the economics of cattle keeping. The input costs and the selling and buying prices of individual cattle in a farm over a period of one year (February 2010 – January 2011) were estimated by farmers. The input costs consisted of purchases of forage and supplements, such as maize and rice bran, and additional feeds such as herbs, eggs and palm sugar for animals participating in the cultural events, veterinary services, AI or natural mating, training for and participating in the cultural events, and hired labour costs. The interviews were used to evaluate the role of cattle in the livelihoods of Madurese people, and the special characteristics of cattle that are important in maintaining local traditions.

Phenotypic characteristics of Madura and crossbred cattle

Phenotypic characteristics of cows in the study farms were determined by taking height at withers, and estimation of body weight by measuring chest girth, using a measurement tape (FHK Ogawa Seki Co. Ltd., Tokyo, Japan). The age of each animal (in years) was determined by inspecting its teeth (Djanah, 1984).

Data analysis

The qualitative data were analysed descriptively. The quantitative data were analysed using one-way ANOVA to compare the different areas (Ott and Longnecker, 2001). Ranking was used to determine the level of agreement of farmers' motivations for keeping cattle. General Linear Model (GLM) (Ott and Longnecker, 2001) was used to analyse ranking preferences. The smallest score of rank meant the most important motivation and the highest score of rank meant the least important motivation.

2.3. Results

The history of cultural cattle events in Madura

Karapan

Karapan has a very long history. Noer and Maduratna (1975) noted that on Sapudi Island, during the 12-13th century, Prince Katandur wanted to make the soils more fertile. He introduced ploughing using a pair of bulls. To encourage people to keep cattle, he created a bull racing game, *karapan*, in which pairs of bulls raced against each other in a field. The equipment used in the race was similar to equipment used in ploughing (Figure 2.3).

Over time *karapan* became a favourite game for Madurese people, organized after the harvest season. These are now held in nearly every village in the eastern sub-districts. In these *karapan* races, two or three pairs of bulls are raced over a course of 100 – 140 meters pulling a sledge with a jockey. The winners and losers of the first round are assigned to separate categories, after which the races continue according to the 'cup system': winners go on, while losers drop out. A major competition is held each year in which all the island's districts are represented. Since 1982, races for tourists are organized in western Madura.

In the 1970's, local government set some rules for *karapan* (Noer and Maduratna, 1975):

1. *Karapan* bulls have to be purebred Madura bulls;
2. The minimum height at the withers of the bulls is 120 cm and the maximum 130 cm;
3. The minimum age of the bulls is 2 years;
4. Mistreating bulls during racing is not allowed;
5. The minimum number of bull pairs having to participate in a sub-district is 40. At that time, there were 20 sub-districts in Madura, so 1,600 bulls had to be used every year.

Nowadays, some of the rules are not respected due to the limited availability of Madura bulls that fulfill the physical and age criteria for karapan. In 2011, in the biggest racing event, no more than 30 pairs of bulls competed.

The total number of bulls actually participating in karapan is about 400 pairs on Sapudi Island and 200 pairs in Madura mainland (Kuswadi, 2010, personal communication).

Sonok

The key events in the *sonok* have resulted from the common practice in Madura that, from about 9 am until 1 pm, cattle are tethered between two pillars, locally named *tacek*, in view of the front veranda of the house. The cattle's forefeet stand on a platform, a piece of wood about 15 cm high, while they are tethered. This tethering practice gives farmers the opportunity to show their great pride in caring for their cattle. In the meantime farmers clean the cattle and the barn, and undertake other activities, such as foot care and horn shaping. In 1963, a village head became particularly interested in farmers' behaviour in caring for their cattle. He showed cattle of good conformation tethered in the front of farmers' houses to high officials who were visiting his village. This idea to show cattle daily became a routine activity in the area (Anonymous, 2007).

Figure 2.3. *Karapan* race (source: Schultinga, M.)

In 1927, Sommerfeld (1927) described *pajengan* in which farmers bring their cattle, especially female cattle, to be tethered together in a field. In 1967 a local government official organized *pajengan* activities twice a week during the tobacco harvest season. *Pajengan* is currently still taking place every month. It gives farmers an opportunity to meet, showing their good cattle and sharing information with the extension officers. Year after year, this event is well supported by farmers (Rudi Haryanto, 2009, personal communication).

Key informants mentioned that in the 1980's, to make *pajengan* more attractive, the competing farmers chose pairs of good females, harnessed to make them walk in pairs and dressed with beautiful adornments. The pairs of cattle, guided by a jockey, have to walk 25 m to reach a finishing line, designed like a gate, while their forefeet step in a harmonious manner. *Saronen*, traditional music, is played to accompany the cattle when they walk to the stage. This event was named *sonok,* see Figure 2.4. The total number of cattle participating in different *sonok* events in Madura is about 600 pairs (Rudi Haryanto, 2009, personal communication).

Sonok cattle are judged by conformation traits, such as height at withers, colour, body conformation, body condition, health, and harmonious walking in a pair. Unlike *karapan*, there are no winners and losers in this event. Every contestant farmer receives a gift from the officials without exception, and there is dancing accompanied by traditional music. There are juries who provide the audience with information about the farmer, scores of performance during walking and their opinion about the matching appearance of the pairs. Often the jury consists of influential people, for example, the head of the *sonok* community group, the inseminator and the head of the district. Since there are no winners, there is no gambling. Although there are no prizes, the contest is very important because during the contest day many transactions amongst farmers take place; farmers can show their cattle and trade them for good prices. The cows that perform well are very popular for breeding.

Madrasin

In the area where crossbreeding is practiced, farmers, encouraged by the government, have organised the *madrasin* contest since 2007. The criteria are body size and body weight, and, for cows, the conformation of their calves.

The cattle are tied up next to each other in the traditional way for Madura cattle: rope goes through the nose of the cattle and is tied between two pillars, and cattle stand with their front legs on a platform. In the *madrasin* contest the cattle do not parade and are not harnessed or dressed with adornments, see Figure 2.5.

Responses from the interviews showed that the number of participants and the number of participating cattle is growing every year, but that it is less attractive to spectators than the *karapan* and *sonok* events.

Livestock farming systems

Table 2.1. gives selected household and farm characteristics for the livestock farming systems in the three study areas. *Karapan* farmers were relatively older than farmers in the other two areas. Most of the farmers have crop production as their main source of farm income. Family size was significantly larger in the *madrasin* area. More than half of farmers in the three study areas only completed elementary school. Farmers had a long experience in cattle keeping, about 20 years or more; *karapan* farmers had significantly more experience than *madrasin* farmers.

Cattle are the main livestock (Table 2.1.). Goats, sheep and chickens are of secondary importance. Even though the land sizes of farmers in Sapudi Island were quite different from those of farmers in the *sonok* area, the number of cattle was not much different. Farmers kept about three head of cattle. Only in the *madrasin* area were the numbers of cattle slightly smaller than in the two other areas.

Farmers in the sonok area will participate in the *sonok* contest only if they have pairs of animals that meet the criteria for participation and if they have sufficient cash available to pay for the fee to join the contest. If farmers in the *karapan* area have a pair of potential racing bulls, they will first enter this pair in a village race. If this pair runs well, they will enter the pair in a regional contest. Again a farmer will need sufficient cash to join the race and to cover the additional costs. When farmers have insufficient cash to purchase cattle, farmers join with other farmers. Around 12% of the farmers were sharing cattle (Table 2.1.). The main occupation of the interviewees was farming, although in the *madrasin* area, 23% were traders or businessmen.

Unique cultural values of Madura cattle

Figure 2.4. *Sonok* contest

Figure 2.5. Picture of a winner in *madrasin* contest

Table 2.1. Characteristics of households and farms in the three study areas

	Area		
	Karapan (n=30)	*Sonok* (n=37)	*Madrasin* (n= 30)
Age of household head (yr.)	$51.6^{a} \pm 13.5$	$45.4^{b} \pm 10.0$	$47.1^{a,b} \pm 10.7$
Land size (ha)	$0.31^{a} \pm 0.19$	$0.56^{b} \pm 0.76$	$0.73^{b} \pm 0.61$
Family size	$3.7^{a} \pm 0.3$	$4.5^{a} \pm 0.3$	$5.7^{b} \pm 0.4$
Experience in cattle keeping (yr.)	$26.4^{a} \pm 2.7$	$22.3^{a,b} \pm 1.7$	$20.1^{b} \pm 2.1$
Number of livestock per farm (n)*			
- Cattle	3 (1-13)	3 (1-6)	2 (1-6)
- Cows	2 (0-6)	2 (0-4)	2 (1-6)
- Heifers	0 (0-2)	1 (1-2)	0 (0-2)
- Males	0 (0-6)	0 (0-1)	0 (0-4)
- Calves	0 (0-2)	0 (0-2)	0 (0-2)
- Small ruminants (goat / sheep)	0 (0-6)	0 (0-4)	0 (0-2)
- Chickens	0 (0-6)	0 (0-6)	0 (0-10)
Cattle ownership (%)			
- Private	87	89	87
- Sharing	13	11	13
Main occupation (%)			
- Farming	100	73	70
- Government official	0	16	3
- Trader / private business	0	8	23
- Labourer	0	3	3
Crops	Maize, cassava, groundnut	tobacco, maize, groundnut, cassava	Rice, maize, tobacco, cassava

[a,b,c]Different superscripts indicate significant differences between areas (P<0.05)
[ns] Non significant; *Number of livestock is presented in mode and range

Motivations for keeping cattle

As in other areas in Indonesia, in Madura cattle-keeping serves various objectives. Table 2.2. shows the ranking of the motivations for cattle-keeping in the three study areas. Farmers mentioned the following motivations: financial security (saving), income, providing manure, utilization of crop by-products, raising the social status of their owner, cultural events, draught purposes, and hobby. Most farmers mentioned 'saving' as the most important motivation. Farmers consider saving in terms of being able to sell cattle to meet unexpected or large expenditures, such as sending children to school, paying hospital bills for a family member, financing a wedding party or a pilgrimage to Mekka. *Sonok* and *madrasin* farmers gave income as the second motive. Farmers consider income as the cash they receive regularly from the annual sale of progeny.

Karapan farmers ranked manure as the second most important motive for keeping cattle. Farmers in the *karapan* area depend on their cattle for ploughing. Since field sizes are small, and land is stony, a bit hilly and dry, cattle are the best option for ploughing. They use both pairs of cows or bulls for ploughing. If needed, they will borrow an animal from a neighbour to match their own animal. *Sonok* cattle are rarely used for ploughing. *Sonok* farmers said that they are afraid that ploughing will negatively affect the beauty of their cattle. They only use cattle that are not participating in *sonok* events for ploughing.

Table 2.2. Farmers' ranking of motivations for keeping cattle in the three study areas

Role of cattle	*Karapan* (n=30) Average score[1]	*Karapan* (n=30) Rank*	*Sonok* (n=37) Average score[1]	*Sonok* (n=37) Rank*	*Madrasin* (n=30) Average score[1]	*Madrasin* (n=30) Rank*
1. Saving	$2.2^{a} \pm 2.1$	1	$1.7^{a} \pm 0.9$	1	$2.1^{a} \pm 2.1$	1
2. Income	$5.1^{b} \pm 3.2$	3	$2.4^{b} \pm 1.7$	2	$3.2^{b} \pm 2.9$	3
3. Manure	$2.6^{a} \pm 0.9$	2	$4.5^{c} \pm 1.8$	4	$3.4^{b} \pm 2.0$	2
4. Social status	$5.9^{bc} \pm 3.0$	5	$4.4^{c} \pm 2.1$	3	$6.3^{c} \pm 2.4$	4
5. Cultural values	$6.4^{c} \pm 2.4$	6	$4.9^{c} \pm 2.3$	5	$8.0^{d} \pm 0.0$	7
6. Draught power	$5.7^{bc} \pm 2.8$	4	$7.5^{d} \pm 1.1$	7	$8.0^{d} \pm 0.0$	7
7. Utilization crop by-product or backyard land	$7.5^{d} \pm 1.3$	7	$7.3^{de} \pm 1.7$	6	$7.5^{de} \pm 1.3$	5
8. Hobby	$8.4^{d} \pm 1.7$	8	$7.3^{e} \pm 2.4$	6	$7.8^{e} \pm 2.2$	6

*Rank = the smallest score of rank (1) means the most important motivation and the highest score of rank (8) means the least important motivation

[1] Different superscripts indicate significant differences between reasons (P<0.05)

Madrasin cattle are never used for ploughing, due to the absence of a hump (needed for the ploughing harness used) and their limited endurance. Another reason is that hand tractors are used extensively in the *madrasin* area, which is a lowland paddy-growing area.

Time allocation for caring for cattle

Table 2.3. gives the time spent caring for cattle in the three different areas. *Sonok* farmers and their family members spent significantly more time per day managing their cattle than *karapan* and *madrasin* farmers. They spent time on cleaning cattle, sunbathing, foot care, and horn shaping. In the *sonok* area significantly more time was spent on these activities than in the other two areas. *Sonok* respondents emphasised the cleanliness of their cattle and the surrounding environment, since the daily appearance of *sonok* cattle, in particular during the contests and *pajengan* meetings, is very important.

Table 2.3. Time allocation per farm in caring for cattle in the three study areas

Activity (h / day)	*Karapan* (n= 30)	*Sonok* (n= 37)	*Madrasin* (n= 30)
1. Cleaning barn	$0.48^{a} \pm 0.40$	$0.74^{b} \pm 0.47$	$0.39^{a} \pm 0.27$
2. Cleaning the cattle, sunbathing, foot caring, horn shape, etc.	$3.40^{a} \pm 0.88$	$3.94^{b} \pm 1.35$	$2.12^{c} \pm 0.34$
3. Gathering feed	$2.17^{a} \pm 0.48$	$2.42^{ab} \pm 0.85$	$2.50^{b} \pm 0.81$
4. Offering feed^{ns}	1.08 ± 1.69	1.36 ± 0.43	1.08 ± 1.98
5. Training	$0.30^{a} \pm 0.57$	$0.38^{a} \pm 0.59$	$0.00^{b} \pm 0.00$
Total time spent (h d^{-1})	$7.42^{a} \pm 1.69$	$8.84^{b} \pm 1.98$	$6.08^{c} \pm 1.12$

^{a,b,c} Different superscripts indicate significant differences between areas (P<0.05); ^{ns} Non significant

Madura cattle are very docile and easy to handle. About once a month, farmers pay attention to horn shape and foot caring. Farmers have a special preference for horn shape. They shape the horns when the cattle are around 4 months of age, by punching holes in the two horns and binding them using a wire: this results in small to medium size horns, curving inwards perfectly symmetrically. Most farmers shape cattle's horns, even when the cattle will not be used for cultural events. They check the hoofs of cattle participants in the *karapan* or *sonok* contest very regularly. Farmers use simple equipment for foot caring.

Madrasin farmers spent the least amount of time on caring for their cattle (P<0.05). However, per animal the time allocation was about the same in the three areas. This was because *madrasin* farmers kept slightly fewer animals than the other farmers, and forage collection took up large amount of time for *madrasin* cattle.

Physical characteristics of the cows

Table 2.4 shows that cows in the *sonok* area were higher and heavier (P<0. 05) than *karapan* and conventional Madura cows in the *madrasin* area. *Madrasin* cows were significantly higher and heavier compared to their conventional Madura herdmates. *Sonok* cows, however, were comparable with *madrasin* cows in these measurements. Both *sonok* and *madrasin* cows had a significantly higher body condition score compared to *karapan* cows and conventional Madura cows in the *madrasin* area.

Table 2.4. Physical characteristics of Madura and *Madrasin* cows in each study area

	Area			
	Karapan	*Sonok*	*Madrasin*	
Physical characteristics	Madura (n=52)	Madura (n=61)	Madura (n=53)	*Madrasin* cross* (n=18)
1. Age (year)^{ns}	4.5 ± 1.9	4.3 ± 1.3	4.9 ± 2.7	4.5 ± 0.2
2. Height at the withers (cm)	116.4^{a} ± 4.9	128.4^{b} ± 6.1	119.2^{c} ± 10.7	125.7^{b} ± 6.2
3. Body weight (kg)	294.3^{a} ± 43.0	392.3^{b} ± 60.4	279.1^{a} ± 89.0	400.1^{b} ± 92.6
4. Body Condition Score (BCS)	2.6^{a} ± 0.5	3.9^{b} ± 0.7	2.6^{a} ± 0.8	3.8^{b} ± 0.7

^{a,b,c} Different superscripts indicate significant differences between areas (P<0.05); ^{ns} Non significant
**Madrasin* cross : cross of Madura (♀) x Limousin (♂)

Selling prices, costs and profit estimates

The time to sell cattle varies with the purpose of cattle-keeping (Table 2.5.). In general, farmers sell animals when they need cash, but they also sell 'surplus' animals because they keep a specific number of animals in relation to the feeds available and the time they have available to care for their animals. Farmers sell weaned cattle for fattening or breeding, usually at 4-6 months after weaning, mainly to traders, whereas cattle for cultural events are sold directly to other farmers who are looking for cattle that can participate in the cultural events. *Sonok* farmers said that sometimes they are looking for cattle whose appearance is well-suited to be paired with one of their own cattle. Once they

Table 2.5. Age, period of keeping, selling price, input costs and cash profit per period of keeping of Madura and madrasin cattle based on the age group, area, purpose of keeping cattle and type of cattle (Million IDR)*

	Area / category of cattle			
	Karapan		*Sonok*	
Age group /	Animals in the event	Animals not in the event	Animals in the event	Animals not in the event
< 1.5 year	n=13: ♂=13;♀=0	n= 22: ♂=10;♀=12	n=12: ♂=0;♀=12	n=18: ♂=6;♀=12
Age (year)	0.60 ± 0.29	0.36 ± 0.21	0.75 ± 0.29	0.51 ± 0.29
Period of keeping[1] (year)	0.47 ± 0.27	0.37 ± 0.20	0.68 ± 0.30	0.48 ± 0.25
Selling price (Million IDR)	14.81[a] ± 8.1	2.85[b] ± 0.87	20.38[a] ± 5.27	5.88[b] ± 2.26
Total input cost per period of keeping (Million IDR)	0.90[a] ± 0.80	0.04[b] ± 0.11	2.83[a] ± 2.16	0.12[b] ± 0.25
• Forage	0.04 ± 0.10	0.04 ± 0.09	0.09 ± 0.14	0.06 ± 0.41
• Additional feed[2]	0.80 ± 0.69 (88.9%)	0.00	1.12 ± 0.93 (39.6%)	0.06 ± 0.11
• Veterinarian	0.01 ± 0.02	0.00	0.01 ± 0.03	0.00
• AI/mating	0.00	0.00	0.00	0.00
• Training, racing /contest	0.07 ± 0.08 (7.8%)	0.00	1.50 ±1.29 (53.0%)	0.00
• Labour	0.00	0.00	0.03 ± 0.09	0.00
Profit per period of keeping (Million IDR)	14.2[a] ± 8.1	2.6[b] ± 0.9	18.1[a] ± 4.3	5.8[b] ± 2.1
>1.5 year	n=10: ♂=10;♀=0	n=6: ♂=0;♀=6	n=10: ♂=0;♀=10	n=11: ♂=0;♀=11
Age (year)	2.86 ± 1.21	3.00 ± 1.38	2.21 ± 0.94	2.85 ± 1.34
Period of keeping (year)	1.03 ±0.08	1.83 ± 0.91	1.27 ± 0.34	2.01 ± 0.70
Selling price (Million IDR)	21.90[a]± 8.70	6.17[b]± 0.68	25.44[a]± 4.40	11.59[a]± 4.43
Total annual input cost (Million IDR)	4.30[a]± 1.80	0.08[b]± 0.10	4.66[a]± 1.60	1.03[b] ± 0.50
• Forage	0.34 ± 0.16	0.07 ± 0.10	0.24 ± 0.22	0.36 ± 0.23
• Additional feed	3.70 ± 1.5 (86.0%)	0.00	2.35 ± 0.94(50.4%)	0.66 ± 0.37
• Veterinarian	0.006 ± 0.02	0.004 ± 0.01	0.009 ± 0.02	0.00
• AI/mating	0.01 ± 0.01	0.01 ± 0.01	0.006 ± 0.01	0.007 ± 0.01
• Training, racing /contest	0.25 ± 0.20(5.8%)	0.00	2.07 ± 0.83 (44.4%)	0.00
• Labour	0.00	0.00	0.00	0.00
Total input cost per period of keeping[3] (Million IDR)	4.4 ± 1.8	0.17 ± 0.3	6.01 ± 3.1	2.1 ± 1.6
Estimated profit per period of keeping[4] (Million IDR)	17.6 ± 7.8	5.9 ± 0.7	19.4 ± 5.5	9.4 ± 4.3
Annual profit[5]	15.9[a] ± 9.6	3.9[b] ± 1.6	17.8[a] ± 11.5	5.1[b] ± 2.5

[a,b]Different superscripts indicate significant difference between different categories of cattle within areas ($P<0.05$); [1]Time needed to keep cattle from purchasing or born until sold; [2]Feeds which are added into the basal diet (forage), such as concentrate, rice bran, maize bran, palm sugar, herbs, etc.

[3]Total input cost per period of keeping (Million IDR) for cattle with age group > 1.5 years was calculated by multiplying total annual input cost (Million IDR) and period of keeping (year); [4]Profit per period of keeping (Million IDR) was calculated by deducting total input cost per period of keeping (Million IDR) from selling price (Million IDR); [5]Annual profit (Million IDR) = Profit per period of keeping (Million IDR) / period of keeping (year); *One US $ = 9,200 IDR;

Table 2.5. (continued)

	Area / category of cattle	
	Madrasin	
Age group /	*Madura* breed	*Madrasin* cross**
< 1.5 year	n=4: ♂=0;♀=4	n=16: ♂=13;♀=3
Age (year)	0.85 ± 0.44	0.68 ± 0.42
Period of keeping[1] (year)	0.77± 0.43	0.64 ± 0.30
Selling price (Million IDR)	5.93[a] ± 2.79	7.65[a] ± 5.53
Total input cost per period of keeping (Million IDR)	0.24[a] ± 0.36	0.23[a] ± 0.28
• Forage	0.14 ± 0.27	0.11 ± 0.18
• Additional feed[2]	0.11 ± 0.88	0.11 ± 0.14
• Veterinarian	0.00	0.00
• AI/mating	0.00	0.00
• Training, racing /contest	0.00	0.00
• Labour	0.00	0.00
Profit per period of keeping (Million IDR)	5.7[a] ± 3.0	7.4[a]± 5.2
>1.5 year	n=9: ♂=0;♀=9	n=29: ♂=16;♀=13
Age (year)	3.27 ± 0.87	2.65 ± 0.89
Period of keeping (year)	1.3 ± 0.62	1.58 ± 0.49
Selling price (Million IDR)	6.59[a]± 1.66	12.15[b]± 4.89
Total annual input cost (Million IDR)	0.45[a]± 0.39	0.91[a]± 0.40
• Forage	0.19 ± 0.25	0.47 ± 0.27
• Additional feed	0.24 ± 0.19	0.42 ± 0.22
• Veterinarian	0.00	0.003 ± 0.009
• AI/mating	0.06 ± 0.02	0.006 ± 0.02
• Training, racing /contest	0.00	0.00
• Labour	0.00	0.05 ± 0.18
Total input cost per period of keeping[3] (Million IDR)	0.6 ± 0.7	1.5 ± 0.9
Estimated profit per period of keeping[4] (Million IDR)	5.9 ± 1.6	10.6 ± 4.7
Annual profit[5]	4.2[a] ± 2.2	7.5[a] ± 4.3

find a well-matched animal they are willing to offer a good price. *Sonok* cows are used not only for the cultural event but also for breeding, while only excellent *karapan* bulls are used as breeding bull. Once *karapan* bulls cannot be used for racing anymore, for instance they are already old or injured, they will be sold for slaughter. During the survey, only two *karapan* bulls were used both in the cultural event and for breeding.

Table 2.5. presents the comparison of cattle prices and input costs among purposes and areas. The selling prices of animals below 1.5 years indicate that animals used for cultural purposes fetch much higher prices ($P<0.05$) that their herdmates not used for cultural events. Also the cash inputs are considerably higher ($P<0.05$) for animals participating in cultural events. At (relatively) the same age and body weight, Madura cattle used for cultural events were valued at prices that were 2-3.5 times higher than cattle not participating in cultural events. *Karapan* and *sonok* farmers spent considerable more money on cattle older than 1.5 y, which participate in cultural activities, 86 and 87% respectively, than on their herdmates with no cultural function. In particular the additional feed costs were high for cattle participating in the cultural events.

The price of *madrasin* cattle usually depends on body size. Even when an animal wins the *madrasin* contest, the slaughter price is based on its body weight. In 2009, a 800 kg crossbred bull won the contest, and a butcher bought it for 22 Million IDR (1 US$ = 9200 IDR), a normal price per kg live weight.

The profits per animal aged more than 1.5 years for cattle participating in *karapan* and *sonok* were 3 and 2 times higher, respectively, than for their non-cultural herdmates (Table 2.5.). *Madrasin* cattle did not show significant higher profit than their conventional Madura herdmate cattle. Cattle not participating in the cultural event in the *sonok* area gave a more-or-less similar profit as *madrasin* cattle.

2.4. Discussion

The introduction of crossbreeding in Madura has highlighted that the Madura cattle population is not homogeneous. There are three cattle production systems, each in a more or less separate area, with now four types of cattle: *karapan*, *sonok*, *madrasin* and conventional Madura cattle. The main source area of *karapan* cattle is Sapudi Island. *Sonok* cattle are found mainly in the northern part of Madura. *Madrasin* cattle and the conventional Madura cattle can be found in the rest of Madura. This zonation reflects different cattle production systems in terms of cattle management practices, and cultural activities. These differences also emphasize the different Madura cattle sub-populations.

Synergy of culture and cattle farming in Madura

Karapan and *sonok* events as well as Madura cattle, are unique, as markers of the traditions and culture for Madurese people (De Jonge, 1990; Smith, 2011). The events are famous, not only in Madura itself but throughout Indonesia and even abroad. So, they are also a tourist attraction. The total number of spectators in all events in a year is approximately 20,000-25,000 people. *Karapan* is much older and better known than *sonok*, but the enthusiasm for *sonok* seems to increase year by year. *Sonok* may become as important for rural tourism as *karapan* and might be preferred in future because there are concerns about cruelty to *karapan* cattle and gambling during racing. Even though there is a rule about not hurting the bulls during racing, in practice, to get the bulls to run faster, people use nails or thorns, causing wounds and then even pour salt or lemon into the wounds (Kuswadi, 2009, personal communication). On Madura, spiritual leaders are already criticizing these practices and the gambling during *karapan* events.

The cultural practices have a marked impact on cattle husbandry. Cattle used for cultural events are well cared for and trained. This gives the owners an overall sense of well-being. Most writers about Madurese society emphasize the attention that is given to the animals. The men are said to be more devoted to their animals than to their wives (De Jonge, 1990). *Karapan* and s*onok* farmers give intensive daily care and exercise to their animals (about 3 h d^{-1} per animal) to improve their physical appearance and performances. They also spend considerably more money (on average 46.5%) on better quality feeds for the animals that participate in the cultural events.

Anderson (2003) mentioned that breed characteristics that are important for socio-cultural practices generally relate to the appearance of an animal, and traits that define the market value of an animal. Also in Madura cultural values have a strong economic component. Most *karapan* and *sonok* farmers argued that they like the race or contest because it keeps the prices of cattle high. *Karapan* and *sonok* farmers received more than 50% higher prices for breeding stock than the normal market prices. Not only the prices of *karapan* and *sonok* cattle that participate in the contests were high, but also the overall input costs (Table 2.5.). In general, farmers in the *sonok* area are relatively well-off due mainly to the income generated from tobacco (Smith, 2011). Part of this income will be invested in their *sonok* cattle and the participation in *sonok* events.

Effect of crossbreeding on culture and cattle farming

Farmers outside the *karapan* and *sonok* areas kept conventional Madura cattle before the introduction of Limousin semen. These were relatively small in size. This made it easy for the government to introduce Limousin semen at that time, as the farmers wanted cattle as big as the *sonok* cattle. Almost all *madrasin* farmers said that they took more pride in keeping *madrasin* cattle than conventional Madura cattle. Table 2.4. shows that crossbreeding increased the body size of cows with about one-third. The body condition score of *madrasin* cows was also much higher than of their conventional Madura herdmates. Crossbred animals were fed better, this resulted in higher feeding costs for *madrasin* cattle (Table 2.5.). Nevertheless, the selling prices minus the total cash costs for the period an animal is kept, show that the cash profits of *madrasin* animals were on average, 55% higher than from conventional Madura herdmates (Table 2.5.). The economic profit estimates in Table 2.5. ignore the other benefits cattle provide, such as manure, draught power and security. A comprehensive economic analysis is needed to calculate the overall benefits of the different types of cattle keeping (Smith, 2011).

Also crossbreeding contributes to the overall pride resulting from keeping cattle that perform well. The *madrasin* contest was initiated by government and seems a top-down initiative. It attracts in particular farmers; no tourists attend. The main motivation of farmers for enrolling their animals in the contest is the expectation that it can result in a fair price for their animals, since all of the participants' cattle are weighed and the price per animal is based on the actual weight. In general, when cattle are sold, the prices that traders offer are based on visual appraisal only.

Crossbreeding is not only influencing the feeding practices and selling prices of cattle, it also influences the cattle trade flows. Key informants explained that most of small-scale slaughter-men in Madura do not like to slaughter crossbred animals as they cannot handle and sell the products within one day. So, crossbred slaughter animals are transported as live animals to the abattoir in Surabaya, the nearest major city in Java.

Conservation and breeding developments

The different farming systems and the different cultural events, and consequently the different types of Madura cattle, show the importance of considering local variation when developing conservation strategies. Government bodies that are concerned with livestock conservation focus primarily on numerical factors (Alderson, 2009). Also, in Indonesia, the inventory of animal genetic resources for the FAO World's Animal Genetic Resources gives only the total number of Madura cattle (Deptan, 2003). It does not distinguish between different Madura types of cattle.

Although Sapudi is designated by the government as an *in-situ* conservation area for Madura cattle (Deptan, 2003), until now no specific conservation strategies have been implemented, except that crossbreeding is not allowed. In the whole of Madura, there are no reliable data on numbers of different cattle. There is urgency to correct that deficiency, especially in the face of the rapid change in the genetic structure of the island's cattle herd because of the high adoption rate of crossbreeding in the major part of the island.

Field observations and the discussions with key stakeholders indicated that the populations of cattle in the *karapan* and *sonok* areas are relatively small: about 45,000 and 50,000 animals, respectively. But there is no immediate threat that these populations will be reduced by crossbreeding because of the continuing importance of the cultural values of the *karapan* and *sonok* events. It is unlikely that the ban of importing other cattle, in particular crossbreds, in Sapudi Island will be lifted. Nevertheless, the future of the *karapan* event is at stake. There is no strict adherence of the government rules for the *karapan* race, and the numbers of bulls that can join a *karapan* race is going down.

Inbreeding is strictly avoided in the *sonok* area, by circulating the bulls between villages whereas, in the *karapan* area, which is an isolated island, selection to avoid inbreeding is not done. This may have contributed to the small size of *karapan* cows. This requires urgent attention, as it can be a threat to *karapan* as well as the capacity for ploughing on Sapudi Island.

AI was introduced in the late 1990s in Sapudi Island, but it was never a success. The main reasons were that infrastructure was poor, the availability of AI personnel limited, farmers considered AI a sin and an abnormal way of mating their cattle, and farmers never trusted the Madura semen used for AI was from a *karapan* bull.

The phenotypic performances of s*onok* cattle are comparable with the performances of *madrasin* cattle. This shows that through good breeding practices, farmers have maintained good performances of *sonok* cattle. This guarantees successful conservation of Madura cattle in the *sonok* area in the future.

It can be speculated that, in the future, the great majority of the conventional Madura cattle will be crossbreds. Farmers outside the *sonok* and *karapan* areas prefer the *madrasin* cattle over conventional Madura cattle due mainly to their heavier body weights and consequently higher market prices, although farmers said that they are aware that there is a risk that second and third generations of crossbred cattle will show poorer performances than the present F_1 crossbreds. Research is needed on performances of future generations of crossbreds to inform farmers about potential losses in production with continuing crossbreeding.

The governmental breeding centre is promoting crossbreeding in the south of Madura and Madura cattle in the north. Unfortunately, it does not distinguish the *sonok* and *karapan* sub-populations. The present top-down approach towards implementing the conservation of Madura breed has to be turned into support approaches that involve the livestock keepers themselves.

Assessment of cultural values

Gandini and Villa (2003) developed a framework for assessing different cultural contributions of livestock breeds in Europe with the aim of strengthening their conservation. The present study illustrates the complexity behind assessing cultural values of local breeds in countries such as Indonesia. Cultural assessments should not be restricted to identifying cultural functions and estimating market value of cultural products and services; they have to include the impact of cultural functions on management and specific requirements for animals that have cultural value, and the social and economic contribution of these animals to the livelihoods of the households concerned.

The Madura example shows that the cultural value of a specific breed can be related to a complex mix of area-specific cultural functions that are associated with different animal performances, management practices and economic benefits. Consequently, participatory research approaches are needed to unravel such complexities, with information collection at animal, farm and regional levels.

2.5. Conclusions

The Madura cattle example shows that cultural values of livestock can be a main driver of maintaining a local breed. The enthusiasm of people and farmers for maintaining the cultural values attached to Madura cattle, and consequently the high prices for cultural cattle are key to conserve the Madura cattle within the areas where the cultural events are maintained. The future of *sonok* cattle is better than *karapan* cattle in terms of performances, and general preference of people. Crossbreeding will not directly influence the cultural events and management practices of Madura cattle in the areas where the cultural events are important. In the areas where the cultural events are not important, farmers, however, take more pride in keeping *madrasin* than conventional Madura cattle, mainly due to their growth performance and the resulting financial benefits. So, crossbreeding is an immediate threat to the future of conventional Madura cattle in a main part of Madura. Monitoring and characterization of animal genetic resources studies have to consider cultural values of livestock breeds and how these values interact with management practices, animal performances and economic benefits.

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Chapter 3

Is crossbreeding of cattle beneficial for mixed farming systems in Central Java?

Farmers in the Dry uplands have the tradition of 'Gumbregan', as a symbol of their gratitude to God

T.S.M. Widi[1,3], H.M.J. Udo[1], K.Oldenbroek[2], I.G.S. Budisatria[3], E.Baliarti[3], A.J. van der Zijpp[1]
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[1]Animal Production Systems Group, Department of Animal Sciences, Wageningen University, the Netherlands
[2] Centre for Genetic Resources, Wageningen, the Netherlands
[3]Department of Animal Production, Faculty of Animal Science, Universitas Gadjah Mada, Indonesia

ABSTRACT

From 1980's onwards, Indonesia's government has been implementing crossbreeding with European beef breeds through artificial insemination to improve the beef performance of local cattle, in response to the increasing demand for meat. Crossbreeding is promoted and implemented throughout the country, regardless of the various agro-ecological zones, each endowed with different feed resources in the smallholder farming systems. This study analyses the impact at farm level of crossbreeding in the different mixed farming conditions in Central Java. Quantitative and qualitative information was collected through participatory approaches involving farmers (n=252) in four study areas representing three agro-ecological zones: Wet lowlands (subdivided in two areas based on the history of breeding local cattle and crossbreeding), Wet uplands and Dry uplands. Phenotypic characteristics, reproductive performances, and carcass characteristics of Ongole and crossbred cattle were assessed, together with farmers' reasons for keeping Ongole or crossbred breeding stock, the functions of cattle on the farms and the Gross Margins (GM) of the cattle component on Ongole and crossbred farms. Across different agro-ecological zones, crossbreeding is not changing the farming systems: herd sizes, farm types, experience in cattle keeping, and functions of cattle were about the same for Ongole and crossbred farms. The agro-ecological zones differed in cropping pattern and feed resources, however they did not differ in amounts of dry matter and crude protein fed to individual animals. Crossbreeding is changing the individual characteristics of cattle and consequently the market prices of animals. In general, mature female crossbred cattle were approximately 25% heavier than mature female local cattle. Male crossbred progeny was 16% heavier their local counterparts, whereas female crossbred progeny was 24% heavier than female local cattle. In terms of reproduction performances, both local and crossbred cows performed well with calf crops ranging between 73% and 86% per year. Most farmers preferred crossbred over Ongole cattle. Simmental cross is the most preferred. GM for crossbred and Ongole farms were comparable within the different study areas; selling prices of crossbreds are higher, but feed costs too. Crossbreeding will continue. It is promoted by government policies and farmers are motivated to keep crossbred cattle as body weights and market prices are higher than for Ongole cattle, however farmers said that they do not prefer upgrading to very high levels of Simmental. A viable Ongole population is needed to reduce the risk of upgrading to too high levels of Simmental.

Keywords*: Indonesia, Agro-ecological zones, Ongole cattle, Simmental crossbreeding, Benefits*

3.1. Introduction

Crossbreeding with exotic breeds is a major driving force for livestock intensification in developing countries (Udo *et al*., 2011). Most studies on the impact of crossbreeding are focused on dairy cattle (Syrstad, 1996; Kahi *et al.*, 2000; Samdup *et al.*, 2010). Ideally, crossbreeding strategies have to match the production environment, of which the feed resources are a main determinant (Kahi *et al.*, 2000; Wollny, 2003). In practice, crossbreeding schemes are characterized by un-systematic use of exotic semen, irrespective of agro-ecological and socio-economic settings (Wollny, 2003).

In Indonesia, crossbreeding is widely applied for beef production. The high human population increase and increased purchasing power are major factors driving the rising demand for red meat from ruminants. In 2010 the human population was about 237 million (BPS, 2010). More than 50% of all cattle are kept on Java, the main island with 57% of the human population of Indonesia (Kementan, 2010). To satisfy the demand for meat, the government has been importing meat and live animals. Particularly in Java, from the 1980's onwards, the government has been promoting artificial insemination (AI) using exotic breeds from temperate regions, such as Simmental, Limousin, Aberdeen Angus and Hereford to improve the beef performance of the local cattle.

In Indonesia, farmers keep cattle not only for meat production, but also for financial security, manure for cropping, social status and draught power (Widi, 2004). About 90 percent of cattle are in smallholder crop-livestock farmers' hands, with fewer than five cattle per farm.

During the colonial period the Dutch administration introduced Ongole cattle from India to replace the indigenous Java cattle (*Bos javanicus*) (Barwegen, 2004). The male and female Ongole cattle were bought from areas surrounding Madras. Ongole were considered more suitable for carrying the heavy loads for the sugar industry. Javanese farmers initially disliked the Ongole breed, because they could not work in forests like the Java cattle (Barwegen, 2004). The pure Ongole was brought to Sumba Island and became the purebred Sumba-Ongole. In Java, the Sumba-Ongole were crossed with Java cattle and formed the Ongole-grade (in Indonesia called *Peranakan Ongole*, PO). Added to this, the Dutch administration introduced Ongole cattle in areas along a main concrete road, '*Daendels* road', located along the south coast in Central Java; the Ongole has been developed and favoured by farmers in this area (Sudardjat and Pambudy, 2003). In the course of the 20th century, Ongole became the prominent cattle breed in Java (Maule, 1990).

Characteristics of Ongole cattle are: a big body, strong power, docile and a quiet temperament, good heat tolerance and ability to survive under restricted feed conditions (Maule, 1990). This makes them good animals for draught power. Ongole cattle grow faster than Madura or Bali cattle. However, they are less fertile than the indigenous Java cattle (Barwegen, 2002; Widi *et al.*, 2006), and Madura and Bali cattle (Maule, 1990). In 2003, the Ongole population was estimated at about 4.4 million. About 90% of them are on Java (Deptan, 2003). Their numbers are, however, rapidly decreasing, mainly because in the period 2006-2011, the percentages of semen from exotic and local breeds distributed by AI centres all around Indonesia were 85 and 15%, respectively (BIB, 2011). In Java, AI is the dominant breeding method for cows. About 85 % female cattle in Java has been served with AI (Sudardjat and Pambudy, 2003).

The performance of breeds depends on environmental conditions and farming systems (Frisch and Vercoe, 1978). In Java, there are broadly speaking two agro-ecological zones, based on the altitude: the Uplands and the Lowlands; and based on the annual rainfall dry and wet subdivisions can be made. Each zone has a different topography, soil type, soil fertility, and agro-climatic conditions. The result is a different cropping pattern, land use management, production potential and consequently variation in feed resources (Budisatria, 2006). Crossbreeding is promoted and implemented throughout the country regardless of the different resources in the various agro-ecological zones and the different functions of cattle in the smallholder farming systems.

Central Java is one of the prominent areas in Indonesia with beef cattle. Crossbreds are already a major part of the cattle population, but also the original breeding areas of Ongole cattle are found here (Widi *et al.*, 2008). In Central Java, feeding conditions are relatively good in the Lowlands and Wet uplands, and poor in the Dry uplands (Sutresniwati, 2006).

Given the large utilization of crossbreds, irrespective of the different mixed farming conditions, we studied the relative performance of Ongole and crossbred cattle to address the question: is crossbreeding an appropriate breeding strategy in the different agro-ecological zones endowed with different feed resources?

3.2. Materials and Methods

Study Areas

This study was conducted in Yogyakarta and Central Java Provinces, situated in the southern part of Central Java (Figure 3.1.). Both provinces have large cattle numbers. The study areas represented two agro-ecological zones, the Lowlands and the Uplands, with different rainfall patterns: Wet lowlands, Wet uplands, and Dry uplands. Wet lowlands are found at less than 100 m above sea level (asl) and their annual rainfall ranges from 2400 – 3000 mm (BPS, 2009). Lowlands have fertile soils and are characterized by irrigated farming systems with paddy and maize as the main crops. Wet uplands are defined as areas above 500 m asl with annual rainfall ranging from 3000-3600 mm (BPS, 2009). This zone has fertile soils and is characterised by both irrigated and rain fed farming systems, with paddy fields, horticulture and forest. Dry uplands are also situated above 500 m asl but have less fertile soils and low annual rainfall: 1800-2400 mm (BPS, 2009). This zone is characterized by rain-fed farming systems with cassava and dry land paddy as the main crops.

There are two rainfall seasons over the year. The wet season usually begins in September and lasts until about April. No grazing areas are available, as all land is used for cropping. The types of forages used include improved grasses, such as Napier and Elephant grasses, rice straw, maize straw, many kinds of tree leaves, cassava leaves, and tree legumes. Native forages, such as weeds and grasses, are collected from farmers' own fields and backyards, roadsides, riversides, and forest edges. During the dry season, when forage sources are limited, farmers buy forages from other areas. The Dry uplands are relatively far away from the input markets, approximately 60 km, 1.5 hours by truck.

For this study, Wet lowlands were divided into two areas, namely Wet lowlands I and II (Figure 3.1.). In Wet lowlands I, located in Yogyakarta Province, crossbreeding is broadly applied in contrast to Wet lowlands II, located in Central Java, where crossbreeding is practiced less frequently. In this area, the local government allocated different locations for maintaining Ongole and for crossbreeding in order to maintain the Ongole in this zone, which is an original Ongole breeding area from colonial times onwards. In each zone, the farmers could be divided into Ongole and crossbred farmers, based on the breed of cattle they kept as breeding stock.

Before 1990, mostly Ongole cows were used for breeding; they were inseminated with Simmental or Limousin semen which resulted in F_1 Simmental or Limousin crossbreds. From 1990 onwards the majority of F_1 and F_2 cows were inseminated using Simmental or Limousin semen, which resulted in F_2 and F_3 Simmental and Limousin crossbreds. Consequently, the number of Ongole cattle has been sharply decreasing since 1990 (Widi *et al.*, 2008).

Data Collection

Secondary data collection

Secondary data related to geographical situation of study areas, cattle population, distribution of semen, and local implementation of national and local policies were collected from The Agricultural Department of Indonesia, Animal Husbandry Office of Yogyakarta Province and Central Java Province, government websites, publications, and reports from institutes. Secondary data provided insight in the recent local situations.

Focus group discussions and farmers' interviews

Participatory approaches started by conducting focus group discussions (FGDs) amongst farmers and key persons such as head of farmers' group and village elders in each area. The purpose of the FGDs was to introduce the study and identify the issues regarding the local and crossbred cattle keeping. All cattle farmers in the study areas were invited via the heads of the farmers' groups. In total 296 participants (60 in Wet lowlands I, 86 in Wet lowlands II, 65 in Wet uplands and 85 in Dry uplands) joined the FGDs.

The issues which were obtained in the FGDs were used for making a checklist for guidance of semi structured interviews for the farmers. In total 252 farmers from 296 FGDs' participants in the four study areas (56 farmers in Wet lowlands I; 63 farmers in Wet lowlands II; 59 farmers in Wet uplands and 74 farmers in Dry uplands) were purposively selected based the criterion of minimum 10 years experience in keeping their own herd of cattle. Most farmer respondents were men, only 4 of them were women, widows. Men are

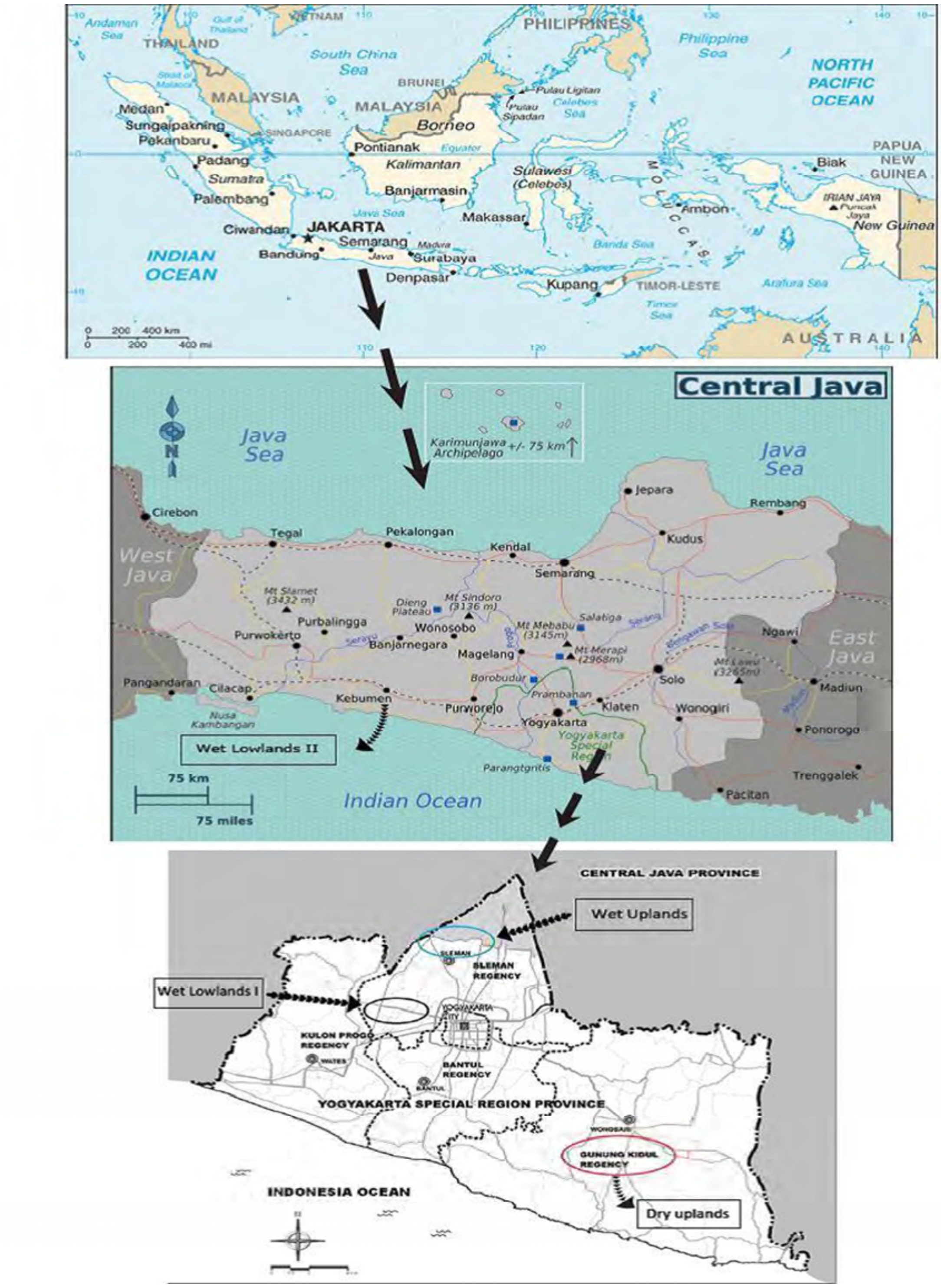

Figure 3.1. Map of Indonesia, Central Java and Yogyakarta Province (Source: Anonymous, 2007 and Pemda-DIY, 2005, cited by Budisatria, 2006)

doing all of the management activities of large animals, like cattle and buffaloes, while women are responsible for smaller animals, such as chickens, goats and sheep. The 252 farmers were interviewed individually about their background, technical aspects, their motivations for keeping animals and reasons to choose Ongole or crossbred cattle as breeding stock. Household members contributed to recall information during the interviews. These data were collected during the first farm visit in the period July – November 2009.

Phenotypic characteristics of Ongole and crossbred cattle

Each animal on all 252 farms was characterised by observing the body, face, nose, leg, tails' hair and vulva colours; existence of dewlap, backline and hump; shape of horns and the thickness of body and heads' hairs. Ongole and crossbred cattle were distinguished based on these characteristics, using a checklist (Maule, 1990; Supiyono, 1998; Triyono, 2003; Sumadi *et al*, 2003; Porter, 2007; Widayanti, 2008) with specific conformation traits, and on information from the farmer on breeding background of the animal concerned.

Quantitative phenotypic characteristics of 294 female cattle of the 252 farms were collected by taking length of the body (LB), girth of chest (GC), height at withers (HW), height at hip (HH), head index (HI) and estimation of body weight (BWe), using a measurement tape with cm and the transformation of chest girth in cm into weight in kg (developed by FHK Ogawa Seki Co. Ltd, Tokyo, Japan), over the period January 2010 to July 2011. Body score condition (BCS) was visually assessed (Ferguson *et al*., 1994 cited by Lassen *et al*., 2003). The age of each animal (in years) was determined by inspecting its teeth (Djanah, 1984). Similar measurements were done for calves (n=127) at weaning and at approximately 11 months of age. Eleven months of age was chosen because most calves are sold before they reach the age of one year.

Feeding practices

Many different feeds were offered. The feeds were categorized in fresh forages, dry forages and supplementary feeds. The proportions of the different fresh forages were estimated by separating the fresh forages again in its components. Feed inputs were calculated based on farmers' estimates and direct observation on kinds and amounts of feeds offered to each individual adult animal, over one year (January 2011-January 2012). The estimations of kind and amount of fresh and dry forages offered were recorded by farmers every day. Enumerators checked the farm recording once a month. Dry forages and supplementary feeds that were bought were estimated from the amounts bought. These estimates were translated into kg dry matter (DM) and crude protein (CP) intake per animal, applying the feed composition tables for feeds available in Central Java of Hartadi *et al*. (2005).

Reproductive performances

Reproductive data were collected over the period January 2010 to July 2011. This recording was done by farmers, guided and assisted by enumerators (n=8) at the start of the monitoring period. Enumerators visited the farmers every month to collect and check the recorded information. Reproductive performances determined were days to postpartum estrus (PPE) days to postpartum mating (PPM), services per conception (S/C), calving interval (CI), weaning age and calf crop. Calving interval estimates were based on calving dates of animals with two calvings in the reporting period or on calving date in the reporting period and a previous calving from before the recording started derived from recall information. Calf crop per study area was calculated as follows:

$$\text{Calf crop in each study area} = \frac{\sum \text{calves born} - \sum \text{pre-weaning calves dead}}{\sum \text{cows}} \times (365 / CI)$$

The reproductive performances of 114 Ongole and 156 crossbred cows were recorded. Cows were defined as female cattle that had calved at least once. The farmers observed and recorded the reproduction cycle of their cows over a period of 1.5 years. Farmers in all study areas have relatively similar knowledge on reproductive management. They obtained it through information sharing amongst farmers, farmers' community groups and formal training from the local extension officer. Farmers do not routinely record reproductive information. For this survey, we asked farmers to fill in a recording sheet for the reproductive data of their cattle. They were explained beforehand and enumerators visited them every month to assist them in recording the reproductive activities. Information on age at first estrus and calving (if available) were also collected by recall. The number of infertile female cattle was very small, not more than 2%. Farmers immediately sold infertile heifers and the cows which are failing to have a next calving (S/C > 5). AI is applied in all the study areas, particularly to crossbred cows.

Carcass characteristics of Ongole and crossbred cattle

We visited the biggest slaughter house in Yogyakarta, and measured the slaughter cattle belonging to two butchers over a period of 15 days. Carcass weight and meat bone ratio (MBR) were measured on 55 cattle (13 Ongole, 29 Simmental cross and 13 Limousin cross). They consisted of 14 female and 41 male cattle. The scales to weigh the cattle and carcasses had an accuracy of 1 kg and the scale to weigh the meat had an accuracy of 20 g.

Gross Margins Analysis

Farmers recorded the inputs and outputs of their cattle over a period of 1.5 year (January 2011 – July 2012). Enumerators (n=8) visited the farmers every month to collect and check the recorded information. This particular period was representative of an average period in terms of rainfall and perceptions of farmers that the revenues from their cattle covered their financial requirements. Only 184 of the 252 farmers sold cattle during the monitoring period. Most farmers used only family labour, only few farmers (n=20) used hired labour, either regularly or on an ad hoc basis.

The Gross Margins analysis was done for each farm for the reporting period. It was based on financial revenues minus variable costs. Procedures in the Gross Margins calculations included:

- Fresh forage costs comprising cultivated grasses and maize foliage bought from forage sellers in the livestock markets or alongside roads
- Dry forage costs comprising rice and maize straws bought from dry forage sellers or collected from the fields and loaded on trucks, involving costs for the fuel, or hiring the trucks and drivers
- Supplementary feeds costs comprising concentrates, rice bran, cassava meal, cassava, tofu (soybean curd) waste and soy bean hulls bought from poultry shops, markets and soy processing factories
- Costs for veterinary services and medicines
- Costs for AI or mating services
- Hired labour costs
- Feeds collected by farmers from communal sources (road sides, forests, communal lands) and transported on the back of farmers or on bicycles were not valued
- Revenues of cattle sales; local traders buy the cattle
- Revenues from the sale of manure; manure in the form of compost is sold to horticulture farmers, ornamental plants farmers, producers of organic fertilizer, or plantations.
- Opportunity value of manure used for crops was not included
- Actual farm gate prices were used for accounting in IDR (Indonesian Rupiah; US $ 1 = 9,200 IDR in 2011).

Data analysis

The qualitative data were analysed descriptively. Ranking was used to determine the level of agreement of farmers' motivations for keeping cattle. Frequency distribution was used to analyse the reasons of the farmers in choosing Ongole or crossbred breeding stock. The quantitative data were analysed using analysis of variance (ANOVA) with breed nested within areas (Ott and Longnecker, 2010). The model was simplified to compare breeds within areas, because for most parameters no interaction was found between breed and area.

3.3. Results and Discussion

Phenotypic characteristics of Ongole and crossbred cattle

By observing the phenotypic characteristics in the study areas, the cattle were identified as Ongole or crossbred, while the crossbred cattle were Simmental or Limousin crosses. The diversity in phenotypic characteristics of crossbred cattle is presented in Figure 3.2. There was not sufficient information to distinguish subsequent crossbred generations, since there is no pedigree recording system kept by farmers nor inseminators. Farmers could also not distinguish subsequent crossbred generations; they purchased their animals from the market or middle men without any pedigree information.

Body sizes of female Ongole and crossbred cattle older than 2.5 years, which most of them were cows, in the four areas are presented in Table 3.1. Simmental crossbred female cattle in all areas were significantly bigger and higher than female Ongole cattle (P<0.05). The height and weight estimates for the Limousin crossbred females did not differ from the Simmental crossbreds.

Body sizes of calves at weaning (approximately at 7 months of age) and at approximately 11 months of age in the study areas are presented in Table 3.2. Weaned crossbred male calves were 16% heavier than Ongole male calves, for female calves this figure was 24%. These differences were significant (P<0.05). At 11 months of age crossbred males were only 2% heavier than Ongole males, for females this difference was 18% (P<0.05). The number of Ongole calves (n=1) in Wet lowlands I was not sufficient for testing of differences between breed types.

Body condition scores of Ongole cows were lower (P<0.05) than those of crossbred cows in the Wet lowlands I, indicating that crossbred cows may have been fed better than Ongole cows in this area. Overall, the body condition scores indicated that cows were in a good body condition (2.7-3.9 in the BCS range of 1-5).

Figure 3.2. Diversity of phenotypic characteristics of crossbred cattle in the study areas. Code 'A' is for Simmental cross and 'B' is for Limousin cross

Table 3.1. Physical characteristics (Mean ± s.d) of female Ongole and crossbred cattle with minimum age 2.5 years in four areas in Central Java

Physical characteristics	Area / Breed										
	Wet lowlands I		Wet lowlands II			Wet uplands			Dry uplands		
	Ongole (n=21)	Sim-cross[1] (n=38)	Ongole (n=36)	Sim-cross[1] (n=36)	Lim-cross[2] (n=4)	Ongole (n=16)	Sim-cross[1] (n=76)	Lim-cross[2] (n=3)	Ongole (n=22)	Sim-cross[1] (n=32)	Lim-cross[2] (n=10)
Age (y)	6.8^{a} ± 3.1	4.7^{b} ±1.6	5.3^{a} ± 2.5	4.0^{b} ± 1.6	3.4^{b}±1.4	5.7^{a}± 2.0	4.1^{b}±1.6	3.0^{b} ± 0.5	5.7^{a}± 3.0	4.3^{b}±1.7	5.9^{a}±1.4
GC (cm)	159.9^{a}±9.8	175.2^{b}±5.0	167.4^{a}±8.6	175.7^{b}±9.6	169.3^{ab}±8.2	157.9^{a}±9.0	172.3^{b}±12.3	172.7^{b}±8.6	159.7^{a}±10.1	176.7^{b}±16.7	176.2^{b}±13.5
HW (cm)	125.1^{a}±3.9	128.2^{b}±5.0	130.4^{a}±5.8	129.7^{a}±6.3	122.8^{b}±6.2	120.8^{a}±3.9	129.3^{b}±6.7	129.8^{b}±6.9	120.9^{a}±6.8	126.7^{b} ±7.5	126.9^{b}±4.9
LB (cm)	107.3^{a}±11.1	116.9^{b}±10.3	111.3^{a}±7.8	121.2^{b}±7.7	119.4^{b}±7.1	104.1^{a}±4.2	120.4^{b}±9.9	115.0^{b}±7.8	108.7^{a}±8.6	115.7^{b}±12.6	120.1±9.8
HI (%)	39.2^{a}±3.5	45.6^{b}±2.8	40.8^{a}±4.1	43.1^{b}±2.9	41.8^{a}±1.4	42.1^{a}±2.9	42.3^{a}±4.1	42.4^{a}±4.0	39.1^{a}±3.0	43.1^{b}±4.4	44.3^{b}±3.9
BWe (kg)	325^{a}±48.2	396^{b}±67.7	368^{a}±51.0	420^{b}±65.4	$380^{a,b}$±45.7	304^{a} ± 82.3	403^{b} ±74.4	399^{b} ± 57.1	321^{a} ± 55.5	434^{b} ±116.7	427^{b} ±30.4
BCS	2.7^{a} ± 0.5	3.2^{b} ± 0.5	3.3^{a} ± 0.4	3.2^{a} ± 0.4	3.9^{b} ± 0.2	3.2^{a} ± 0.4	3.2^{a} ±0.4	3.8^{b} ± 0.3	3.1^{a}± 0.5	3.1^{a}±0.6	3.3^{a}± 0.2

[1]Sim-cross = Simmental cross; [2]Lim-cross = Limousin cross;
CG = girth of chest ; HW= height at the withers; LB= length of the body; HI= head index, is calculated by dividing length of head from the width of head in percentage
BCS= body condition score, is visual assessment of body tissues (Ferguson et al., 1994 cited by Lassen et al., 2003). The range is 1 – 5, where 1 is the lowest and 5 is the highest (Baliarti, 1999); BWe = body weight estimation; [a,b,c] Different superscripts indicate significant differences among breeds within the same area ($P<0.05$)

Table 3.2. Physical characteristics (Mean ± s.d) of progeny at weaning and at about 11 months of age of Ongole and crossbred cows in three study areas in Central Java

Physical characteristics	Area					
	Wet lowlands II		Wet uplands		Dry uplands	
	Ongole (n=32)	Crossbred (n=12)	Ongole (n=2)	Crossbred (n=28)	Ongole (n=11)	Crossbred (n=42)
	at weaning					
Age (month)^{ns}	5.9 ± 1.5	5.8 ± 1.3	5.5 ± 0.7	6.8 ± 1.3	7.1 ± 1.4	6.1 ± 1.0
GC (cms)	110.2^{a} ± 11.3	121.7^{b} ± 9.3	129.0^{a}±18.4	125.2^{a} ± 9.0	119.0^{a} ± 11.2	120.0^{a}±12.1
HW (cms)^{ns}	110.6 ± 7.7	100.0 ± 6.5	108.0 ± 18.4	100.4 ± 6.6	99.5 ± 8.3	97.2 ± 6.9
LB (cms)	78.2^{a} ± 7.4	86.4^{b} ± 8.2	84.0^{a} ± 11.3	86.8^{a} ± 5.8	77.8^{a} ± 8.1	82.5^{a} ± 10.2
HI (%)^{ns}	45.0±5.5	42.9±7.7	43.0±4.2	45.1±3.9	42.9±3.4	45.3±4.8
BWe (kg)	116^{a}± 35.1	154^{b}±31.1	185^{a}±71.4	167^{a}± 33.0	148^{a}± 39.3	150^{a}±44.7
	at approximately 11 months of age					
Age (month)^{ns}	10.5 ± 1.6	10.3 ± 2.1	9.5 ± 0.7	11.1± 1.4	11.7 ± 2.7	10.4 ± 2.0
GC (cms)	126.0^{a}± 9.2	136.8^{b} ± 9.3	136.0^{a}±18.4	132.6^{a}±9.2	134.2^{a}±12.3	133.5^{a}±16.5
HW (cms)	110.2^{a} ± 6.9	111.5^{a} ± 6.2	113.5^{a} ± 3.5	107.6^{a} ± 5.8	109.4^{a} ±7.6	107.5^{a} ± 8.8
LB (cms)	90.5^{a} ± 9.7	98.1^{b}± 10.0	90.0^{a} ± 11.3	93.4^{a}± 6.1	89.2^{a}± 9.7	92.1^{a}± 11.2
HI (%)	44.8^{a} ± 4.7	46.4^{a} ± 4.9	45.9^{a} ± 0.6	46.7^{a} ± 3.3	44.8^{a} ± 3.0	46.4^{a} ± 3.4
BWe (kg)	170^{a}± 34.4	214^{b}± 37.9	213^{a}±79.2	197^{a}±36.6	205^{a}±54.2	202^{a}±65.6

CG = girth of chest; HW= height at the withers; LB= length of the body; HI= head index, is calculated by dividing length of head from the width of head in percentage; BWe = body weight estimation

^{a,b} Different superscripts indicate significant differences among breeds within the same area and in all areas (P<0.05)

^{ns} Non significant

Table 3.3. gives household and farm characteristics for the livestock farming systems in the four study areas. The land sizes of the farms in Dry uplands were significantly larger than in the other areas, but most of this land is infertile. Crossbred farmers had significantly more (crop) land than Ongole farmers in the Dry uplands (0.6 vs 0.4 ha), but in the other areas the farms sizes were the same for both farm types. Farmers had on average 21 years' experience in cattle keeping. The experience in cattle keeping was not different between Ongole and crossbred farms within the areas, except in Wet lowlands II where the crossbred farmers had 4 years less experience in cattle keeping than Ongole farmers. Experience in cattle keeping differed significantly between the areas with the longest experience in keeping cattle in the Dry uplands; farmers in this area were also slightly older (58 y) than in other areas (50 y). However, no differences (P<0.05) were found in uptake of crossbreeding in relation to experience of cattle keeping. Cattle are the main livestock. Goats, sheep and chickens are of secondary importance. The herd sizes of Ongole (2.0-2.5 head) and crossbred (2.2-3.2 head) farms were the same in the areas, except in Wet lowlands II where crossbred farmers had significantly (P<0.05) more cattle (3.2) than Ongole farmers (2.0). Education level only seemed to have affected uptake of crossbreeding (P<0.05) in the Dry uplands (Table 3.3.). On average, more than 50% of the cattle were cows.

Table 3.2. (continued)

Physical characteristics	Overall average (sex / breed)			
	Male		Female	
	Ongole (n=15)	Crossbred (n=65)	Ongole (n=30)	Crossbred (n=38)
	at weaning			
Age (month)[ns]	5.7 ± 1.6	6.4 ± 1.3	6.4 ± 1.4	6.1 ± 1.4
GC (cms)	115.3[a]±14.1	122.1[b]±10.3	112[a]± 11.7	121.0[b]±12.3
HW (cms)[ns]	100.9± 7.9	99.3±6.7	100.5±7.8	98.3±7.7
LB (cms)	76.9[a]±7.9	85.0[b]±8.5	79.1[a]± 7.4	84.1[b]± 10.0
HI (%)[ns]	45.7±5.2	44.6±4.5	43.8 ±4.9	45.7 ± 5.5
BWe (kg)	135[a]±44.4	157[b]±37.4	123[a]±39.2	152[b]±42.6
	at approximately 11 months of age			
Age (month)[ns]	10.8 ± 2.1	10.5 ± 1.7	10.8 ± 1.9	10.6 ± 1.9
GC (cms)	130.3[a]±11.3	131.4[b]±12.7	127.5[a]±10.7	134.7[b]±13.5
HW (cms)	111.7[a]± 7.9	107.2[b]±7.1	109.1[a]±6.4	109.1[a]±8.2
LB (cms)	90.9[a]± 10.6	92.0[a]± 8.7	89.8[a]± 9.2	94.1[a]±11.1
HI (%)	45.7[a]± 3.6	46.7[a]± 3.6	44.4[a]± 4.4	46.4[a]± 3.4
BWe (kg)	188[a]±45.6	192[a]±49.1	177[a]±43.2	208[b]±57.1

Livestock farming systems and motivations of keeping cattle

About 10% of farmers were sharing cattle (sharing implies the cattle on the farms were owned by other parties; the benefits are shared by mutual agreement); only in Wet lowlands I, no sharing took place (Table 3.3a.).

There was no difference between Ongole and crossbred farms in the proportion of farmers sharing cattle with owners within the areas. In Wet lowlands I, less than 50% of farmers had farming as their main occupation. Many were labourers (53% for Ongole farmers and 31% for crossbred farmers, since the access to employment in the capital city, Yogyakarta, is near. In the other areas the percentage of farming as main occupation varied from 61 to 83. However, the percentage distribution between Ongole and crossbred farms was not significantly different within areas (P<0.05). It could be speculated that the relatively low body condition scores of Ongole cattle in Wet lowlands I may be the result of the fact that many of the farmers working as labourer could pay less attention to their cattle than fulltime farmers.

Most of the Ongole cattle were cows. In the Dry uplands and Wet lowlands II area also a substantial number of Ongole calves were kept. Wet lowlands II is an area with specific Ongole breeding tracts. In Wet lowlands I and Wet uplands, there were very few Ongole calves. This indicates that farmers who were still keeping Ongole cows, in these two areas, had their cows inseminated with exotic semen.

As in other areas in Indonesia, in Central Java cattle keeping serves various objectives. Both Ongole and crossbred farmers reported that capital savings, additional income and manure were the main motivations for keeping cattle (Table 3.4.). Farmers consider security (capital savings) as being able to sell cattle to meet unexpected or large expenditures, such

Table 3.3. Characteristics of Ongole and crossbred households in the four study areas, established in July – November 2009

	Area / breed			
	Wet lowlands I (n=56)		Wet lowlands II (n=63)	
	Ongole (n=17)	Crossbred (n=39)	Ongole (n=31)	Crossbred (n=32)
Age of household head (y)	54.6[a] ± 11.0	51.3[a] ± 10.3	50.4[a] ± 9.9	49.1[a] ± 7.1
Land size (ha)	0.13[a] ± 0.13	0.14[a] ± 0.09	0.36[a] ± 0.8	0.21[a] ± 0.12
Family size (person)	4.5[a] ± 1.6	4.3[a] ± 1.5	4.7[a] ± 1.4	5.1[a] ± 1.6
Education level (%)				
- No school	0.0	2.6	3.2	0.0
- Elementary school	52.9	41.0	64.5	68.8
- Junior high school	35.7	28.2	22.6	21.9
- Senior high school	11.4	23.1	9.7	6.3
- Higher education	0.0	5.1	0.0	3.1
Experience in cattle keeping (y)	19.3[a] ± 7.6	17.6[a] ± 10.9	16.6[a] ± 10.5	12.4[b] ± 3.8
Livestock ownership				
• Cattle (head)	2.2[a] ±1.0	2.2[a] ± 0.9	2.0[a] ± 0.9	3.1[b] ± 1.7
- Cow (%)	64.7	58.6	57.4	47.5
• Small ruminants (head)	0.8[a] ±1.4	1.4[a] ± 1.9	0.9[a] ± 1.9	0.8[a] ± 1.3
• Poultry (head)	0.5[a] ± 1.2	2.1[b] ±2.4	1.1[a] ± 1.7	1.6[a] ± 2.1
Cattle ownership status (%)				
- Owning	100	100.0	80.6	59.3
- Sharing	0	0	16.1	18.8
- Both	0	0	3.3	21.9
Main occupation (%)				
- Farming	47.1	46.2	77.4	75.0
- Government official	0.0	7.7	3.2	6.3
- Trader / private business	0.0	15.4	19.4	0.0
- Labourer	52.9	30.8	0.0	18.8

[a,b] Different superscripts indicate significant differences among breeds within areas (P<0.05)
*P value among areas

as sending children to school, financing a wedding or circumcision party, or buying a motorcycle. They consider income as the cash they receive relatively regularly from the sale of progeny (weaners). Most farmers considered manure the third important motive for keeping cattle. As with farmers in other areas in Java, farmers in the four study areas depend on livestock manure to fertilize soils. It is also common in Java that farmers sell excess manure to horticulture and ornamental plants farmers, producers of organic fertiliser, or plantations. Draught power was the least important motivation in all areas and for all types of cattle. Nowadays farmers use hand tractors to plough their land.

Tables 3.5. and 3.6. show the reasons of farmers to choose Ongole or crossbred cattle as their main breeding stock. The most frequent reasons for choosing local Ongole cattle were lack of capital, less feed required, easy management and most knowledge/custom. While the most frequent reasons for choosing crossbreds were big body size and the high prices when progeny were sold. In general, farmers keep only one or two cows. When farmers have enough money to purchase a crossbred animal, they tend to replace an Ongole cow by a crossbred cow. The Simmental crossbred is preferred because

Table 3.3. (continued)

	Area / breed				P value*
	Wet uplands (n=59)		Dry uplands (n=74)		
	Ongole (n= 12)	Crossbred (n=47)	Ongole (n=30)	Crossbred (n=44)	
Age of household head (y)	44.3[a]± 11.8	51.2[b] ± 13.8	58.6[a]± 14.5	56.9[a]± 11.4	0.00
Land size (ha)	0.17[a] ± 0.06	0.16[a] ± 0.16	0.44[a] ± 0.29	0.55[b] ± 0.50	0.00
Family size (person)	4.7[a] ± 1.5	4.4[a] ± 1.3	4.0[a] ± 1.6	3.9[a] ± 1.4	0.02
Education level (%)					
- No school	0.0	0.0	16.7	9.1	
- Elementary school	33.3	38.3	53.30	3.8	
- Junior high school	41.7	14.9	26.7	20.6	
- Senior high school	25.0	23.4	3.3	27.3	
- Higher education	0.0	23.4	0.0	11.4	
Experience in cattle keeping (y)	23.6[a]±12.6	21.1[a] ±15.0	31.2[a] ± 14.5	29.0[a] ±10.4	0.19
Livestock ownership					
• Cattle (head)	2.3[a] ± 1.0	2.5[a] ±1.0	2.2[a] ± 1.0	2.5[a] ± 1.6	0.37
- Cow (%)	57.1	58.9	46.1	56.1	0.13
• Small ruminants (head)	1.2[a]± 1.5	0.7[a]± 1.4	1.9[a] ± 1.7	1.4[a] ± 1.7	0.02
• Poultry (head)	1.3[a] ± 2.3	1.4[a] ± 2.2	1.5[a] ± 1.8	1.4[a] ± 2.0	0.91
Cattle ownership status (%)					
- Owning	83.4	93.6	90.0	86.4	
- Sharing	8.3	6.4	10.0	11.4	
- Both	8.3	0.0	0	2.2	
Main occupation (%)					
- Farming	75.0	61.7	83.3	61.4	
- Government official	0.0	17.1	3.3	11.4	
- Trader / private business	0.0	10.6	3.3	20.5	
- Labourer	25.0	10.6	10.0	6.8	

of its nice appearance, the shiny red coat and rectangle head shape (Sutresniwati, 2006).Crossbred farmers (75-86%) preferred F_1 cows; the preference for specific crossbred generation for young animals was less pronounced (Table 3.6.).

Feeding

All farms used stall-feeding. The feed types, the fresh feed intakes, and DM and CP intake estimates of Ongole and crossbred cattle are shown in Table 3.7. In most cases, the forage collected by farmers was a mixture, rather than a single type. The majority of the feeds offered were the locally available forages. The proportion of the forages in a ration varied between the areas, reflecting the different cropping patterns. In the Dry uplands, proportion of native grass in the forage ration was about 40%, while in other study areas this was lower (25-30%). Cassava leaves, ground nut haulm and legumes were offered more frequently in this area, compared to other areas. The maize foliage in Dry uplands came partly from outside this area. Rice bran was the most common supplementary feed in all study areas. Tofu waste and compound concentrates were supplementary feeds fed in Wet lowlands I and Wet uplands. In Wet lowlands II and Dry uplands, farmers offered cassava to their cattle as supplementary feed. Cassava is more abundant in Dry uplands. Crossbred

Table 3.4. Farmer's ranking motivations for keeping cattle in four study areas in Central Java

Motivation	Area / Breed															
	Wet lowlands I (n=56)				Wet lowlands II (n=63)				Wet uplands (n=59)				Dry uplands (n=74)			
	Ongole (n=17)		Crossbred (n=39)		Ongole (n=31)		Crossbred (n=32)		Ongole (n=12)		Crossbreed (n=47)		Ongole (n=30)		Crossbred (n=44)	
	Average score	Rank*	Average score	Rank*	Average score	Rank*	Average score	Rank*	Average score	Rank*	Average score	Rank*	Average score	Rank*	Average score	Rank*
1. Saving	1.5±0.7	1	1.4±0.7	1	1.7±0.8	1	1.8±0.6	2	1.1±0.3	1	1.8±0.8	1	1.5±0.6	1	1.4±0.6	1
2. Income	2.3±1.3	2	1.8±0.6	2	1.8±0.9	2	1.5±0.8	1	2.3±1.1	2	1.9±1.1	2	2.5±1.3	2	2.9±1,7	2
3. Hobby	4.9±1.9	4	5.0±1.6	5	5.3±1.9	6	5.3±1.7	6	5.2±0.9	6	4.5±1.9	5	5.0± 1.8	5	4.9±1.7	5
4. Utilisation crop by-product or backyard	5.4±1.6	6	4.7±1.4	4	4.0±1.6	4	5.2±1.2	5	5.0±1.3	5	4.3±1.4	4	5.6±1.2	6	5.4±1.2	6
5. Manure	3.8±0.9	3	3.8±0.9	3	3.9± 0.9	3	3.6±0.9	3	3.2±0.6	3	3.9±1.2	3	2.9±0.7	3	2.8±1.0	3
6. Social / status	5.0±1.2	5	5.2±0.9	6	5.1±1.0	5	4.1±0.9	4	3.9±0.8	4	4.8±0.9	6	4.2±0.5	4	4.5±1.2	4
7. Draught power	6.1±1.9	7	6.7±1.4	7	6.3±1.3	7	7.0±0.0	7	7.0±0.0	7	6.9±0.4	7	7.0±0.0	7	6.9±0.2	7

*Rank = the smallest score of rank (1) means the most important motivation and the highest score of rank (7) means the least important motivation

Table 3.5. Farmer's reasons to choose Ongole cattle in four study areas in Central Java

Reason	Area							
	Wet lowlands I (n=17)		Wet lowlands II (n=31)		Wet uplands (n=12)		Dry uplands (n=30)	
	Average score	Rank*	Average score	Rank*	Average score	Rank*	Average score	Rank*
1. Lack of capital	2.1 ± 1.6	2	2.6 ± 1.4	2	2.7 ± 1.4	3	2.5 ± 1.6	2
2. Less feed required	1.8 ± 0.6	1	2.3 ± 0.9	1	1.5 ± 0.7	1	1.9± 1.1	1
3. Easy management	3.1 ± 1.0	3	3.4 ± 0.9	3	2.6 ± 0.8	2	3.4± 1.1	3
4. Most knowledge / custom	3.8 ± 0.9	4	2.3 ± 1.5	1	5.9 ± 1.7	6	4.3 ± 1.4	4
5. Good reproduction performance	4.3 ± 1.1	5	4.8 ± 1.3	4	5.7 ± 2.0	4	5.4 ± 1.9	6
6. Government program	6.4 ± 1.2	6	5.4 ± 0.8	5	5.8 ± 2.2	5	6.5 ± 0.9	8
7. Draught power	7.0 ± 1.0	8	6.5 ± 0.9	6	5.9 ± 1.4	6	5.9 ± 1.3	7
8. *Idul Adha* Festivity	6.9 ± 1.1	7	6.5 ± 0.9	6	6.3 ± 1.7	7	4.8 ± 2.2	5
9. Good meat quality	8.1 ± 1.4	9	6.8 ± 1.2	7	7.8 ± 1.5	8	6.8 ± 1.5	9

*Rank = the smallest score of rank (1) means the highest priority and the highest score of rank (9) means the lowest priority

Table 3.6. Farmer's reasons to choose crossbred cattle and preferences of crossbred level in four study areas in Central Java

Reason	Wet lowlands I (n=39)		Wet lowlands II (n=32)		Wet uplands (n=47)		Dry uplands (n=44)	
	Average score	Rank*	Average score	Rank*	Average score	Rank*	Average score	Rank*
1. High growth rate	1.1± 0.9	1	1.0 ± 0.0	1	1.3 ± 0.8	1	2.0 ± 1.1	2
2. High price of sold	1.9± 0.2	2	2.0 ± 0.0	2	2.0 ± 0.5	2	1.5 ± 0.6	1
3. Not picky eaters	4.3± 0.9	4	4.1 ± 0.8	4	4.0 ± 0.9	4	2.7 ± 0.7	3
4. Trend	3.5± 0.8	3	3.5 ± 0.7	3	3.3 ± 0.9	3	4.4 ± 0.8	5
5. Appearance	4.0± 0.7	5	4.6 ± 0.5	5	4.3 ± 0.8	5	4.3 ± 0.6	4

Preference of crossbred level	Wet lowlands I (n=39)	Wet lowlands II (n=32)	Wet uplands (n=47)	Dry uplands (n=44)
• For breeding stock (%)				
- F_1	77	81	75	86
- Does not matter	23	19	25	14
• For fattening (%)				
- > F_1	82	47	77	36
- Does not matter	18	53	23	67

*Rank = the smallest score of rank (1) means the highest priority and the highest score of rank (5) means the lowest priority cattle were fed more (P<0.05) in terms of DM, on average, 10.5 vs 8.7 kg DM d^{-1} for Ongole cattle. Overall, the estimates of DM and CP offered per kg metabolic body weight of crossbred cattle were significantly higher than for Ongole cows. So, in general farmers were able to collect extra forages and buy extra supplementary feed for crossbred stock. Both Ongole and crossbred cows consumed DM at 2.6% of their body weight. Ongole and crossbred cows consumed CP 8.9 and 9.3% of DM, respectively. Feeding guidelines for beef cattle (both Ongole and crossbred) show that DM and CP requirements for maintenance are: 2.5 – 3% of body weight (Tillman *et al.*, 1998) and 9.76% of DM (NRC, 1996). So, the current feeding levels are in the range of the maintenance requirements.

Reproductive performances

Table 3.8. presents the reproductive performances of Ongole and crossbred cows in the four study areas. In the Wet and Dry uplands, Simmental and Limousin crossbred cows expressed post-partum oestrus (PPE) significantly earlier than Ongole cows. In the other two areas, Simmental and Limousin crossbred cows also expressed PPE earlier than local cows, but these differences were not significant. Farmers usually had their cows inseminated immediately after PPE was expressed. In the Wet and Dry upland areas the services per conception (S/C) of Ongole cows were relatively fewer than those of crossbred cows. In Wet lowlands II and Dry uplands, natural mating was used, in particular for Ongole cows (86 and 24%). Ongole cows expressed PPE later than Simmental cross herd mates. This resulted in longer CI in Ongole cows than in Simmental cross cows in the Wet uplands area. Overall, CI of Ongole cows was 448 d and of crossbred cows 436 d. In the end, the estimates for calf crops of Ongole and crossbred cows were the same in all areas: 81-85% for Ongole farms and 73-86% for crossbred farms. Both Ongole and crossbred cows performed well compared to, e.g., Bali cattle in Bali and Nusa Tenggara Provinces which had an estimated calf crop of 47% (Bamualim and Wirahayati, 2002; Toelihere, 2002).

About one-third of crossbred farmers complained about repeat breeding (high number of S/C), mostly after the fourth or fifth calving. This is in agreement with the relatively higher S/C of crossbred cows. Purwo (2010, personal communication) and Budiyanto (2012) suggested that reproductive problems occur, in particular, in F_2 and F_3 generation cows. Farmers usually decide to sell the cows with these problems to middle men who sell these animals to local butchers as soon as possible, and buy a pregnant cow or heifer. The farmers complained also about silent heat, but this was not directly reflected in our reproduction data. In 2003, Hasbullah (2003) found that 28% of Ongole and 38% of Simmental cross cows (most likely F_2 and F_3 cows) had repeat breeding problems.

The farmers reported that they usually sell the 'good' calves, as soon as possible after weaning, in order to obtain a high price with very few inputs. The farmers defined 'good' or 'poor' from body conformation and the visibility of ribs, which is also used to measure body condition score (BCS). They want to avoid the risk of low growth rates in crossbred calves when they are not able to provide the calves good feed. Good weaned crossbred calves are bought by local traders who sell them to other farmers or commercial feedlot farmers.

Table 3.7. Feeding practices, feed intake (FI), dry matter (DM) and crude protein intake (CP) (in kg d^{-1} and g $BW^{-0.75}$ d^{-1}) (Mean ± s.d) for Ongole and crossbreds cows in four study areas in Central Java

Type of feeds	Area			
	Wet lowlands I		Wet lowlands II	
Fresh forages fed and proportion in the forage ration (%)	*Pennisetum purpureum* (30%) Maize foliage (10%) Native grass (30%) Ground nut haulm (5%)		*Pennisetum purpureum* (25%) Maize foliage (10%) Native grass (35%) Rice stalk and ground nut haulm (10%)	
Dry forages fed	Rice straw		Rice straw	
Supplementary feeds fed	Rice bran, concentrate, wheat bran, tofu waste		Rice bran, cassava	
Feed intake	Breed			
	Ongole (n=17)	Crossbred (n=39)	Ongole (n=31)	Crossbred (n=32)
Average body weight (BW)(kg)	308^{a}± 47.8	370^{b}± 47.8	357^{a}±45.6	404^{b}± 55.8
FI of fresh forage (kg d^{-1})	24.5^{a} ± 1.2	29.6^{b} ± 1.9	23.8^{a}± 2.0	31.1^{b}± 2.8
FI of dry forage (kg d^{-1})	3.1^{a} ± 0.3	3.5^{b}± 1.1	4.9^{a}± 0.9	6.0^{b}±1.8
FI of supplementary feed (kg d^{-1})	0.4^{a} ± 0.3	1.2^{b}± 0.7	0.2^{a}± 0.1	0.6^{b}±0.6
DM (kg d^{-1})	7.5^{a}±0.4	9.7^{b}± 0.9	8.4^{a}± 0.7	10.7^{b}± 1.2
CP (kg d^{-1})	0.9^{a}±0.0	1.2^{b}± 0.1	0.6^{a}± 0.1	0.9^{b}± 0.1
DM (g $BW^{-0.75}$ d^{-1})	103.9^{a}±11.6	115.8^{b}±13.9	103.6^{a}±11.7	119.3^{b}±10.7
CP (g $BW^{-0.75}$ d^{-1})	12.4^{a}± 1.5	14.0^{b}± 1.6	7.9^{a}±0.8	9.5^{b}± 0.9
DM (% BW)	2.5^{a} ± 0.4	2.7^{a} ± 0.4	2.4^{a} ± 0.3	2.7^{b} ± 0.4
CP (% DM)	12.0^{a} ± 0.2	12.1^{a} ± 0.6	7.6^{a} ± 0.2	8.0^{b} ± 0.3

[a,b] Different superscripts indicate significant differences between breeds within areas (P<0.05)

Carcass characteristics of Ongole and crossbred cattle

Table 3.9. presents the sex-specific carcass characteristics of Ongole and crossbred cattle. In the same sex, the ages of Ongole and crossbred cattle which were slaughtered in a slaughterhouse in Yogyakarta Province did not differ. Male cattle were slaughtered at younger ages compared to female cattle.

At similar ages, in both males and females, the body weight at slaughter and total carcass and meat weights of Ongole cattle were significantly lower (P<0.05) than those of their crossbred mates. However, carcass and meat percentages did not differ among breeds in the same sex. Meat bone ratio (MBR) was significantly higher in male Ongole and Limousin crosses than in Simmental crosses, while the MBR of female cattle was not different among breeds.

On average, the meat weights of crossbred cattle were 1.42 times higher compared to local cattle (Table 3.9.). Local small-scale butchers said that slaughtering crossbred cattle is not always more profitable than slaughtering Ongole cattle. It depends on the condition of the cattle and how accurately they estimated the weight and the price of the cattle. In contrast, the feedlot and slaughterhouse companies prefer to slaughter crossbred cattle,

Table 3.7. (continued)

Type of feeds	Area					
	Wet uplands		Dry uplands			
Fresh forages fed and proportion in the forage ration (%)	*Pennisetum purpureum* (30%) Maize foliage (10%) Native grass (25%) Cassava leaves, ground nut haulm (5%)		*Pennisetum purpureum* (25%) Maize foliage (10%) Native grass (40%) Cassava leaves, ground nut haulm, legumes (15%)			
Dry forages fed	Rice straw		Rice straw, maize straw			
Supplementary feeds fed	Rice bran, concentrate, wheat bran, soy bean hull		Rice bran, cassava			
Feed intake	Breed				Overall average	
	Ongole (n=12)	Crossbred (n=47)	Ongole (n=30)	Crossbred (n=44)	Ongole (n=90)	Crossbred (n=162)
Average body weight (BW)(kg)	305^{a}± 32.7	398^{b}± 54.3	347^{a}±46.6	440^{b}±72.2	337^{a}±49.2	404^{b}± 66.5
FI of fresh forage (kg d^{-1})	27.4^{a}± 2.0	32.6^{b}± 2.4	24.5^{a}± 1.9	28.2^{b}± 2.1	24.6^{a}± 2.1	30.4^{b}± 2.8
FI of dry forage (kg d^{-1})	4.7^{a}± 1.1	4.8^{a}± 1.8	4.4^{a}± 1.2	5.7^{a}± 2.2	4.4^{a}± 1.1	5.0^{b}± 2.0
FI of supplementary feed (kg d^{-1})	0.6^{a}±0.4	1.0^{b}± 0.5	0.8^{a}± 0.3	1.0^{a}± 0.4	0.5^{a}± 0.4	0.9^{b}± 0.6
DM (kg d^{-1})	8.8^{a}±0.7	10.3^{b}± 1.0	9.6^{a}± 0.7	11.2^{b}± 0.9	8.7^{a}± 1.0	10.5^{b}± 1.1
CP (kg d^{-1})	0.7^{a}± 0.4	1.0^{b}± 0.5	0.9^{a}± 0.1	1.0^{b}± 0.1	0.8^{a}± 0.1	1.0^{b}± 0.1
DM (g $BW^{-0.75}$ d^{-1})	120.5^{a}± 6.9	115.8^{a}±8.9	120.2^{a}± 9.6	117.8^{a}±10.2	111.6^{a}±13.1	117.1^{b}±10.9
CP (g $BW^{-0.75}$ d^{-1})	9.6^{a}± 0.5	9.6^{a}±1.0	10.8^{a}±1.9	10.5^{a}±0.9	9.9^{a}±2.0	10.9^{b}±2.1
DM (% BW)	2.9^{a} ± 0.2	2.6^{b} ±0.3	2.8^{a} ± 0.3	2.6^{b} ± 0.3	2.6^{a} ± 0.4	2.6^{a} ±0.3
CP (% DM)	7.9^{a} ± 0.2	8.3^{a} ± 0.8	9.0^{a} ± 0.2	8.9^{a} ± 0.3	8.9^{a} ± 1.6	9.3^{a} ± 1.7

because of their higher body weights which provide economies of scale in slaughtering processes.

Gross Margins

Table 3.10. shows the financial results of the cattle component of Ongole and crossbred farms over a period of 1.5 y. The biggest expenses of both Ongole and crossbred farmers were forages and supplementary feeds. No significant differences in gross margins (GM) were observed between local and crossbred farms within the same area. The GM of cattle, Ongole or crossbred, in the dry upland area was the lowest of the four areas, since total variable costs were the highest in this area due to higher costs for forages and supplementary feeds. The variation between farms in supplementary feeds used was large, see the large SDs (coefficient of variation 173%). Mainly during the dry season, the availability of forages is limited, especially in the Dry uplands area. About 6 years ago farmers in the Dry uplands still preferred local cattle because of the shortage of forages in the dry season (Sutresniwati, 2006). Currently, the infrastructure in this area, as well as inother areas, is improving and gives the farmers easy access to feed resources and cattle markets. Trade in forages which come from outside the local land-use systems, has become big business (Paryadi, 2010, personal communication). In the Dry uplands area cassava meal

Table 3.8. Reproductive performances (Mean ± s.d) of Ongole and crossbred cows in four study areas in Central Java, over the period January 2010 – July 2011

Reproductive performance parameter	Area / Breed								
	Wet lowlands I (n=61)		Wet lowlands II (n=80)		Wet uplands (n=62)		Dry uplands (n=67)		
	Ongole (n=22)	Sim-cross[1] (n=39)	Ongole (n=48)	Sim-cross[1] (n=32)	Ongole (n=19)	Sim-cross[1] (n=43)	Ongole (n=25)	Sim-cross (n=33)	Lim-cross[2] (n=9)
PPE (days)	$122.7^{a} \pm 52.9$	$99.2^{b} \pm 36.0$	$121.9^{a} \pm 37.8$	$117.2^{a} \pm 29.4$	$151.2^{a} \pm 61.6$	$103.0^{b} \pm 45.8$	$151.2^{a} \pm 63.8$	$112.7^{b} \pm 49.6$	$97.8^{b} \pm 50.5$
PPM (days)	$128.2^{a} \pm 51.5$	$101.1^{a} \pm 35.8$	$130.0^{a} \pm 36.3$	$123.8^{a} \pm 31.6$	$155.6^{a} \pm 58.3$	$115.7^{b} \pm 43.5$	$153.2^{a} \pm 62.3$	$119.5^{b} \pm 52.4$	$140.7^{a,b} \pm 55.4$
S/C	$2.2^{a} \pm 1.0$	$2.8^{a} \pm 1.9$	$1.9^{a} \pm 1.3$	$2.3^{a} \pm 1.1$	$1.9^{a} \pm 0.9$	$2.4^{b} \pm 1.3$	$2.0^{a} \pm 0.9$	$3.1^{b} \pm 2.2$	$2.0^{a} \pm 0.9$
CI (days)	$440.2^{a} \pm 58.9$	$422.1^{a} \pm 53.3$	$433.3^{a} \pm 47.4$	$435.0^{a} \pm 38.7$	$457.7^{a} \pm 65.8$	$428.2^{b} \pm 48.1$	$459.5^{a} \pm 64.3$	$446.2^{a} \pm 73.7$	$447.8^{a} \pm 56.2$
BCS	$2.8^{a} \pm 0.4$	$2.9^{a} \pm 0.5$	$2.6^{a} \pm 0.4$	$2.9^{a} \pm 0.3$	$2.0^{a} \pm 0.3$	$2.7^{b} \pm 0.5$	$2.4^{a} \pm 0.3$	$2.8^{b} \pm 0.4$	$2.9^{b} \pm 0.6$
WA (months)	$4.6^{a} \pm 0.6$	$5.1^{a} \pm 1.6$	$4.0^{a} \pm 0.7$	$3.9^{a} \pm 0.7$	$4.9^{a} \pm 2.0$	$4.3^{b} \pm 1.2$	$5.9^{a} \pm 2.3$	$6.1^{a} \pm 1.0$	$6.0^{a} \pm 0.9$
Calf crop (%/y)^{ns}	84.5 ± 12.1	85.8 ± 17.2	85.3 ± 10.1	84.6 ± 7.8	81.2 ± 10.8	86.2 ± 8.7	80.8 ± 10.6	75.5 ± 26.7	73.0 ± 22.3
Methods of mating (%)									
• AI	100	100	8	100	100	100	40	98	100
• Natural	0	0	86	0	0	0	24	0	0
• Mix (AI and natural)	0	0	6	0	0	0	36	2	0

[1]Sim-cross = Simmental cross; [2]Lim-cross= Limousin cross; PPE= post-partum estrus; PPM= post-partum mating; S/C= services per conception; CI=calving interval; WA=weaning age

BCS= Body condition score, is visual assessment of body tissues (Ferguson et al., 1994 cited by Lassen et al., 2003). The range is 1 – 5, where 1 is the lowest and 5 is the highest (Baliarti, 1999)

AI = artificial insemination; [a,b] different superscripts indicate significant differences among breeds within the same area (P<0.05); ns non-significant

Table 3.9. Quantity of carcass and meat and meat bone ratio (MBR) (Mean ± s.d) of slaughtered Ongole and crossbred cattle in Yogyakarta Province

Parameter	Sex / Breed					
	Male			Female		
	Ongole (n=5)	Sim-cross[1] (n=25)	Lim-cross[2] (n=11)	Ongole (n=8)	Sim-cross[1] (n=4)	Lim-cross[2] (n=2)
Age (y)	$2.8^{a} \pm 0.5$	$2.6^{a} \pm 0.7$	$2.5^{a} \pm 0.7$	$4.3^{a} \pm 1.5$	$4.0^{a} \pm 1.5$	$4.5^{a} \pm 0.7$
Body weight at slaughter (kg)	$386^{a} \pm 105.5$	$517^{b} \pm 87.0$	$516^{b} \pm 87.3$	$335^{a} \pm 58.0$	$480^{b} \pm 103.2$	$526^{b} \pm 33.9$
Carcass weight (kg)	$203^{a} \pm 35.8$	$279^{b} \pm 51.3$	$272^{b} \pm 27.1$	$168^{a} \pm 34.0$	$246^{b} \pm 46.3$	$268^{b} \pm 17.7$
Carcass percentage (%)	$54.2^{a} \pm 8.5$	$54.3^{a} \pm 7.7$	$53.7^{a} \pm 7.8$	$50.1^{a} \pm 4.0$	$51.6^{a} \pm 2.3$	$50.9^{a} \pm 0.1$
Meat weight (kg)	$168^{a} \pm 29.4$	$217^{b} \pm 46.8$	$226^{b} \pm 24.1$	$128^{a} \pm 26.6$	$189^{b} \pm 58.1$	$209^{b} \pm 15.6$
Meat percentage (%)	$45.0^{a} \pm 7.2$	$41.9^{a} \pm 5.0$	$44.6^{a} \pm 7.0$	$38.5^{a} \pm 5.9$	$38.7^{a} \pm 3.9$	$39.7^{a} \pm 0.4$
MBR	$4.8^{ab} \pm 0.3$	$3.9^{b} \pm 1.3$	$4.9^{a} \pm 0.5$	$3.6^{a} \pm 1.3$	$3.6^{a} \pm 1.7$	$3.6^{a} \pm 0.1$

[1]Sim-cross = Simmental cross; [2]Lim-cross = Limousin cross; [a,b] different superscripts among breeds within the same sex indicate significant difference (P<0.05)

Table 3.10. Inputs, revenues and Gross Margins (in Million IDR)* of Ongole and crossbred cattle farms in four areas in Central Java for the period of January 2011 – July 2012

	Area / Breed							
	Wet lowlands I (n=56)				Wet lowlands II (n=63)			
	Ongole (n=17)		Crossbred (n=39)		Ongole (n=31)		Crossbred (n=32)	
	Mean	s.d	Mean	s.d	Mean	s.d	Mean	s.d
Number of cattle kept (head)[ns]	2.6	1.0	2.4	1.0	2.3	0.8	2.6	1.5
Total time spent per day (*h d*$^{-1}$)	4.5[a]	0.7	5.0[b]	0.7	4.9[a]	0.9	5.4[a]	1.4
• Cleaning cattle (%)	4.4		3.2		5.6		4.7	
• Cleaning the barn (%)	17.0		16.7		18.4		16.3	
• Collecting feed (%)	51.7		54.0		47.8		50.5	
• Offering feed (%)	26.9		26.1		28.2		28.5	
Total variable costs (Million IDR)	0.88[a]	0.30	1.56[b]	0.80	0.58[a]	0.16	0.87[b]	0.50
• Forage	0.31[a]	0.04	0.32[a]	0.09	0.40[a]	0.10	0.38[a]	0.12
• Supplementary feed	0.42[a]	0.32	1.05[b]	0.80	0.13[a]	0.13	0.25[b]	0.25
• AI / mating and reproduction services	0.08[a]	0.03	0.10[a]	0.08	0.04[a]	0.04	0.22[b]	0.24
• Other costs (hired labour, veterinary services, other)[ns]	0.06[a]	0.01	0.09[a]	0.12	0.01[a]	0.04	0.02[a]	0.05
Total output (Million IDR)	4.19[a]	3.04	4.11[a]	3.12	3.58[a]	2.14	5.04[b]	2.33
• Selling cattle	4.04[a]	3.03	3.97[a]	3.17	3.51[a]	2.17	4.91[b]	2.31
• Selling manure	0.16[a]	0.48	0.13[a]	0.17	0.08[a]	0.13	0.13[a]	0.20
Gross Margins*** (Million IDR)	3.32[a]	2.98	2.55[a]	2.93	3.01[a]	2.15	4.17[b]	2.30
Gross Margins per family labour time**** (Thousand IDR h^{-1} d^{-1})	1.41[a]	1.36	0.97[a]	1.14	1.26[a]	1.21	1.54[a]	0.97

[a, b] Different superscripts indicate significant differences between breeds within an area; [ns] Non significant
*One US $ = 9,200 IDR
**P value among areas
***Gross Margins (Million IDR)= Total output (Million IDR) – Total variable costs (Million IDR)
****Gross Margins per family labour time = Gross Margins per day / total time spent per day (Thousand IDR)

is an opportunity to reduce feed costs, since it is abundant in this area. Currently, the demand for cassava meal is increasing to produce bio-ethanol (Suradal, 2010, personal communication). It remains to be seen what effect the reduced access to cassava meal will have on the gross margins in the Dry uplands area. During the dry season, farmers in the Dry uplands area sell some of their livestock to buy forages and additional feeds. The higher feed costs have negatively affected the GM compared to the wet areas, but the difference in the GM between crossbred and Ongole farms in the Dry uplands is negligible. Overall, GM

Table 3.10.(continued)

	Area / Breed								P value**
	Wet uplands (n=59)				Dry uplands (n=74)				
	Ongole (n=12)		Crossbred (n=47)		Ongole (n=30)		Crossbred (n=44)		
	Mean	s.d	Mean	s.d	Mean	s.d	Mean	s.d	
Number of cattle kept (head)[ns]	3.2	1.1	2.6	0.9	2.0	0.7	2.8	2.4	0.70
Total time spent per day ($h\ d^{-1}$)	4.9[a]	0.9	4.8[a]	1.0	4.0[a]	1.5	4.4[a]	1.4	0.03
• Cleaning cattle (%)	5.7		4.2		3.2		4.2		
• Cleaning the barn (%)	15.8		17.5		3.3		4.8		
• Collecting feed (%)	45.0		47.4		65.8		60.4		
• Offering feed (%)	33.5		30.9		27.7		30.6		
Total variable costs (Million IDR)	1.46[a]	0.72	1.92[a]	1.50	1.00[a]	0.58	2.42[b]	3.62	0.01
• Forage	0.40[a]	0.07	0.43[a]	0.07	0.66[a]	0.48	1.28[b]	0.94	0.00
• Supplementary feed	0.89[a]	0.69	1.33[a]	1.67	0.27[a]	0.20	0.91[a]	2.03	0.00
• AI / mating and reproduction services	0.09[a]	0.03	0.11[a]	0.02	0.07[a]	0.03	0.11[a]	0.16	0.32
• Other costs (hired labour, veterinary services, other)[ns]	0.08[a]	0.13	0.13[a]	0.26	0.002[a]	0.009	0.12[a]	0.56	0.18
Total output (Million IDR)	5.17[a]	3.18	3.48[a]	3.41	3.48[a]	2.47	4.20[a]	5.16	0.84
• Selling cattle	4.94[a]	3.12	3.37[a]	3.38	3.48[a]	2.47	4.20[a]	5.16	0.86
• Selling manure	0.23[a]	0.19	0.11[b]	0.17	0.00	0.00	0.00	0.00	0.00
Gross Margins*** (Million IDR)	3.71[a]	2.87	1.56[a]	3.68	2.47[a]	2.34	1.78[a]	3.22	0.01
Gross Margins per family labour time**** (Thousand IDR $h^{-1}\ d^{-1}$)	1.43[a]	1.02	0.53[b]	0.14	1.29[a]	1.49	0.69[a]	1.59	0.03

per h of family labour input was significantly higher for Ongole farms than for crossbred farms (1319 vs 880 IDR per h d^{-1}).

Future of crossbreeding

Government started to promote crossbreeding in the 1980’s in order to improve the meat production of Ongole cattle and the productivity of smallholder farmers (Deptan, 2003). Only exotic semen was provided; there was no assistance in terms of feeding and breeding management.

In the early years of crossbreeding crossbred animals fetched a much higher price than the meat value, as there was a big demand for crossbred breeding stock (Barwegen, 2004; Sutresniwati, 2006). This gave a big boost to crossbreeding. When the importation of frozen meat and live cattle from Australia was high, however, the price of cattle, both local and crossbreds decreased. For example, during 2009-2011, the volume of imported frozen meat was high, and it was distributed to the wet market which depressed the sale price of cattle. Farmers were disappointed that the prices of crossbred cattle decreased more than of local cattle (40% vs 25%) (Suseno, 2011, personal communication). This was either due to their high price expectation or high initial price paid for crossbred cattle. Crossbreeding is now a routine practice and prices for both crossbred and local cattle are based on body weight estimates, being their actual meat value in the market.

Good fertility of the cows, high survival of calves and good quality weaned calves are very important for the farmers. The productivity of the herds can be expressed by combining the calf crop estimates with the weaning weight estimates. On average the Ongole farms produced 129 kg weaner weight per year, whereas the crossbred farms are more productive from this point of view: 154 kg weaner weight per year. Most farmers said they prefer crossbreds over Ongole, because of bigger body sizes and higher selling prices. Prices of crossbred weaners are in the range of approximately 5.0 – 7.5 million IDR, whereas Ongole weaners are sold for prices in the range of 3.5 - 4.5 million IDR.

Most farmers do not consider the higher feed requirements of crossbreds (Table 3.10.). The higher selling prices are much more tangible than the economic evaluation in terms of GM. So, crossbreeding will continue.

The crossbreeding of ‘beef’ cattle in smallholder mixed farms in Java confirms the general trend of crossbreeding in dairy type animals by smallholders in many different areas, that it is done rather un-controlled (Wollny, 2003). Systemic crossbreeding seems not possible, as there is no reliable pedigree information available and Simmental semen is used, irrespective of the crossbred generation type of the cows (Widi *et al*., 2008). Farmers in all zones said they do not prefer upgrading to very high levels of Simmental, as they expect poorer growth and less optimal reproductive performances of high levels of upgraded cattle. They are already satisfied with the performance of existing crossbred cattle. This implies that in future Ongole semen has to be used on higher grade crossbred animals. The local government has started a breeding initiative ‘*Return to Ongole’*. The main aim of this programme is to contribute to maintaining a viable Ongole population. In this programme farmers get a subsidy for every pregnant Ongole cow. This programme is only carried out in the Wet lowlands II and Dry uplands. The Return to Ongole breeding plan was set up in areas with a minimum Ongole productive cow population of 2000 head. The selection goal is growth rate from weaning to one year of age. The best yearling calves are transferred to a Performance Test Station from which the best bulls and cows are selected. This programme has resulted in an increasing demand for Ongole cattle.

In Indonesia meat production has increased from 399.7 tonnes in 2005 to 593.5 tonnes in 2013 (BPS, 2013). In the same period the total number of cattle has increased from 10.6 million to 12.8 million (BPS, 2013). Crossbreeding has certainly contributed to the increase in meat production. In Central Java the majority of the cattle are already crossbreds. The productivity of crossbreds in terms of the productivity parameter weaned weight per farm is higher than in Ongole farms. The number of cows per farm was the same for Ongole and crossbred farms.

The assumption in literature that the introduction of more productive breeds will result in keeping fewer animals and so lessening the impact on the environment (Steinfeld *et al*., 2006; Marshall, 2014) is not confirmed by the cattle herd sizes in the smallholder mixed farming systems in Central Java. The herds at the farms have always been very small, crossbreeding will not change that situation. Farmers keep a specific number of animals in relation to their limited resources. There is no information of numbers of specific crossbreeding generations and Ongole cattle in Indonesia. Marshall (2014) concludes that the impact of the introduction of new breed types on indigenous populations should be monitored by regular census. Such information is needed to support informed decision making on future (cross) breeding strategies. In Indonesia, census data on livestock numbers are available, however, unfortunately census data do not distinguish different breed or crossbred generation types.

Limitations of the impact analysis used

Marshall (2014) suggests that strategic research is needed to assess the impact of different breed types from a range of viewpoints: household level, food and nutrition security at different scales and environmental sustainability. The present analysis of the impact of crossbred animals on smallholder cattle keeping in Central Java considers only farm level developments, such as animal performances, herd sizes, objectives of keeping cattle and financial results. These data helped to understand why crossbred farmers opt for crossbreds. Research at other levels is needed to complete the picture of the impact of crossbreeding. Our farm level data on animal weights and feed intakes might lack in accuracy, as detailed measurements are not possible on large numbers of animals in the field. The GM analysis only included the financial flows on the farms, the additional benefits of cattle in terms of manure use on own crop land and the security function of the cattle are not included. We expect no differences between the farm types in manure use, however the security function of crossbred cattle might be slightly higher than for Ongole, as estimates of this are generally based on financial value of the cattle kept and sold (Udo *et al*., 2011). So, crossbred cattle present a higher capital asset value than Ongole cattle.

3.4. Conclusions

In Indonesia, crossbreeding has become a common practise over a period of about 30 years. The question whether or not crossbreeding is beneficial for the mixed farming systems in Central Java can be looked at from farmers' points of view and from national level point of view. The comparisons of households with Ongole and crossbred cattle in different agro-ecological zones in Central Java show that crossbreeding is not changing such farming systems: household and farm characteristics, and herd sizes and structures were not really different between farmers keeping Ongole or crossbred breeding stock.

Crossbreeding has also not changed the basic motives of keeping cattle. The main motives for keeping cattle, either Ongole or crossbred, were the capital asset function (saving), income and manure production. The reasons for choosing either type of breeding stock, however, differed: lack of feed and capital are reasons for not choosing crossbreds, whereas expectations of better growth and better selling prices trigger keeping crossbreds.

In all agro-ecological areas included in this study, the crossbreds reached considerably higher body weights and consequently fetched higher sale prices, but they also required more feed resulting in comparable gross margins for farmers with crossbred or Ongole breeding stock. So, crossbreeding is not bringing financial gains for the farmers. Nevertheless, in all study areas, farmers prefer Simmental crosses because of their nice appearance, high growth rate and high price of progeny sold compared to Ongole.

At national level crossbreeding is contributing to increased meat production. The amount of weaned weight per farm was 20% higher on crossbred farms than on Ongole farms. Hence, crossbreeding will continue in Indonesia, since farmers are satisfied with the performances of crossbred cattle, such as their higher body weights and consequently higher market prices across agro-ecological zones. Government bodies continue to promote crossbreeding, however, at the same time conservation of Ongole has started three years ago in its original breeding area and is supported by a structured breeding program. There is no breeding strategy to maintain current crossbred levels. A viable Ongole population is needed to reduce the risk of upgrading to too high levels of Simmental.

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Chapter 4

Is crossbreeding of cattle beneficial for the environment? The case of mixed farming systems in Central Java, Indonesia

Farmers collect forages everyday along roadsides, and from fields, river banks, or forests

T.S.M. Widi[1,3], H.M.J. Udo[1], K. Oldenbroek[2], I.G.S. Budisatria[3], E. Baliarti[3], T.C. Viets[1], A.J. van der Zijpp[1]

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[1]Animal Production Systems Group, Department of Animal Sciences, Wageningen University, the Netherlands

[2]Centre for Genetic Resources, the Netherlands

[3]Department of Animal Production, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia

ABSTRACT

Crossbreeding with European beef breeds has become a standard approach for the intensification of smallholder cattle production in Indonesia. It is often suggested that intensification will mitigate the negative environmental impact of livestock. However little is known about the environmental impact of the intensification of cattle keeping in a smallholder setting. This study assessed the environmental impact of crossbreeding, in terms of Global Warming Potential (GWP) and land use. We sampled 90 local Ongole and 162 crossbred cattle farms in four study areas representing three agro-ecological zones: Wet lowlands (subdivided into two areas), Wet uplands and Dry uplands. Expressed per kilogram of live weight of young stock produced, GWP (26.9 kg CO_2–equivalents) and land use (34.2 m^2) of Ongole cattle were not significantly different from the GWP (28.9 kg CO_2–equivalents) and land use (37.4 m^2) of crossbred cattle. Crossbred young stock grew faster, but in general crossbred cattle required more feed. GWP per kilogram of live weight produced was highest in the Dry uplands; this area had different forage feeding practices (more native grasses and dry forages were fed than in the other areas) and higher emissions due to transportation of forages than other areas. Land use per kilogram of live weight tended to be higher in the Wet lowlands I and Wet uplands, the two most fertile areas, than in the other two areas, as more local fresh forages were fed in these areas. In the current smallholder production system, the dominant crossbreeding practice of using Simmental semen on Ongole and F_1 crossbred cows does not result in lower greenhouse gas emissions or land use per kilogram of live weight produced compared to farms with Ongole cows. The advantage from the faster growth of crossbreds is counteracted by the higher emissions and land use from feed production for crossbreds.

Keywords: Crossbreeding, Mixed farming systems, Ongole, Simmental, Life Cycle Assessment, Multi-functionality, Indonesia

4.1. Introduction

Intensification of livestock production is widely promoted as a strategy to meet the increasing demand for animal source foods and to improve the livelihoods of smallholder livestock farmers (Delgado *et al.*, 2000; Otte and Upton, 2005; Pica-Ciamarra, 2007). Intensification of livestock production is also seen as an important way of reducing the environmental impact of livestock, in particular in smallholder production systems (Steinfeld *et al.*, 2006; Gerber *et al.*, 2013). Various global studies suggest that intensification of livestock production will reduce emissions of greenhouse gasses (GHG) per unit of production (Steinfeld *et al.*, 2006; Gerber *et al.*, 2013). Intensification is also expected to reduce the pressure on land, resulting in less cultivation of natural areas and destruction of woodlands (Steinfeld *et al.*, 2006).

In resource-poor environments, crossbreeding with breeds selected for high production has become a standard intensification approach for cattle husbandry. Field studies on the impact of intensification through crossbreeding have mainly been undertaken for dairy cattle. These studies showed that smallholder dairying using crossbreds resulted in economic gains for the households involved (McDermott *et al.*, 2010; Samdup *et al.*, 2010; Udo *et al.*, 2011), although it was not feasible for really resource-poor households (Udo *et al.*, 2011). Weiler *et al.* (2014) showed, however, that intensification of dairy farming does not necessarily lead to lower emissions per kilogram of milk produced. Consideration of how off-farm feed production contributes to environmental impact is particularly important. Production levels may be higher in more intensive production systems but more feed supplements are also being used.

Little is known about the impact of the intensification of beef cattle systems in smallholder settings on GHG emissions. Wall *et al.* (2009) and Scholtz *et al.* (2012) suggest that genetic improvement and crossbreeding may be sustainable ways of reducing the carbon footprint of beef cattle, but no results from field studies support this hypothesis. Intensification will require increased use of inputs, which may offset any beneficial impact of increased production on the environmental impact per unit of production.

In Indonesia, crossbreeding with European breeds has been promoted as a strategy to intensify its beef production. It is implemented throughout the country, regardless of differences in agro-ecology, of which the variation in available feed resources is a main element (Widi *et al.*, 2015). About 90% of cattle in Indonesia are owned by smallholder farmers with fewer than five head of cattle per farm and about 0.1 to 0.4 ha of crop land. The population pressure in the main island Java means that all agricultural land is used for cropping. As a consequence, the cattle management systems are predominantly based on cut-and-carry (stall) feeding (Palte, 1989).

In Java, crossbreeding is mainly practised by using Simmental semen on the local Ongole population (Widi *et al.*, 2015). Indonesian farmers, in common with smallholders in developing countries, keep cattle not only for meat production, but also for financial security, draught power, manure for cropping and social status (Widi, 2004). Comparisons of crossbred and Ongole cattle production systems in different agro-ecological zones in Central Java have shown that the reasons for keeping cattle are similar for both systems (Widi *et al.*, 2015). Reproductive performances were not different between the two types of breeding stock. But at comparable ages, crossbred cows and progeny reached approximately 25% and 17% heavier body weights than Ongole cows and progeny. Crossbred cattle fetched higher sale prices, but they were fed more supplementary feed (Widi *et al.*, 2015). Consequently, no differences in the Gross Margins from cattle keeping were observed between farms with Ongole cattle and farms with crossbred cattle within the same agro-ecological zone (Widi *et al.*, 2015).

Is intensification through crossbreeding indeed beneficial for the environment? There is a lack of field studies to substantiate the claims about the environmental benefits of intensification. Life cycle assessment (LCA) is commonly used to assess the environmental impact of producing livestock products (de Vries and de Boer, 2010; de Boer *et al.*, 2011). Environmental impacts from beef cattle production have mainly been estimated for intensive systems in Europe and America (Casey and Holden, 2006; de Vries and de Boer, 2010; Nguyen *et al.*, 2010). In such studies the impacts are generally expressed per unit of meat produced. In resource-poor cattle keeping systems, the different livelihood functions should be included when assessing impacts per unit of production and mitigation opportunities (Weiler *et al.*, 2014). This will not only give a more realistic picture of the impacts but will also reflect farmers' realities when considering mitigation options. The objective of this study was to assess the environmental impact, in terms of GWP and land use, of Ongole and crossbred beef cattle production systems in different agro-ecological zones in Central Java. This was achieved by applying the LCA methodology.

4.2. Materials and methods

Study areas

The study areas were situated in the southern part of Central Java. They represented two agro-ecological zones, the Uplands and the Lowlands, with three different rainfall patterns. Wet lowlands, Wet uplands and Dry uplands could be distinguished. The study areas differ in topography, soil types, soil fertility and agro-climatic conditions. Wet lowlands (lower than 100 m above sea level; annual rainfall of 2400-3000 mm; BPS, 2009) have fertile soils and are characterised by irrigated farming systems with paddy and maize as the main crops. Wet uplands (higher than 500 m above sea level with annual rainfall of 3000-3600 mm; BPS, 2009) also have fertile soils and are characterised by both irrigated and rain-fed farming systems, with paddy fields, horticulture and forest. Dry uplands (higher than 500 m above sea level) have less fertile soils and low annual rainfall (1800-2400 mm; BPS, 2009). This zone has rain-fed farming systems with mainly cassava and dry land paddy.

Wet lowlands were divided into Wet lowlands I, located in Yogyakarta Province, where crossbreeding is broadly applied, and Wet lowlands II, located in Central Java Province, where crossbreeding is less frequently applied. Wet lowlands II is a traditional breeding area of local cattle (Ongole, in Indonesia called *Peranakan Ongole*, PO). In this area, the local government allocated several districts (an administration unit within an area) for maintaining Ongole cattle.

All farms apply stall-feeding. The feed resources for cattle production are mainly cut native grasses and crop by-products. Rice straw is more frequently available in the lowlands than in the uplands. Supplementary feeds, such as wheat bran, fresh cassava, dried cassava, cassava waste, tofu (soybean curd) waste and soybean hulls are available locally. Cassava and legumes are available more frequently in the Dry uplands. Rice bran is produced by the local milling factories. Compounded concentrates are usually produced by feed mill companies, which are located outside the study areas, particularly in areas where dairy farming is practised. Compounded concentrates are distributed to cooperatives and local shops selling farming supplies.

Most smallholder farmers in Central Java keep cattle for capital savings and additional income and to produce manure, which is beneficial for their crops. Farmers consider capital savings as security to be able to meet unexpected or large expenses. They consider income as the cash they receive from the sale of progeny (Widi *et al.*, 2015). They usually sell calves after weaning, which is around seven months, until approximately one year of age. The smallholder farmers can be regarded as cattle breeders, they sell animals to traders and middle men. These intermediaries sell stock to other farmers, feedlots or butchers. Butchers either slaughter the animals immediately or fatten them for several months before slaughtering. The farmers store the manure in or close to the barns for several months and utilise all manure to fertilise soils for crop production.

Data collection

We sampled data from mixed farms owning cattle for ten years or longer and owning at least one cow. In total, 252 farms were purposively selected, for monitoring inputs, outputs and on-farm resource flows: 56 (17 Ongole and 39 crossbred) farms in Wet lowlands I, 63 (31 Ongole and 32 crossbred) farms in Wet lowlands II, 59 (12 Ongole and 47 crossbred) farms in Wet uplands and 74 (30 Ongole and 44 crossbred) farms in Dry uplands (Widi *et al*., 2015). Farmers could not distinguish subsequent crossbred generations.

LCA calculations were based on the inputs and outputs of the cattle component of the study farms during the period from January 2011 until January 2012. Feed was the major input. Many different feeds were offered to the cattle. The feeds were categorised as fresh forages, dry forages and supplementary feeds. The proportions of the different fresh forages were estimated by separating the fresh forage into its components. Feed inputs were calculated based on farmers' estimates and direct observation of the types and amounts of feeds offered to each individual animal during one year. The estimates of the types and amounts of fresh forages offered were recorded by farmers each day. Trained enumerators (n=8) checked the farm recording once a month. Young animals, approximately 6 to 12 months, were fed only fresh forages, and it was assumed that they get a half portion compared to adult animals. The amounts of dry forages and supplementary feeds that were bought were estimated from the amounts purchased. These estimates were translated into kilograms of dry matter (DM) and crude protein (CP) intake per animal, applying the feed composition tables of Hartadi *et al.* (2005) for feeds available in Central Java.

Weights of cows, other adult stock (e.g. bulls and heifers) and young stock were estimated by the enumerators by measuring the chest girth using a measurement tape that transformed the chest girth in centimetres into live weight in kilograms (developed by FHK Ogawa Seki Co. Ltd, Tokyo, Japan) (Widi *et al*., 2015).

In the LCA procedures, the emissions were allocated to the relative economic values of the different functions. The measurement of economic values took place over a period of 1.5 years (January 2011-July 2012), to ensure that the participating farms produced young stock in that period. The first author recorded, through monthly visits to the sample farms, farmers' inputs and outputs of cattle keeping during this period.

LCA procedures

A LCA is usually divided into four steps: goal and scope definition, inventory analysis, impact assessment and interpretation (ISO 14040 1997; ISO 14041 1998; ISO 14042 2000 and ISO 14043 2000). The first step of a LCA includes the definition of the system boundary, the 'Functional Unit' (FU) to which environmental impacts are allocated, the method of allocation and the impact categories to be analysed.

The system boundary of the LCA determines which processes of a production system shall be included within the LCA. The system boundary of the cattle component in Ongole and crossbred farms is shown in Figure 4.1. We assessed all processes up to the farm-gate, including the cattle (enteric fermentation), cut-and-carry forages and supplementary feeds. Transportation of forages by trucks was only found in the Dry uplands area. Emissions for manure were not assigned to the cattle component, as all manure was used for cropping (Figure 4.1.).

Given the system boundary, we computed the emissions of the main GHG: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The method used to calculate GHG emissions from enteric fermentation was based on the intergovernmental panel on climate change (IPCC) good practice guidance, Tier 2 approach (IPCC, 2006). We considered emissions under the current production conditions. Global warming potential and land use were assigned to all the feeds offered to the cattle on the farms on a yearly basis. Ecoinvent data 2.2.allowed us to compute the GWP and land use for each feed ingredient (Ecoinvent 2.2, available at http:/pre-sustanability.com). If recent yield data were not available in Ecoinvent 2.2, we used production data from the FAO statistical database, and computed GWP and land use per feed ingredient using Simapro7.3 (Simapro 7.3, available at http:/pre-sustanability.com).

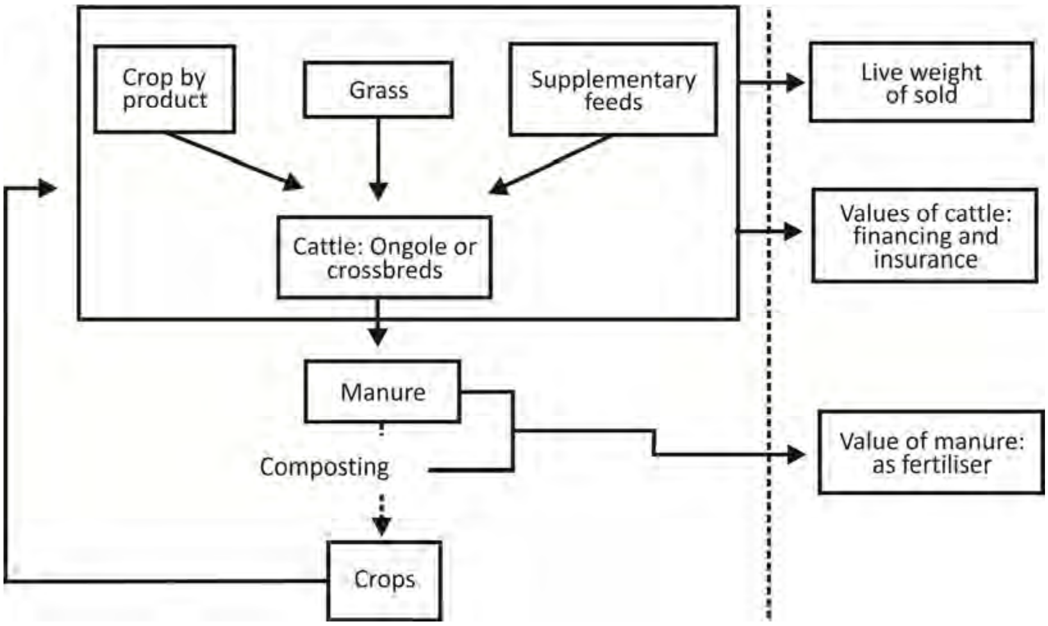

Figure 4.1. System boundaries for the LCA of local and crossbred cattle production systems

Allocation procedures

The FU in a LCA analysis should represent the main function of the analysed system. Because of the multi-functionality of cattle keeping in the study areas, two allocation approaches were used: (i) allocation to live weight of young stock produced in the farms, and (ii) allocation to live weight of young stock produced taking into account the other functions of cattle keeping. ISO 14044 (2006) provides guidelines on how to allocate the environmental impact of a process or production system in the case of multiple functions. In this study we used economic allocation, which implies the allocation of GWP and land use to the different functions based on their economic values. When crop by-products were used as feed, economic allocation was applied based on the economic value of the crop for human food consumption and the value of its by-products for animal feed.

Economic allocation to the different functions of cattle keeping

Live weight of young stock sold has a direct market value, whereas young stock not sold represent an opportunity value. The economic value of cattle as a means of finance and insurance and the use of manure as fertiliser can only be assessed indirectly.

The economic value of live weight produced was calculated as follows:

$LC_k = SC_k$ x head price,

where LC_k is the total economic value of live weight produced during one year in Indonesian Rupiah (IDR), SC_k is the number of cattle produced in one year (head) and head price is the cattle price (IDR), which is determined by body weight estimation.

The head prices of cattle sold were provided by the individual farmers. Village traders or middle men buy cattle from farmers. Prices are based on exterior appearance of the cattle. We interviewed farmers regarding the price of young stock produced at the farms.

The opportunity values of weaners still present on the farms were based on estimates of the farmers or traders.

The economic value of manure used as fertiliser was estimated based on synthetic N fertiliser equivalents, in this case urea ($CO(NH_2)_2$), which was the common fertiliser that farmers used. The economic value of manure used was calculated as follows:

$$MANURE = N_{manure} \times \text{fertiliser price},$$

where, MANURE is the total economic value of manure used as fertiliser during one year (IDR), N_{manure} is kilograms N in manure used as fertiliser and fertiliser price is economic value of N in urea ($CO(NH_2)_2$) expressed as (IDR/kg N). Manure production in terms of kilograms per day (kg d^{-1}) of DM was calculated by multiplying the estimated weight of fresh manure produced per animal per day and the DM content of fresh manure. We assumed that an adult Ongole produces 15 kg d^{-1} of fresh manure and an adult crossbred 20 kg d^{-1}, and that the DM content is 15% (Pertiwinigrum, personal communication). We assumed that cattle manure has a N content of 1.7%, based on Moore and Gamroth (1993) and that 50% of N was lost during storage (Moore and Gamroth, 1993). The price of fertiliser (urea) was estimated at 1,600 IDR per kilogram in 2011, and therefore we estimated the price of N at 3,478 IDR per kilogram (N content of urea is 46%; Hartadi *et al.*, 2005).

Estimation of the intangible benefits of cattle was based on Bosman *et al.* (1997), Moll (2005) and Moll *et al.* (2007). The intangible benefit from financing is related to not having to pay interest when borrowing money from a bank or an informal money lender (Moll, 2005; Moll *et al.*, 2007). The benefit of financing was estimated as:

$$F_k = LC_k \times f,$$

where F_k is benefit of financing, LC_k is total economic value of live cattle sold in a farm in one year (IDR) and f is financing factor. The total economic value of live cattle sold, LC_k, refers to the direct economic value of the cattle. The formal interest rate of credit in the study areas was 12% (Bank BNI Yogyakarta, 2013, personal communication).

Bosman *et al.* (1997) described the intangible insurance benefit of livestock as the economic value of the stock as insurance for the household, i.e. to pay premium in case of health insurance or another type of insurance. The intangible insurance benefit was estimated as:

$$I_k = SF_k \times s,$$

where I_k is insurance benefit, SF_k is number of cattle on farm multiplied by estimates of price per head (IDR), and s is insurance factor. The factor s was set at 9% (Asuransi Prudential – Yogyakarta, 2003, personal communication). This represents the human health insurance premium that would have to be paid for health insurance.

Impact assessment

The impact categories considered were Global Warming Potential (GWP) and land use. The carbon footprint, GWP in CO_2-equivalents (CO_2-eq) per kilogram animal product, is widely used to assess the climate change impact of cattle (Steinfeld *et al*., 2006; Gerber *et al.*, 2013). In Java, land use is very much under pressure as almost all agricultural land is used for crop production. Grazing lands have disappeared and cattle are kept in a cut-and-carry management system. To assess the GWP of Ongole and crossbred cattle farms, emissions of CO_2, CH_4 and N_2O were summed based on their equivalence factors in terms of kilograms of CO_2-equivalents: 1 for CO_2, 25 for CH_4 and 298 for N_2O (IPCC, 2007). Land used for producing the different types of feed was expressed in square metres (m^2) (Phong *et al.*, 2011). Interpretation of the results is based on the FU, live weight produced in the study period.

We compared the emission intensities and farm characteristics of the 25th percentile of Ongole farms, representing farms with lower emission intensities, with the emission intensities and farm management characteristics of all the other Ongole farms. The same analysis was conducted for crossbred farms. This analysis was conducted to explore why some farms had lower emission intensities than others, analogous with Gerber *et al.* (2013).

Data analysis

One-way ANOVA was performed to analyse the variation in GWP and land use per kilogram live weight produced among areas, with breed nested within areas (Ott and Longnecker, 2010). The model was simplified to compare breeds within areas, because for most parameters no interaction was found between breed and area.

4.3. Results

Characteristics of Ongole and crossbred cattle farms

Table 4.1. presents the farm characteristics for the four study areas. Land size was not significantly different between the two types of farms within the four study areas. Most of the land was used for crop production. Farmers usually planted forages along the boundaries of their fields. Cut-and-carry feeding was practised in all study areas. Forages were collected from the fields, riversides, roadsides, forest edges and backyards. Supplementary feeds were offered irregularly. In Lowlands II, rice bran was only offered during the rice harvesting period, because farmers utilised the by-product of their own harvested rice, whereas in the other areas rice bran was offered independent of the harvesting period.

Table 4.2. presents the inventory results for cattle herds, feeding practices and manure estimates for Ongole and crossbred farms. The total number of cattle did not differ between Ongole (2.4) and crossbred (2.6) farms within the four study areas. The amounts of the different feed types fed differed significantly amongst areas. More fresh forages were fed on Wet uplands farms than in the other three areas. More dry forages were fed on Wet

Table 4.1. Characteristics of farms with Ongole and crossbred cattle in Wet lowlands areas in Central Java

	Area /Breed			
	Wet lowlands I (n=56)		Wet lowlands II (n=63)	
	Ongole (n=17) Mean ± s.d	Crossbred (n=39) Mean ± s.d	Ongole (n=31) Mean ± s.d	Crossbred (n=32) Mean±s.d
Land size (ha)	0.13[a] ± 0.13	0.14[a] ± 0.09	0.36[a] ± 0. 80	0.21[a] ± 0.12
Crops	Paddy, maize, soybeans, shallots, groundnut, soybean, cassava, sweet potato and horticulture		Paddy, maize, cassava, sweet potato, groundnut, mung beans, fruits and, horticulture	
Feeds offered to cattle				
• Fresh forages	*Pennisetum purpureum*, *Panicum maximum*, maize foliage, native grass, fresh groundnut haulm		*Pennisetum purpureum*, *Panicum maximum*, native grass, maize foliage, rice stalk and groundnut haulm	
• Dry forages	Rice straw		Rice straw	
• Supplementary feeds	Rice bran, wheat bran, concentrates**, tofu waste		Rice bran, fresh cassava	

[a,b] Different superscripts indicate significant differences between breeds within area and in all areas (P<0.05)
**Concentrate composition: rice bran, palm kernel meal, cassava meal, maize cob, molasses, urea

Table 4.2. Composition of the cattle herd, feeding practices and manure produced for Ongole and crossbred farms in the four study areas in Central Java, January 2011-January 2012

	Area /Breed					
	Wet lowlands I (n=56)		Wet lowlands II (n=63)		Wet uplands (n=59)	
	Ongole (n=17) Mean ± s.d	Crossbred (n=39) Mean ± s.d	Ongole (n=31) Mean ± s.d	Crossbred (n=32) Mean ± s.d	Ongole (n=12) Mean ± s.d	Crossbred (n=47) Mean ± s.d
Number of cattle kept						
•Cow (head)	1.41[a]±0.62	1.23[a]±0.49	1.13[a]±0.62	1.53[b]±0.84	1.42[a]±0.67	1.45[a]±0.58
•Heifer (head)	0.35[a]±0.49	0.31[a]±0.52	0.32[a]±0.54	0.16[a]±0.45	0.58[a]±0.67	0.09[b]±0.35
•Male (head)[ns]	0.12±0.33	0.13±0.41	0.13±0.34	0.06±0.25	0.33±0.65	0.19±0.54
•Calf (head)[ns]	0.76±0.66	0.74±0.82	0.68±0.65	0.84±0.92	0.83±0.58	0.87±0.77
•Total cattle (head)[ns]	2.6±1.0	2.4±1.0	2.3±0.8	2.6±1.5	3.2±1.1	2.6±0.9
•Total cattle (TLU)**[ns]	2.3[a]±0.9	2.1[a]±0.8	2.0[a]±0.7	2.3[a] ±1.3	2.8[a]±1.0	2.3[b]±0.8
Amount of feed offered						
•Fresh forage (000 kg/farm/year)	20.1[a]±0.8	21.9[a]±0.8	16.9[a]±0.8	24.1[b]±1.2	27.1[a]±0.9	25.6[a]±0.9
•Dry forage (000 kg/farm/year)	2.1[a]±0.9	2.1[a]±1.2	2.8[a]±1.3	3.9[a]±2.7	4.0[a]±0.4	3.0[a]±1.7
•Supplementary feed (000 kg/farm/year)	0.28[a]±0.25	0.68[b]±0.44	0.13[a]±0.09	0.37[b]±0.35	0.56[a]±0.45	0.60[a]±0.42
Live weight of produced cattle (kg/farm/year)	139[a]±64.4	161[a]±56.6	116[a]±28.3	141[b]±56.5	128[a]±45.8	150[a]±50.2
Manure produced (000 kg/farm/year)	12.8[a]±5.2	14.0[a]±5.2	9.9[a]±3.4	15.1[b]±8.4	16.2[a]±6.1	15.0[a]±5.3

[a,b] Different superscripts indicate significant differences between breeds within area and in all areas (P<0.05).
[ns] Non-significant; *P value among areas.

Table 4.1. (continued)

	Area /Breed				P value*
	Wet uplands (n=59)		Dry uplands (n=74)		
	Ongole (n=12) Mean ± s.d	Crossbred (n=47) Mean ± s.d	Ongole (n=30) Mean ± s.d	Crossbred (n=44) Mean±s.d	
Land size (ha)	$0.17^a \pm 0.06$	$0.16^a \pm 0.16$	$0.44^a \pm 0.29$	$0.55^a \pm 0.50$	0.0
Crops	Paddy, cassava, maize, groundnut, fruits and, horticulture		Paddy, maize, cassava, groundnut		
Feeds offered to cattle					
• Fresh forages	*Pennisetum purpureum*, *Panicum maximum*, maize foliage, native grass, groundnut haulm, cassava leaves		*Pennisetum purpureum*, *Panicum maximum*, maize foliage , native grass, groundnut haulm, legumes		
• Dry forages	Rice straw		Rice and maize straw		
• Supplementary feeds	Rice bran, tofu waste, concentrates**, soybean hull		Rice bran, fresh and dried cassava, and cassava waste.		

*P value among areas

Table 4.2. (continued)

	Area / breed		Average		*P value
	Dry uplands (n=37)				
	Ongole (n=30) Mean ± s.d	Crossbred (n=44) Mean ± s.d	Ongole (n=90) Mean ± s.d	Crossbred (n=162) Mean ± s.d	
Number of cattle kept					
•Cow (head)	1.07^a±0.25	1. 48^a±1.36	1.20^a±0.55	1.42^b±0.89	0.73
•Heifer (head)	0.07^a±0.254	0.23^a±0.48	0.28^a±0.50	0.19^a±0.45	0.25
•Male (head)^{ns}	0.03±0.83	0.09±0.36	0.12±0.36	0.12±0.41	0.15
•Calf (head)^{ns}	0.87±0.73	1.05±1.14	0.78±0.67	0.88±0.92	0.38
•Total cattle (head)^{ns}	2.0±0.7	2.8±2.4	2.4±0.9	2.6±1.6	0.70
•Total cattle (TLU)**^{ns}	1.7^a±0.5	2.4^a±2.0	2.1^a±0.8	2.3^a±1.3	0.62
Amount of feed offered					
•Fresh forage (000 kg/farm/year)	14.4^a±0.5	23.9^b±0.2	18.0^a±0.8	24.0^b±1.3	0.02
•Dry forage (000 kg/farm/year)	1.84^a±0.6	3.7^b±3.8	2.5^a±1.4	3.1^b±2.6	0.01
•Supplementary feed (000 kg/farm/year)	0.36^a±0.20	0.71^a±1.24	0.29^a±0.27	0.60^b±0.74	0.01
Live weight of produced cattle (kg/farm/year)	100^a±25.2	142^b±101.9	117^a±41.2	149^b±70.2	0.00
Manure produced (000 kg/farm/year)	8.7^a±2.5	15.9^b±13.1	10.9^a±4.7	15.0^b±8.6	0.22

lowlands II and Wet uplands farms than in the other two areas and less supplementary feeds were fed in Wet lowlands II than in the other three areas. Overall, the amounts fed of fresh forages, dry forages and concentrates were significantly higher for crossbred farms than for Ongole farms. In Wet lowlands I the amount of fresh forages fed hardly differed between Ongole and crossbred farms, but the amount of concentrates fed was significantly higher for crossbred farms (680 kg per farm per year for crossbred farms versus 280 kg for Ongole farms). Overall, live weight produced was also significantly higher for crossbred farms (149 kg) than for Ongole farms (117 kg). In all areas, crossbred farms produced more kilograms of live weight of young stock than Ongole farms, but the variation between farms was high, so the differences between breeds within areas were only significant in Wet lowlands II.

Economic allocation of the multiple functions for Ongole and crossbred cattle farms

Cattle have multiple economic functions. Table 4.3. shows the relative contributions of the different functions that could be quantified. The biggest contribution was from live cattle produced; this accounted for 71.8% of total value for Ongole cattle and 71.4% for crossbred cattle. The contribution of live weight produced was not significantly different ($P<0.05$) between the two types of cattle farms within the different study areas. The insurance function of cattle comprised 18% of the total value of Ongole cattle, and 19% of the total value of crossbred cattle. The additional two functions, which we quantified contributed little to the total value of cattle, an average contribution of 8.1% for financing and 1.1% for manure used as fertiliser.

Global warming potential of Ongole and crossbred cattle production systems

Table 4.4. shows the total GWP and the GWP per kilogram of live weight produced for the cattle component of the two farm types in the four study areas. Ongole farms tended to have a significantly lower GWP than crossbred farms (4,000 versus 5,600 kg CO_2-eq per year, $P<0.05$). On average, 76% of GWP was due to methane emissions from enteric fermentation. The remaining 24% came from feeds and transport of forages. Use of fresh home-produced forages in crossbred farms resulted in significantly higher GWP per farm compared to Ongole farms. Among areas, emissions from the use of forages was significantly higher in the Dry uplands than in other areas ($P<0.05$). Most of the forages in the Dry uplands were native grasses.

Ongole and crossbred cattle did not have a significantly different impact in terms of GWP per kilogram of live weight produced. When all the GWP was allocated to live weight produced, the average GWP per kilogram of live weight produced was 38.7 kg CO_2-eq for Ongole farms and 42.3 kg CO_2-eq for crossbred farms. The GWP per kilogram of live weight based on economic allocation to the different functions of cattle averaged 26.9 kg CO_2-eq for Ongole cattle farms and 28.9 kg CO_2-eq for crossbred farms (Table 4.4.).

Table 4.3. Economic allocation of the multiple functions (IDR/year) and allocation factor (%) forOngole and crossbred farms in the four study areas in Central Java, January 2011-July 2012

Cattle function	Area/Breed								Average		*P value
	Wet lowlands I (n=56)		Wet lowlands II (n=63)		Wet uplands (n=59)		Dry uplands (n=74)				
	Ongole (n=17)	Crossbred (n=39)	Ongole (n=31)	Crossbred (n=32)	Ongole (n=12)	Crossbred (n=47)	Ongole (n=30)	Crossbred (n=44)	Ongole (n=90)	Crossbred (n=162)	
	Mean ± s.d	Mean ±s.d	Mean ± s.d	Mean ± s.d	Mean ± s.d	Mean ± s.d	Mean ± s.d	Mean ± s.d	Mean ± s.d	Mean ± s.d	
Live weight produced (Million IDR)	3.93^{a}±1.5	4.91^{b}±1.5	2.91^{a}± 0.93	3.62^{b}±1.31	3.43^{a}±1.30	5.09^{b}±2.01	3.02^{a}±0.73	4.76^{b}±3.79	3.21^{a}±1.10	4.67^{b}±2.48	0.01
Financing (Million IDR)	0.44^{a}±0.15	0.54^{b}±0.15	0.33^{a}±0.07	0.43^{b}±0.13	0.34^{a}±0.13	0.51^{a}±0.20	0.33^{b}±0.07	0.54^{b}±0.41	0.36^{a}±0.11	0.52^{b}±0.26	0.01
Manure (Million IDR)	0.06^{a}±0.02	0.06^{a}±0.02	0.04^{a}±0.01	0.06^{b}±0.04	0.07^{a}±0.03	0.07^{a}±0.02	0.04^{a}±0.01	0.06^{b}±0.06	0.05^{a}±0.02	0.07^{b}±0.04	0.19
Insurance (Million IDR)	1.10^{a}±0.51	0.97^{a}±0.05	0.68^{a}±0.33	1.16^{b}±0.70	1.30^{a}±0.59	1.43^{a}±0.61	0.70^{a}±0.24	1.30^{b}±1.17	0.8^{a}±0.5	1.2^{b}±0.8	0.01
Total value** (Million IDR)	5.53^{a}±1.84	6.49^{a}±1.82	3.96^{a}±0.97	5.27^{b}±1.70	5.22^{a}±1.94	7.16^{a}±2.44	4.10^{a}±0.55	6.68^{b}±0.51	4.47^{a}±1.45	6.49^{b}±3.21	0.00
Allocation factor*** (%)	70.8^{a}±7.2	75.3^{b}±7.5	72.8^{a}±8.2	68.8^{a}±9.3	66.0^{a}±5.6	70.7^{b}±7.2	73.7^{a}±3.6	70.9^{a}±8.4	71.8^{a}±6.8	71.4^{a}±8.1	0.02

^{a,b} Different superscripts indicate significant differences between breeds within area and in all areas (P<0.05).
*P value for differences betweenareas.
**Total value = Live weight produced + Financing + Manure + Insurance.
***Allocation factor = (Live cattle sold / total value) x 100.

Table 4.4. Global warming potential (GWP) of Ongole and crossbred cattle production systems in the four study areas in Central Java, January 2011-January 2012

	Area/Breed								Average		*P value
	Wet lowlands I (n=56)		Wet lowlands II (n=63)		Wet uplands (n=59)		Dry uplands (N=74)				
	Ongole (n=17)	Crossbred (n=39)	Ongole (n=31)	Crossbred (n=39)	Ongole (n=12)	Crossbred (n=47)	Ongole (n=30)	Crossbred (n=44)	Ongole (n=90)	Crossbred (n=162)	
	Mean ± s.d	Mean ± s.d	Mean ± s.d	Mean±s.d	Mean ± s.d	Mean ± s.d	Mean ± s.d	Mean±s.d	Mean±s.d	Mean±s.d	
Total GWP (000 kg CO_2 –eq) in 1year	$4.3^{a}\pm1.6$	$5.0^{a}\pm1.8$	$3.6^{a}\pm1.3$	$5.3^{b}\pm2.9$	$5.2^{a}\pm1.9$	$5.3^{a}\pm1.7$	$3.7^{a}\pm1.3$	$6.7^{b}\pm5.9$	$4.0^{a}\pm1.5$	$5.6^{b}\pm3.6$	0.24
• On farm cattle	$3.4^{a}\pm1.3$	$3.9^{a}\pm1.4$	$2.9^{a}\pm1.0$	$4.2^{b}\pm2.4$	$3.8^{a}\pm1.4$	$4.1^{a}\pm1.4$	$2.5^{a}\pm1.0$	$4.5^{b}\pm3.8$	$3.0^{a}\pm1.2$	$4.2^{b}\pm2.5$	0.7
• Forage	$0.4^{a}\pm0.2$	$0.5^{a}\pm0.2$	$0.2^{a}\pm0.1$	$0.3^{a}\pm0.2$	$0.6^{a}\pm0.2$	$0.5^{a}\pm0.2$	$0.6^{a}\pm0.2$	$1.1^{b}\pm0.9$	$0.4^{a}\pm0.2$	$0.6^{b}\pm0.5$	0.0
• Supplementary feed	$0.1^{a}\pm0.1$	$0.4^{b}\pm0.2$	$0.07^{a}\pm0.04$	$0.2^{b}\pm0.2$	$0.3^{a}\pm0.4$	$0.3^{a}\pm0.2$	$0.2^{a}\pm0.1$	$0.4^{a}\pm0.6$	$0.2^{a}\pm0.19$	$0.3^{b}\pm0.4$	0.01
• Rice straw	$0.3^{a}\pm0.1$	$0.3^{a}\pm0.2$	$0.4^{a}\pm0.2$	$0.5^{a}\pm0.4$	$0.6^{a}\pm0.3$	$0.4^{a}\pm0.2$	$0.3^{a}\pm0.1$	$0.5^{b}\pm0.5$	$0.6^{a}\pm0.2$	$0.4^{b}\pm0.4$	0.1
• Transportation of forage (off farm)	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	$0.1^{a}\pm0.0$	$0.2^{b}\pm0.2$	$0.04^{a}\pm0.06$	$0.06^{a}\pm0.1$	0.0
Without allocation GWP/FU (kg CO2 –	$35.9^{a}\pm16.2$	$35.9^{a}\pm18.7$	$35.9^{a}\pm24.9$	$43.6^{a}\pm23.4$	$44.8^{a}\pm15.1$	$38.6^{a}\pm14.7$	$40.6^{a}\pm17.6$	$50.9^{a}\pm24.9$	$38.7^{a}\pm18.1$	$42.3^{a}\pm21.6$	0.02
With allocation GWP/FU (CO_2 –eq per kg LW)**	$24.8^{a}\pm10.2$	$26.2^{a}\pm 12.1$	$24.7^{a}\pm10.4$	$28.0^{a}\pm13.2$	$29.1^{a}\pm8.9$	$26.5^{a}\pm7.9$	$29.5^{a}\pm11.8$	$34.3^{a}\pm11.2$	$26.9^{a}\pm10.8$	$28.9^{a}\pm11.4$	0.0

^{a,b} Different superscripts indicate significant differences between breeds within area and in all areas (P<0.05); ^{ns} Non-significant.
*P value of differences between areas; **Without or with allocation to different livelihood functions.

The 25th percentile of Ongole farms with the lowest emission intensities had a 46% lower GWP per kilogram live weight produced than the other farms (Table 4.5.). The result for crossbred farms was similar, with 45% lower GWP per kilogram live weight. The 25th percentile of both farm types owned fewer animals (1.6 versus 2.1 for Ongole farms, and 1.6 versus 2.3 for crossbred farms), but produced more kilograms of live weight (169 kg versus 100 kg for Ongole farms and 238 kg versus 120 kg for crossbred farms) (Table 4.5.). The amount of feed offered per animal (kg DM/head per day) was higher for the 25th percentile of farms compared to all the other farms for Ongole farms (10.0 versus 8.3 kg d^{-1}) and crossbred farms (12.0 versus 10.0 kg d^{-1}). Calving interval (days) was significantly shorter for the 25th percentile of farms than for the other farms for both Ongole farms (377 versus 469 days) and crossbred farms (404 versus 472 days). Body condition scores for the 25th percentile of farms were also higher than on the other farms for both Ongole (3.0 versus 2.4) and crossbred farms (3.1 versus 2.8).

Land use in Ongole and crossbred cattle production systems

Table 4.6. shows the land use per farm and per kilogram live weight for the cattle component of Ongole and crossbred farms in the four study areas. In all areas the land use (off-farm and on-farm land use) for the cattle component of Ongole cattle farms tended to be lower than for crossbred cattle farms. In the Wet lowlands II and Dry uplands, this difference was significant ($P<0.05$). Overall this parameter was also significantly lower ($P<0.05$) for Ongole farms, 5339 m^2 compared to 7467 m^2 for crossbred farms. Table 4.5. shows that nearly all of this land use (96%) was for fresh forage production. The land use for producing supplementary feeds (0.1 m^2 for Ongole farms and 0.2 m^2 for crossbred farms) was significantly higher for crossbred farms than for Ongole farms. The amount of land

Table 4.5. Comparison of cattle management characteristics between the 25th percentile of farms with lowest GWP per kg live weight produced and all other farms for Ongole (a.) and crossbred farms (b.), January 2011-January 2012

a. Ongole farms

No.	Variable	25th percentile (n=22)	others (n=68)
1.	GWP (kg CO_2-eq per kg live weight produced)	$14.3^a±2.0$	$31.0^b±9.2$
2.	Dry matter (DM) per cow (kg /head /day)	$10.0^a±0.4$	$8.3^b±0.7$
3.	Body weight produced (kg)	$169.1^a±47.5$	$99.5^b±18.6$
4.	Calving interval (days)	$377.3^a±4.2$	$469.1^b±45.8$
5	Body Condition Score	$3.0^a±0.0$	$2.4^b±0.4$

[a,b] Different superscript indicates a significant difference between the 25th percentile and the other farms.

b. Crossbred farms

No.	Variable	25th percentile (n=40)	others (n=122)
1.	GWP (kg CO_2-eq per kg live weight produced)	$14.9^a±2.9$	$33.4^b±9.2$
2.	Dry matter (DM) per cow (kg /head per day)	$12.0^a±0.9$	$10.0^b±0.7$
3.	Body weight produced (kg)	$237.8^a±85.6$	$119.5^b±26.7$
4.	Calving interval (days)	$404.1^a±45.7$	$471.6^b±52.6$
5	Body Condition Score	$3.1^a±0.5$	$2.8^b±0.4$

[a,b] Different superscript indicates a significant difference between the 25th percentile and the other farms.

Table 4.6. Land use (LU) of Ongole and crossbred cattle production systems in the four study areas in Central Java, January 2011-January 2012

	Area/Breed								Average		*P value
	Wet lowlands I (n=56)		Wet lowlands II (n=63)		Wet uplands (n=59)		Dry uplands (n=74)				
	Ongole (n=17)	Crossbred (n=39)	Ongole (n=31)	Crossbred (n=39)	Ongole (n=12)	Crossbred (n=47)	Ongole (n=30)	Crossbred (n=44)	Ongole (n=90)	Crossbred (n=162)	
	Mean±s.d	Mean±s.d	Mean±s.d	Mean±s.d	Mean±s.d	Mean±s.d	Mean±s.d	Mean±s.d	Mean±s.d	Mean±s.d	
Total LU (000 m^2)	7.8^a±2.8	8.1^a ± 2.9	3.8^a±1.6	5.4^b±2.8	9.2^a ±3.1	8.7^a±3.0	4.3^a±1.4	7.1^b±5.8	5.3^a±2.7	7.5^b±4.0	0.0
•Forage	7.2^a±2.8	7.8^a ± 2.7	3.7^a±1.5	5.2^b±2.8	9.0^a±3.0	8.5^a±2.9	4.0^a±1.3	6.7^b±5.4	5.1^a ±2.8	7.2^b±3.8	0.0
•Supplementary feed	0.05^a±0.04	0.17^b±0.23	0.02^a±0.01	0.07^b±0.06	0.1^a±0.08	0.1^a±0.07	0.2^a ±0.1	0.3^a±0.3	0.1^a±0.1	0.2^b±0.2	0.0
•Rice straw	0.07^a±0.03	0.07^a±0.04	0.09^a±0.05	0.13^a±0.09	0.14^a±0.08	0.10^a±0 .06	0.06^a±0.02	0.13^a±0.13	0.09^a±0.05	0.11^b±0.09	0.0
Without allocation LU/FU (m^2/kg LW)**	57.4^a±23.7	55.7^a±26.9	37.5^a±23.5	43.3^a±23.4	78.0^a±29.2	61.7^a4.1	46.0^a±19.5	53.6^a±28.0	49.5^a±26.3	54.4^a±26.3	0.0
With allocation LU/FU (m^2/kg LW)**	39.6^a±14.6	40.7^a±17.0	25.7^a±12.2	27.9^a±11.8	50.6^a±18.1	42.3^a±13.1	33.4^a±12.9	36.1^a±12.3	34.2^a±15.8	37.4^a±14.6	0.0

^{a,b} Different superscripts indicate significant differences between breeds within area and in all areas (P<0.05).

*P value of differences between areas.

**Without or with allocation to different livelihood functions.

required to produce one kilogram of live weight was slightly higher for crossbred cattle (37.4 m^2) than for Ongole cattle (34.2 m^2) (Table 4.6.). Amongst areas, the Wet lowlands I and Wet uplands showed higher ($P<0.05$) total land use and land use per kilogram live weight produced than the other two areas, both without and with economic allocation to the different livelihoods functions. More home-produced forage is used in these areas.

4.4. Discussion

Methodology: multi-functionality

In this study, the cattle were components of mixed farming systems and served multiple functions that were linked to each other. Including the various functions of cattle in our LCA calculations resulted in approximately 30% lower emissions per unit of live weight produced compared to the calculations in which multiple functions were not considered. The estimate for the insurance function of cattle was relatively small (approximately 20%) relative to the total value of cattle. This is in contrast with the finding of Widi *et al.* (2015) that farmers regarded 'saving' as the most important motive for keeping cattle When farmers need cash for big expenses, they sell one of their cattle. It seems likely that our method of valuing the insurance function of cattle still underestimates the true value of this function of keeping cattle in Indonesia. The function of security will remain important in the future, as farmers regard cattle as an attractive way to accumulate capital (Widi *et al.*, 2015).

Farmers considered manure as the third most important motive for keeping cattle (Widi *et al.*, 2015). Our estimation of the economic value of manure (1.1% of the total economic value of cattle keeping) seems to underestimate its real value. This estimate was based only on the synthetic fertiliser N-equivalent and therefore excludes the P and K values of manure, and the positive effects of manure on soil organic matter and water-holding capacity (Hiernaux and Diawara, 2014). Manure production will be valued higher in the future because farmers appreciate its effect on soil fertility and structure and because of the rising cost of fertilisers.

The effect of crossbreeding on GWP and land use

Global studies have estimated that emission intensities for beef are highest in developing regions, e.g. South Asia, Sub-Saharan Africa, Latin America and the Caribbean, and East and Southeast Asia (Gerber *et al.*, 2013). Gerber *et al.* (2013) mention that the high emissions in these regions are largely caused by low feed digestibility (leading to higher enteric and manure emissions), poorer animal husbandry and lower slaughter weights (slow growth rates leading to more emissions per kilogram of meat produced), and higher age at slaughter (longer life leading to more emissions).

It is difficult to compare our results with other studies in the literature because the FU differs. Our results are expressed as GWP per kilogram of live weight produced because the weaners were sold to other farmers as breeding stock or to feedlot companies for fattening.

Other studies in the literature use a different FU, especially kilogram of carcass weight. Our estimates of 27 to 29 kg CO_2-equivalents per kilogram of live weight are slightly higher compared with the estimate of 46 kg CO_2-equivalents per kilogram carcass weight (equivalent to 23 kg CO_2-eq per kilogram live weight at slaughter) in South Asia of Gerber *et al.* (2013). Suckler beef systems in Ireland, United Kingdom (UK) and Canada have much lower emissions, ranging from 5.6 to 11.2 kg CO_2-equivalents per kilogram of live weight produced (de Vries and de Boer, 2010).

The global call for the intensification of livestock production to improve productivity in order to reduce GHG emission intensities (Steinfeld *et al.*, 2006; Herrero *et al.*, 2010; Gerber *et al.*, 2013) is not supported by the results of our field research on the environmental impact of crossbreeding in mixed farming systems of Central Java. The postulated paradigm that breeding strategies, such as crossbreeding, can reduce the carbon footprint of cattle production (Scholtz *et al.*, 2012) is not straightforward in complex mixed farming systems. In our case, intensification through crossbreeding resulted in increased production: 25% higher body weights for adult crossbred cows and about 20% higher body weights for weaners compared to local Ongole cattle (Widi *et al.*, 2015). However there were no differences in GWP per kilogram live weight produced between local Ongole and crossbred cattle production systems. Crossbreds required more feed; they were fed more forages, which were collected from the farm and communal sources or bought, and more supplementary feeds, such as rice bran, pollard, compound concentrates, tofu (soybean curd) waste, and soybean hulls (Table 4.2.). The advantage from the faster growth of crossbreds in terms of reduced GWP per kilogram liveweight produced is counteracted by the higher emissions from feed production for crossbreds. Thus the expectation that local breeds in local production systems would have higher emissions per unit product than "improved" breeds, in this case crossbred of Ongole and Simmental cattle, was not substantiated.

Crossbreeding did not result in lower land use. The Ongole and crossbred beef cattle farms in the study areas had the same land use, approximately 36 m^2 per kilogram of live weight produced. Forages contributed the most to total land use. The use of supplementary feeds was low. Crop by-products, such as rice bran and maize cobs, have a low financial value. Therefore only a small fraction of land use for crops is allocated to crop by-products for beef production.

Crossbreeding is not done in a systematic way. The majority of crossbred farmers keep F_1 stock, however, this is gradually changing towards F_2 stock. Farmers do not prefer to upgrade to higher levels of Simmental (Widi *et al.*, 2015). The current crossbreeding practices have not improved the environmental performance of cattle production in Central Java. However, our estimates do not include the impact of crossbreeding on the final fattening stage. This fattening is often done by butchers, large scale farmers (>50 heads) or feedlots (>1,000 heads). Their feeding practices are comparable to those of the smallholders in the present study. The only component in the crossbreeding strategy is the use of exotic semen. Farmers do not receive any assistance in feeding and breeding management. Thus, crossbreeding has not changed the farming systems in the study areas; herd sizes and management practices did not differ between farms with crossbred or Ongole breeding stock. Crossbreeding has also not affected the motives for keeping cattle, which were similar between Ongole and crossbred cattle farms (Widi *et al.*, 2015).

Increasing animal productivity requires both better quality and greater quantities of feed (Steinfeld *et al.*, 2006; Gerber *et al.*, 2013). Growing more feed crops might conflict with other land uses, given the limited availability of land in Java. A current regulation stipulates that farmers are not allowed to plant non-food crops on productive lands (Setneg RI, 1999). Farmers do not have sufficient cash to buy more forages and supplements. These constraints suggest that there is little scope to increase the quality and quantity of feed. Nevertheless, there is large heterogeneity among farmers; the coefficients of variation for the overall emission intensities and land use are approximately 40 to 45%. The driving force behind the differences between farmers is the difference in kilograms of live weight produced. The 25thpercentiles of Ongole and crossbred farms with the lowest GWP per kilogram live weight produced fed their animals more in terms of DM compared to other farms. They also had lower calving intervals and higher body condition scores for their cows, indicating that they managed their animals in a more efficient way (Table 4.4.).

Conservation of genetic resources and the relation with emissions and land use

In Indonesia, the policy of crossbreeding and the increasing demand for meat are putting considerable pressure on local farm animal genetic resources. Policies that promote crossbreeding run concurrently with more recent policies promoting breeding programmes for local cattle (Widi *et al.*, 2015). This paradox is also found in the international literature. There is a large global literature on livestock biodiversity and the need for conserving local farm animal genetic resources (Hall, 2004; FAO, 2007; FAO, 2010a). On the other hand, the global literature considers local ruminant breeds as less efficient in their potential for mitigating GHG emissions than improved breeds. Local ruminant breeds are expected to have higher emission intensities than improved breeds as they are usually fed roughages and crop residues only, and have low outputs (Steinfeld *et al.*, 2006; FAO, 2010b). Hoffmannn (2010) expressed concern that the pressure to reduce GHG emissions from ruminants may disadvantage local breeds. In two of the study areas, Wet lowlands II and Dry uplands, the local government has started a ‘Return to Ongole’ breeding programme. Our results indicate that the promotion of local breeds does not necessarily conflict with efforts to reduce the intensity of GHG emissions from cattle keeping in mixed farms in Java.

4.5. Conclusions

Crossbreeding (as a tool for intensification) was not more efficient in mitigating GHG emissions and reducing land use per kilogram of live weight produced than local breeds in the current smallholder farming systems in Central Java. The biggest contribution to GWP was from enteric fermentation, which is closely related to the low quality of feeds available. The advantage from the faster growth of crossbreds in terms of GWP and land use per kilogram live weight produced was counteracted by the higher emissions and land use from feed production for crossbreds.

Crossbreeding has not changed current cattle keeping practices. Only exotic semen is provided; sustainable crossbreeding will require assistance in terms of feeding and breeding management. This could improve environmental performance, as the farms with lower emission intensities had, on average, lower calving intervals and higher body condition scores.

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Chapter 5

Designing genetic impact methodology based on crossbreeding with exotic beef breeds in mixed farming systems in Indonesia

A focus group discussion among farmers, key persons and scientists

T.S.M.Widi[1,3], H.M.J. Udo[1], K. Oldenbroek[2], I.G.S. Budisatria[3], E. Baliarti[3], A.J. van der Zijpp[1]
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[1]Animal Production Systems Group, Department of Animal Sciences, Wageningen University, the Netherlands
[2]Centre for Genetic Resources, PO Box 16, 6700 AA Wageningen, the Netherlands
[3]Department of Animal Production, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia

ABSTRACT

A genetic impact assessment is developed based on identification of issues and indicators for two case studies on crossbreeding with exotic beef breeds in mixed farming systems in Indonesia. The Indonesian government is stimulating the country's beef production by crossbreeding with exotics. In Madura the locally adapted Madura cattle are crossed with Limousin sires, and in Java the locally adapted Ongole cattle are crossed with Simmental sires. The Madura case study explores the impact of crossbreeding on the cultural values of cattle and their productivity. The Central Java case study explores the impact of crossbreeding on beef production, the mixed farming systems and the environment for different agro-ecological zones. During focus group discussions, farmers and other stakeholders mentioned relevant crossbreeding issues. Farmers identified economic benefits, feed availability, cattle management, animal performance, additional functions of cattle, and health and fertility as issues. Other stakeholders mentioned meat production, environmental quality and diversity in farm animal genetic resources as important issues. Indicators were chosen for these issues at farm level. The indicators were tested with data from the two case studies. The Madura case shows that crossbreeding for meat yield may not be competitive with income from cultural values of cattle. The case study on the crossbreeding of Ongole and Simmental in Java shows, meat production has increased with crossbreeding, but labour productivity was negatively affected and environmental performance not improved. Therefore crossbreeding may not always be an automatic choice to improve cattle production.

Keywords: Genetic impact, Crossbreeding, Mixed farming systems, Java, Madura

5.1. Introduction

Indonesia is an emerging economy with an increasing demand for beef. To meet this demand, the Indonesian government has adopted a strategy of importing exotic breeds since 1980. The locally adapted native breeds, (for this FAO definition see Martyniuk *et al*., 2010), which are usually the *Bos indicus* or *Bos sondaicus* type, are crossed with exotic *Bos taurus* cattle, such as Simmental and Limousin. In the last decade, this has become the dominant breeding strategy on smallholder farms in densely populated areas (Sudardjat and Pambudy, 2003; Sutresniwati, 2006). Many different types of cattle currently exist in Indonesia as a result of the crossbreeding policy and the locally adapted native breeds are declining in numbers.

Worldwide, the introduction of exotic livestock is an important element in the intensification of farming systems. Intensification is expected to contribute to the required increased production of animal source foods, to improve the livelihoods of rural households and to reduce the environmental impacts of the production of animal source foods (Steinfeld *et al*., 2006; Gerber *et al*., 2013). The introduction of exotic stock is often done unsystematically and this threatens the existence of locally adapted native breeds (Mathias and Mundy, 2005). In addition, exotic genes are often introduced without prior consideration of the consequences for the farming systems concerned (Wollny, 2003; Marshall, 2014).

According to the CBD (Convention on Biological Diversity) regulations, the national government is responsible for its farm animal genetic resources. This genetic diversity comprises locally adapted native breeds that were developed in the past in a certain (isolated) area and are, by natural selection, adapted to a specific local environment (feed availability, climate, disease threats). These adaptations to different circumstances have led to a wide variety of breeds worldwide. Selection by farmers for specific breeding goals related to their specific production systems has enhanced the farm animal genetic diversity, i.e. breeds and subpopulations of breeds.

Threats to the loss of local farm animal genetic diversity from breeding strategies should be assessed and eliminated before the strategies are implemented. Breeding strategies, such as crossbreeding and importation of exotic breeds, are traditionally evaluated at the level of the individual animal (Syrstad, 1996); only the impact of the strategy on the characteristics of the animals is assessed. New breeding strategies, which involve exotic breeds, should be evaluated, however, at different levels in the food production chain and across a range of technical, socio-economic and environmental issues (Hall and Bradley, 1995; Gandini and Oldenbroek, 2007; Samdup *et al*., 2010; Marshall, 2014). Hall and Bradley (1995) state that, in analogy with the 'environmental impact statement' for infrastructural projects, livestock development proposals should be evaluated beforehand with a 'genetic impact assessment' (GIA).

No exact definitions nor methodologies have been proposed for a GIA. In this study, a GIA is defined as an assessment that establishes the effect of a change in the genetic make-up of a population on its performance in the actual socio-economic and ecological context. A GIA can help to ensure that initiatives for livestock development include the conservation and sustainable use of biodiversity. GIA provides opportunities to ensure that other values (such as cultural values) are also recognised and to ensure that only livestock development initiatives are introduced, which are socio-economically and ecologically appropriate in the given context. The objective of a GIA is to make farmers, policy makers and other stakeholders aware of the consequences of introducing exotic breeds in local production systems, and to identify the changes that are required to ensure a successful introduction. Such changes may include: availability of concentrates to improve the quality of diets, management of fertility and disease, and performance recording. In an ideal situation, breeding policies are established based on the outcomes of a GIA and comprise the relevant aspects and opportunities of the breed(s), farming systems and livelihoods.

This study aims to develop a GIA that identifies and assesses the consequences for the different stakeholders, especially farmers, of crossbreeding with exotic beef breeds in mixed farming systems in Indonesia. The GIA is developed for two specific situations. Firstly, a comparison of the Madura cattle breeding systems versus the exotic crossbreeding system in Madura. Secondly, a comparison of the Ongole breed (in Indonesia called *Peranakan Ongole)* with the exotic crossbreeding system in Java.

5.2. Conceptual framework

Impact assessments

Comprehensive impact assessments of livestock innovations, including introductions of new breeding strategies, require indicators at several levels varying from the global level (e.g. climate change impact) to farm level (e.g. contributions to livelihoods) (Oosting, 2002; Udo *et al*., 2011; Marshall, 2014). Sustainability analysis, sustainable livelihoods approaches, and life cycle assessment (LCA) are examples of methods or approaches for conducting comprehensive assessments of innovations at different aggregation levels (Chambers and Conway, 1992; Ellis, 2000; de Boer, 2003; Mollenhorst, 2005). These approaches include the agro-ecological impact at regional level and the socio-economic impact at household level. Studies using these approaches have inspired the current study and the development of a GIA and its implementation in the context of the introduction of exotic genes in smallholder cattle systems in Indonesia. Common steps in the approaches mentioned above are: identification of stakeholders and issues using a participatory approach, literature review and expert consultation, selection of indicators and integrative assessment (Bell and Morse, 2003; Mollenhorst, 2005). The issues and indicators are placed in the different aggregation levels with which they are associated (Oosting, 2002; Cornelissen, 2003). In this study we focus on the farm level. Our approach to developing a GIA is shown in Figure 5.1.

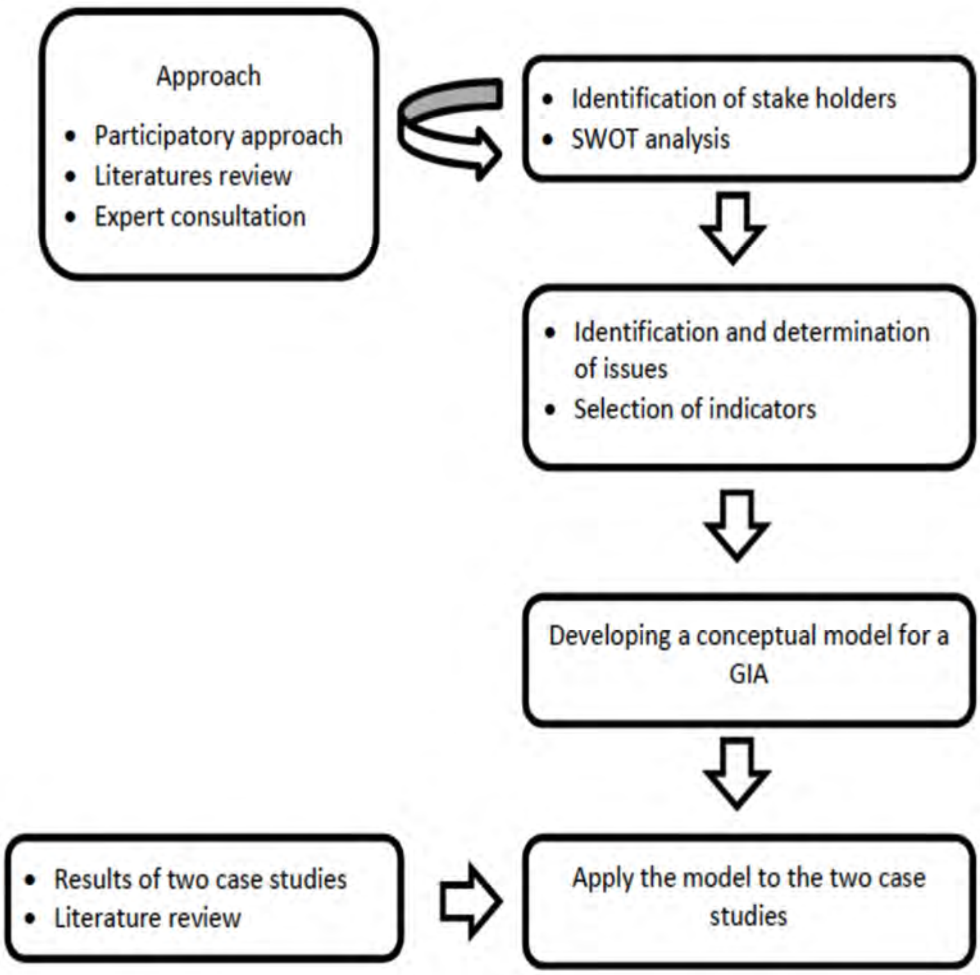


Figure 5.1. Process of developing a GIA model, based on two case studies

Identification of stakeholders

Stakeholders are individuals or groups who participate in the value chain of cattle to realise their own goals and on whom the production system depends. Different stakeholders may have different goals and different perceptions about the relative importance of the various components of the system (Eilers *et al.*, 2001). Oldenbroek (2007) concludes that many stakeholders are involved in the introduction of exotic genes and the conservation and use of animal genetic resources: national governments, institutes for research and education (including universities), non-governmental organisations, breeders' associations, farmers and pastoralists, part-time farmers and hobbyists, and breeding companies. In Indonesia, traders and butchers also play an important role in the value chain of cattle, but do not have much influence on Indonesian agricultural policy, which is dominated by governmental authorities.

Sutresniwati (2006) divides the stakeholders of crossbreeding in Indonesia into primary (farmers and government) and secondary (scientists, inseminators, vets, cattle traders, butchers and food sellers) stakeholders. Ultimately, livestock keepers are the key actors in managing the different types and breeds of animals. Therefore the farm and household level is the level where most changes caused by breeding policies will occur, such as changes in feeding, reproduction, growth, livelihood, income, environmental effects and food safety (Marshall, 2014). For this reason and because our data were sampled and analysed at farm level, we emphasise the impacts of crossbreeding at farm level and the implications of these impacts for policy makers.

Identification and determination of issues

Participatory methods involving a heterogeneous group of stakeholders maximise the chance of obtaining a complete list of relevant issues (Mollenhorst, 2005). Participatory methods facilitate the exchange of ideas, experiences and knowledge of relevant stakeholders and create a basis for implementation of the final results (Chambers *et al*., 1989; Mollenhorst, 2005). A SWOT (strengths and weaknesses, opportunities and threats) analysis is often used for the identification of issues (Mollenhorst, 2005) and this method is also used in this study.

Selection of indicators

For each selected issue, indicators have to be defined and selected. Relevance (appropriate for the context and objectives), realism (data are available and easy to measure) and end user value (easy for the users to interpret) are often mentioned as the selection criteria for indicators (Hiemstra *et al.*, 2006; Lebacq *et al*., 2013). Data will not always be available for a GIA, in particular when comparable data do not exist or when the environment in which the exotic breed is raised differs significantly from the environment of the local breed. If data are unavailable, qualitative estimations can be used for indicators.

Integrative assessment and GIA overview

Once the stakeholders and issues have been identified and selected, the indicator scores need to be determined. Following this step, a GIA overview can be developed. Assessment of the impacts can be done by appraising the positive and negative impacts for the qualitative indicators and by normalising the quantitative indicators and comparing the different indicator types. A useful device for visualising and communicating outputs is an amoeba (often called a spider web) diagram. Each arm represents an indicator and this enables the comparison of indicators (ISPC, 2014). The results are inevitably context specific with regard to time and location. For this study, the results are specific to the current situation in Indonesia. The final model depends on the relevance and importance of the issues, the quantitative and qualitative indicators and the accessibility of data. Application of the GIA model to different cases can provide information about the generic applicability of the model.

5.3. Background of the case studies

To develop the GIA model, two case studies of crossbreeding practices were used, the first in Madura (Widi *et al*., 2014) and the second in Central Java (Widi *et al*., 2015). The Madura case study explores the impact of crossbreeding on the cultural values of livestock (cattle) and productivity (Widi *et al.*, 2014). The Central Java example explores the impact of crossbreeding on beef production, the mixed farming systems and the environment for different agro-ecological zones (Widi *et al*., 2015 and Widi *et al*., submitted). Table 5.1. describes the main characteristics of the two case studies.

Table 5.1. Characteristics of crossbreeding for the two selected case studies in Madura and Java

Characteristic	Case study	
	Madura[a]	Java[b]
Local breed	Madura cattle	Ongole cattle
Exotic breed	Limousin	Simmental and Limousin
Start of crossbreeding	2000's	1980's
Driving force of crossbreeding	Government's objective to increase beef production	Government's objective to increase beef production
Motivation for keeping cattle	Multiple: culture, beef production, financing, savings/insurance, social status, providing manure	Multiple: beef production, financing, savings/insurance, social status, providing manure
Main breeding goal	Cultural events and beef production	Beef production

[a] Widi *et al*., 2014
[b] Widi *et al.,* 2015

The Madura cattle breed is one of the local cattle breeds in Indonesia, which is mainly confined to the island of Madura. This is a small, densely populated island located off the northeast coast of Java. There are two social-cultural activities that involve Madura cattle, *sonok* (cow conformation contest) and *karapan* (bull racing). These two activities are restricted to two specific areas in Madura. The activities are identity markers of the Madurese throughout Indonesia (Widi and Hartatik, 2009). Madura cattle play a unique role in cultural events, which are a source of income for farmers and attract many spectators, from both Java and Madura and tourists from abroad. Thus in two specific areas in Madura, the breeding goal is focused on the traits related to the animal's performance in cultural events, in combination with beef production traits.

In Madura, crossbreeding only began in 2001, using Limousin sires. In areas outside the areas with traditional cultural events, the crossbreeding with Limousin results in *madrasin* cattle. A cow conformation contest with *madrasin cattle* was recently initiated by the local government.

In Java, the breeding goal is largely determined by beef production traits. Ongole has become the prominent cattle breed in Java in the course of the 20th century (Maule, 1990). Crossbreeding in Java started in the 1980's with Simmental and Limousin sires (Widi *et al*., 2015). Simmental is the most preferred breed, as farmers perceive them to have a nice appearance. Due to the change in breeding policy in recent decades, crossbreds currently form a major part of the cattle population in Central Java. In this case study, Ongole cattle are compared to Simmental crossbred cattle in four agro-ecological zones, namely Wet lowlands I and II (the difference between I and II is the attention given to Ongole breeding in II), Wet uplands, and Dry uplands (Widi *et al*., 2015).

5.4. Materials and methods

The Madura case study and the Central Java case study were used to identify issues and to determine indicators. These studies focused at the farm level and were based on in-depth investigation of groups of farmers, their cattle and cultural events.

Stakeholders and the strengths and weaknesses of crossbreeding

We identified the different stakeholders from a literature review and from prior discussions with experts who are involved in crossbreeding. We categorised the stakeholders as primary or secondary stakeholder groups. The key primary stakeholders are smallholder farmers. Large-scale commercial farmers, feedlot companies, and farmers' groups were also asked for their opinions about crossbreeding. In the Madura case study, farmers were divided into conventional farmers and cultural (*karapan* and *sonok*) farmers. The cultural farmer groups play an important role in maintaining cultural events with Madura cattle, and in determining the direction of breeding goals.

Other primary stakeholders in crossbreeding are policy makers. The policy makers consulted in this study were representatives from central government and their supporting team of scientists and experts from universities.

Secondary stakeholders are representatives of local government and services, such as AI companies, inseminators, veterinarians and extension workers. Traders (including middle men), butchers and meat retailers are also secondary stakeholders.

Seven focus group discussions (FGDs) amongst farmers and key persons, such as the heads of farmers' groups and village elders, were held in the period from July to December 2009. In total, 296 participants (60 in wet lowlands I, 86 in wet lowlands II, 65 in wet uplands and 85 in dry uplands) in Central Java, and 125 participants (40 in *karapan*, 45 in *sonok* and 40 in *madrasin* areas) in Madura were involved in the FGDs. A SWOT analysis was done during each FGD. Each FGD took between three and five hours. Most of the stakeholders, particularly farmers, found it difficult to distinguish between strength and opportunity and between weakness and threat. We therefore chose not to distinguish between internal and external factors and the SWOT analysis is in effect a SW analysis. The FGDs were rather informal; they were led by the first author of this paper, assisted by undergraduate students.

Two workshops with other stakeholders were held in July 2009 and March 2010. The aim of the first workshop (July 2009) was to identify the critical issues and the indicators, by brainstorming and using SW analysis. In total, 145 participants were involved in this workshop. The second workshop (March 2010), with a similar purpose as the first workshop, involved 32 inseminators and reproduction service staff from AI companies and 7 scientists. During the two workshops, scientists gave presentations on crossbreeding issues; the presentations covered problems with crossbreeding and provided evidence of the advantages and disadvantages. The animal scientists were also actively involved in the discussions with farmers in such a way that their critical overview helped to clearly formulate the farmers' issues.

Identification of issues, selection of indicators, and indicator scores

Relevant issues were selected on the basis of the participatory SW analysis, literature review and expert consultation. The main issues from the case studies were chosen based on the frequencies of the issues raised in the SW-analysis. For each selected issue, we defined potential indicators, which fulfilled the required criteria such as relevance, realism, and end user values. The indicators were defined and selected based on the differences found between the locally adapted native breeds and crossbred cattle in the two case studies. Qualitative or quantitative indicators were selected.

When crossbreeding gave a positive impact compared to the locally adapted native breeds, it was judged as positive. Neutral was given in the situation when crossbreeding gave a similar result or no change compared to the locally adapted native breeds. Negative was given when the result of crossbreeding was lower (gives a decrease) compared to the locally adapted native breeds. For quantitative indicators, the assessments of positive, neutral and negative were given based on statistically significant differences between the results of crossbreds and local breeds.

Amoeba diagrams were used to visualise the GIA at farm level. For each selected quantitative indicator, we defined minimum (B_{min}) and maximum (B_{max}) benchmarks, enabling us to rescale indicator values into scores between 0, indicating a worst-case situation, and 100, indicating an optimal situation. This rescaling enables the comparison of indicators for different aspects of sustainability (Meul *et al.*, 2008). To normalise the score for each indicator, the performance was converted into a scale from 0 through 100, using formulas (1) and (2).

$$\text{Score} = 100\,(y - B_{min})/(B_{max} - B_{min}) \quad (1)$$

$$\text{Score} = -100\,(y + B_{max})\,/\,(B_{max} - B_{min}) \quad (2)$$

where y is the observed value, B_{max} is the 90th percentile observation and B_{min} is the 10th percentile observation. Formula (1) was applied when the desirable situation is the maximum value, e.g. growth rate, phenotypic and reproductive performances and feed consumption. Otherwise, formula (2) was applied, e.g. for environmental impact indicators.

The tenth percentile of best performing farms within our data were given a score of 100, whereas the tenth percentile of worst performing farms were given a value of 0.

Intermediate values were converted into linear scores using the formulas above (Dolman *et al*., 2012).

5.5. Results and discussion

The GIA model at farm level

Stakeholders and issues derived from the SW analysis

Table 5.2. gives the stakeholder and SW analysis for Madura and Central Java. Between the two case studies, there are similarities in the impacts on farming systems, economic benefits, multiple functions of cattle and some performance traits of the cattle. The difference between the two case studies is in the breeding goals of the cattle breeds or

Table 5.2. SW analysis of the impact of crossbred cattle in Madura[1] and Central Java[2]

Stakeholders	Strengths	Weaknesses
Primary stakeholders		
Farmers[1,2]	Non-selective feeders[2] Higher body weight gain[1,2] No change in management[1,2] Crossbreds are more attractive in colour and shape[2] Higher market prices[1,2] Higher income[1,2] Increased security[2] More manure[1] Higher status[1]	More capital needed[1,2] Higher feed requirements[1,2] Poor reproductive performance[2] Complex and long bureaucratic procedures to access credit[2]
Cultural (*karapan* and *sonok*) farmer[1], cultural group[1]		Crossbred cattle cannot be used for cultural events
Policy makers[1,2]	Higher meat yields Presence of breeding and research institutions Crossbred cattle may enrich the genetic diversity Utilisation of crop and industrial by-products	Herds are small Local cattle will decrease in numbers
Secondary stakeholders		
Local government	Crossbred cattle can be used for different type of cultural event[1]	Crossbreds less resistant to parasites[2] Long market chain[2] Lack of feeds[1]
Inseminators/ veterinarian/extension worker[1,2]	Easy to handle No change in management	Crossbreds less resistant to parasites[2] More susceptible to reproductive problems[2]
Butchers[1,2]	More profit, economies of scale for large-scale butchers[2]	Meat contains more moisture[2] Small-scale butchers prefer local cattle; they sell meat in smaller portions[1,2]
Traders[1,2]	High market price and demand for crossbred cattle	

sub-populations of breeds. In Java, cattle are kept mainly for meat production and growth determines the breeding goal. In Madura, cultural aspects strongly affect the decision of farmers to keep local cattle with specific characteristics, which fulfil the performance requirements in the areas with traditional cultural events. Because the *sonok* and *madrasin* cultural events require well developed animals, this does not conflict with the second breeding goal, beef production. Farmers in both case study areas, with the exception of *sonok* farmers*,* consider the high growth rate of crossbred cattle as their major strength. As a consequence of the higher growth rate, higher market prices for crossbred progeny are expected. Farmers mentioned that when they want to purchase and keep crossbreds, they need more capital and the crossbred's requirements for feed are higher. Farmers consider the opportunities to access cash and to obtain the required credit to purchase and keep crossbred cattle to be limited. For example, after selling an animal to a butcher or trader, it may take a long time before the money is transferred to the farmer. Cultural farmers in Madura do not like crossbreds, as crossbreds cannot be used for traditional cultural events. In Central Java, farmers like the non-selective feeding habits of crossbreds; crossbreds consume whatever is available, irrespective of the quality of the feed. Farmers are worried about the reproductive performance of crossbreds, in particular crossbreds with a high percentage of exotic genes. This concern was confirmed by the veterinarians.

Policy makers perceived 'high meat yield' as the greatest strength of crossbreds. This was also the most important reason for their promotion of crossbreeding. Policy makers appeared to neglect the higher feed requirements, reproductive failure and higher land use of crossbreds. Traders and butchers were also in favour of crossbreds, except the small-scale butchers and *bakso* sellers. The latter prefer to slaughter local cattle, as they sell meat in small portions (Widi *et al*., 2014). Scientists mentioned preservation of local breeds, cultural events and environmental impacts as areas of concern in the case of uncontrolled crossbreeding or upgrading with exotic breeds*.*

Limitations of the SW analysis

SW-analysis was a useful tool in our case studies and facilitated the next step of exploring issues at farm level. In these discussions, it was very difficult for the stakeholders to distinguish between strengths and opportunities and between weaknesses and threats. Opportunities were also considered as strengths and threats as weaknesses. This proved not to be a problem for the identification of issues in this study. However, when the ultimate goal of the SWOT analysis would have been the establishment of action plans for individual stakeholders, this approach would have been less appropriate.

Issues

The following issues were identified in the SW analysis and considered to be relevant at farm level: economic benefits, feed availability, cattle management, performance of the animals, additional functions of cattle including the cultural value, health, fertility and environmental effects. The issues are included in Figure 5.2. and may impact on more than one level. Economic benefits, feed availability, health and fertility are not only important issues at farm level, but also at regional level. Feed availability is one of the most important issues at farm level due to the higher feed requirements and resulting high feed cost of crossbred cattle. This issue is also important at the regional level, because land availability is limited in both Madura and Java. Health, fertility and diseases are issues at farm level and regional level. Animal welfare is an issue at global, regional and farm level. It was not mentioned during the FGDs.

Non-production functions of cattle, such as financing, insurance/saving, social status and providing manure, are important issues at the farm/household level. The financing and insurance functions can also be an issue at the regional level, because they depend on the accessibility of financial services such as banks and credit providers. The cultural value of

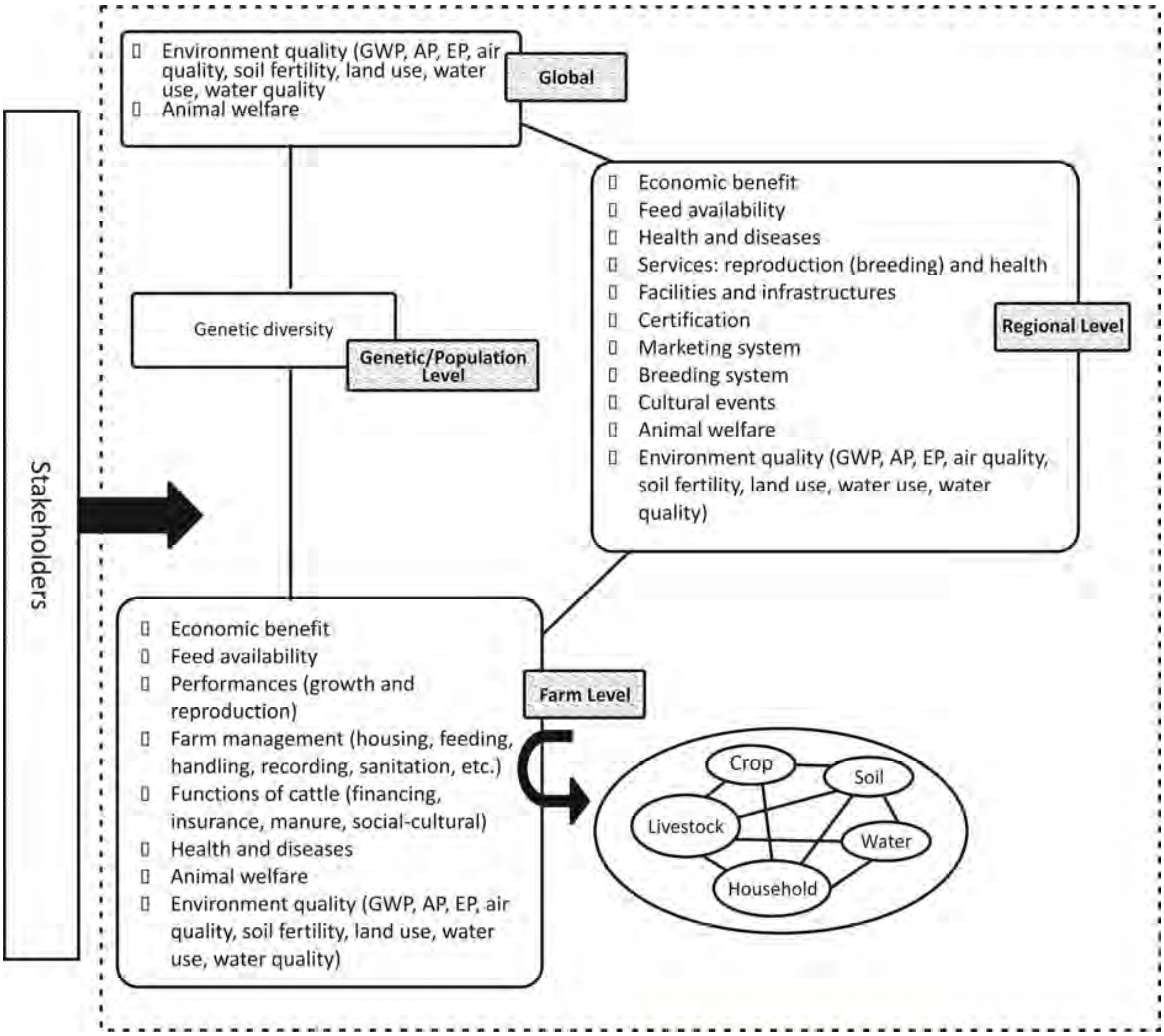


Figure 5.2. Conceptual framework for the GIA

local cattle can be an issue at regional level, as is the case in Madura, where traditional events attract tourists from abroad and create economic benefits for non-farmers.

Indicators

The quantification of indicators for the different issues in the Madura and Central Java case studies was based on Widi *et al*. (2014) and Widi *et al*. (2015). For the Madura case study, we selected indicators for the following issues: economic benefit, cattle management, performance and additional functions of cattle. Economic benefit was represented by labour productivity, expressed as GM per family labour hour per day (IDR per h d^{-1}) (Moll, 2005; Moll *et al*., 2007). Performance was represented by an indicator for the live weight of cows, expressed in kilograms (kg), and an indicator for the appearance of cows, represented by the selling price of cows at 1.5 years of age, expressed in thousands of Indonesian Rupiah per cow (000 IDR). The additional functions of cattle were represented by a qualitative indicator which gave the relative importance (ranking) of the following functions: cultural, financing, insurance/saving, social status, draught power and providing manure.

We defined indicators for the following issues at farm level for the Central Java case: economic benefit, feed availability, cattle management, performance, additional functions of cattle, health and environmental quality. The economic benefit and cattle management issues were represented by the same indicators as in the Madura case study. Two quantitative indicators were used to measure feed availability, daily consumption of dry matter (DM) and crude protein (CP), both expressed as grams per kilogram of live body weight per day (g $BW^{-0.75}$ d^{-1}). The cattle management issue was represented by five indicators: farm size, feeding system, housing system, recording of breeding and reproduction. Farm size was measured as the number of cattle owned by the farmer. The feeding system was a qualitative indicator that represented the types of feed provided (foraging and supplementary feeds). Housing system and recording of breeding were both qualitative indicators. Reproduction was measured by the percentage of artificial insemination used in breeding (% AI). Five quantitative indicators were chosen for the performance issue: live weight of cows, weaners and young stock at 11 months of age, all expressed in kilograms (kg); calf crop, expressed as the percentage of weaned calves per cow per year (% per year); and meat yield, expressed as kilograms of meat per slaughtered animal (kg) (Toelihere, 2002; Charvalho *et al*., 2010). The qualitative indicator for the additional functions of cattle was the same as for the Central Java case study. The health issue was represented by an indicator for the prevalence of diseases or health problems, expressed as a percentage (%). Lastly, two indicators represented the environmental quality. Global warming potential (GWP) was expressed as kilograms of CO_2-equivalents per kilogram of body weight (kg CO_2-eq per kg body weight) and land use was expressed as square metres per kilogram of body weight (m^2 per kg BW) (de Vries and de Boer, 2010; de Boer *et al*., 2011).

Fewer indicators were selected for the Madura case study than for the Central Java case study due to the lack of available data and the different focus of the case study.

Impact assessment for the Central Java and Madura case studies

Quantitative and qualitative estimates of the impact of crossbreeding in Madura and Central Java are presented in Tables 5.3. and 5.4. Figure 5.3. presents quantitative indicators in amoeba diagrams.

The biggest difference between the two case studies is the cultural value of cattle. In Central Java, the cultural value of cattle is not a relevant issue. In Madura, the cultural value determines the breeding goal, as expressed in the size of the *sonok* cattle or the running speed of *karapan* bulls. In Table 5.3., we compare the impact between crossbreds (*madrasin*) and non-cultural Madura cattle and between *madrasin* and two types of cultural

Table 5.3. Comparison of non-cultural and cultural Madura cattle and *madrasin* cattle and the impact of crossbreeding in Madura

Indicator (unit)	Quantitative assessment Madura		
	Non-cultural	*Cultural: Karapan*	*Cultural: Sonok*
Economic benefit			
• GM (IDR per h d^{-1})	1,175 ± 659.8	4,590 ± 2,715	4,314 ± 2,603
Feed availability	N/A		
Cattle management			
• Farm size (cattle ownership) (head)	< 5	< 5	< 5
• Feeding system	Browsing in communal land	Browsing in communal land	Browsing in communal land
• Housing	Semi-permanent	Semi-permanent	Semi-permanent
• Recording	No	No	Yes, traditionally
• Reproduction	Mating: 50% Natural	Mating: 100 % Natural	Mating: 87% Natural
Performances			
• Cattle appearance with age of 1.5 y, expressed by selling price (000 IDR)	9.94 ± 5.6	29.88 ± 6.8	27.00 ± 4.8
• Liveweight of adult female (kg)	279.1 ± 89.0	294.3 ± 43.0	392.3 ± 60.4
Additional function of cattle			
• Financing (rank)	N/A	3	2
• Insurance (rank)	N/A	1	1
• Social status (rank)	N/A	5	3
• Cultural (rank)	N/A	6	5
• Manure (rank)	N/A	2	4
• Draught power (rank)	N/A	4	7
Quality of environment	N/A		

N/A because this was assessed within the *sonok, karapan and madrasin* areas. A farmer with cultural cattle also has non cultural cattle

† Impact of crossbreeding on non-cultural Madura cattle; ‡ Impact of crossbreeding on non-cultural Madura cattle

Madura cattle, the *sonok* and *karapan*.

In the Madura case study, crossbreeding had a positive impact on the live weight, compared to both non-cultural and *karapan* Madura cattle, but not compared to *sonok* cattle (Figure 5.3.). *Madrasin* had a positive impact for all three indicators in Figure 5.3. in comparison to non-cultural Madura cattle. The selling price of *madrasin* had a positive impact in comparison to non-cultural Madura cattle and a negative impact in comparison to *sonok* and *karapan* cattle. The price of cultural cattle is high due to the value Madurese place on their cultural traditions. The labour productivity between *madrasin* and non-cultural Madura cattle was not significantly different. The economic benefit between *madrasin* and non-cultural Madura cattle was not significantly different. Even though cultural Madura cattle farmers spent considerably more money in buying additional feeds and in preparing the animals for the contest/racing events, this was compensated by the

Table 5.3. (continued)

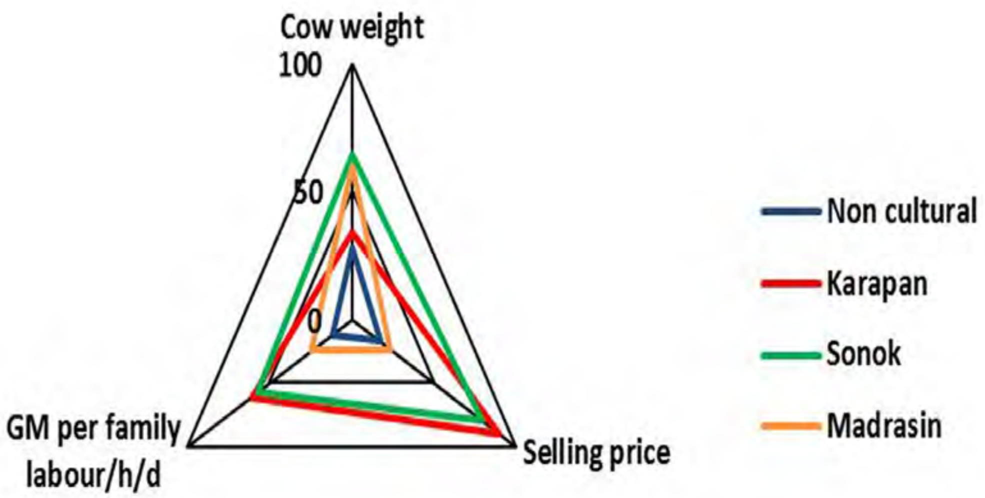
Indicator (unit)	Quantitative assessment Madrasin	Level of impact (Qualitative assessment) †	‡
Economic benefit			
• GM (IDR per h d^{-1})	2,020 ± 1,512	Positive	Negative
Feed availability		N/A	
Cattle management			
• Farm size (cattle ownership) (head)	< 5	No change	No change
• Feeding system	Browsing in communal land	No change	No change
• Housing	Semi-permanent	No change	No change
• Recording	No	No change	No change
• Reproduction	Mating: 100% AI	Positive	Positive
Performances			
• Cattle appearance with age of 1.5 y, expressed by selling price (000 IDR)	11.65 ± 4.89	Positive	Negative
• Liveweight of adult female (kg)	400.1 ± 92.6	Positive	Positive
Additional function of cattle			
• Financing (rank)	3	N/A	No change
• Insurance (rank)	1	N/A	No change
• Social status (rank)	4	N/A	No change
• Cultural (rank)	7	N/A	Negative
• Manure (rank)	2	N/A	Positive
• Draught power (rank)	7	N/A	Negative
Quality of environment		N/A	

Table 5.4. Comparison of Ongole cattle and crossbred cattle and impact of crossbreeding in Central Java

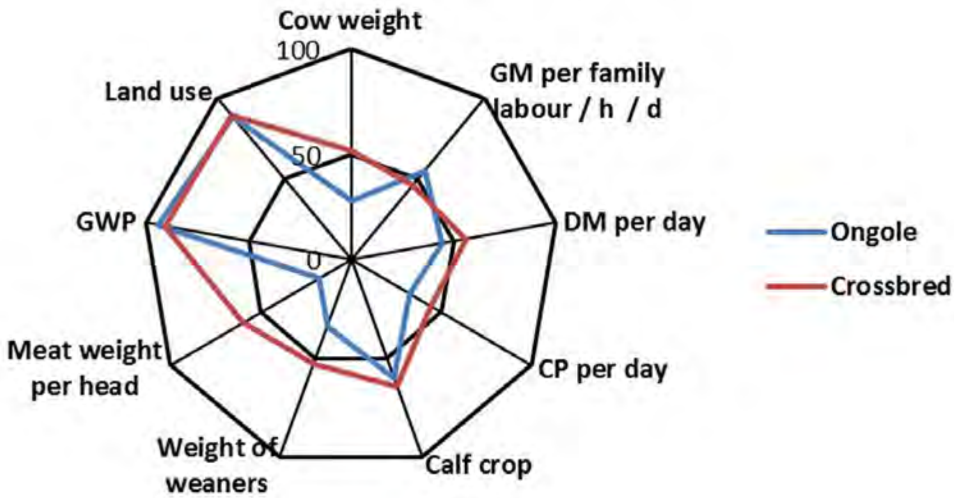
Indicator (unit)	Quantitative assessment		Level of impact (qualitative assessment)
	Local breed (Ongole)	Crossbred	
Economic benefit			
• GM (IDR per h d^{-1})[a]	1,319 ± 1,298	880 ± 1,357	Negative
Feed availability :			
• Feed consumption (DM, g $BW^{-0.75}$ d^{-1})[a]	111.6 ± 13.1	117.1 ± 10.9	No change
• Feed consumption (CP, g $BW^{-0.75}$ d^{-1})[a]	9.9 ±2.0	10.9 ±2.1	No change
Cattle management[a]			
• Farm size (cattle ownership)	< 5	< 5	No change
• Feeding systems	Forage: browsing on communal lands[b] Supplementary feeds: rare[b]	Forage: browsing on communal lands[b] Supplementary feeds: rare-often[b]	No change
• Housing	Semi permanent – permanent	Semi permanent – permanent	No change
• Recording	No	No	No change
• Reproduction	Mating: 62% AI	Mating: 100% AI	Positive
Performance			
• Growth rate (ADG, kg d^{-1})	N/A		
• Liveweight of adult female (kg)	307.6 ± 90.1	385. 3 ± 95.5	Positive
• Liveweight of weaner progeny (kg)	123.2 ± 39.2	151.5 ± 42.6	Positive
• Liveweight at approximately 11 months	182 ± 44.4	200 ± 53.1	Positive
• Calf crop, % yr^{-1}	82.3 ± 15.4	84.0 ± 15.2	No change
• Meat yield (kg)	148 ± 28	210 ± 36.2	Positive
Additional function of cattle			
• Financing (rank)	Rank 2	Rank 2	No change
• Insurance (rank)	Rank 1	Rank 1	No change
• Social status (rank)	Rank 4	Rank 5	No change
• Cultural (rank)		N/A	
• Manure (rank)	Rank 3	Rank 3	No change
• Draught power (rank)[a]	Rank 7	Rank 7	No change
Health and diseases			
• Prevalence of diseases or health problems (%)	*Cascado* disease : 0[c] Less reproduction problems[a]	*Cascado* disease : 6.9[c] More reproduction problems[a]	No change
Quality of environment			
• GWP (kg CO_2 –eq per kg BW)	26.9 ± 10.8[c]	28.9 ± 11.4[c]	No change
• Land use (m^2 per kg BW)	34.2 ± 15.8[c]	37.4 ± 14.6[c]	No change

[a] Widi *et al*. (2015); [b] Widi *et al*. (submitted); [c] Widi and Widodo (2007); N/A Not available

high market price for selling cultural Madura cattle (Widi *et al*., 2014). To further ensure that purebred Madura will be safeguarded for cultural events in the future, some of the additional economic benefits accruing to other stakeholders (e.g. tourist organisations or the Indonesian government) could be transferred to farmers. Given the potential of



a. Madura case study



b. Central Java case study

Figure 5.3. Scores obtained for the indicators measuring the impact of crossbreeding at the farm level in Madura and Central Java

the Madura breed for growth and size, the investment in the Limousin for crossbreeding appears unnecessary.

Feed consumption (DM and CP) indicators showed a difference between crossbred and local cattle in Central Java. Crossbred cattle had higher DM and CP consumption. Large differences in the scores for meat weight, live weight of adult females, and weaner weight at 11 months were observed between crossbred and local cattle in Central Java (Table 5.4. and Figure 5.3.), all in favour of crossbred cattle. Reproductive performance, represented by the calf crop indicator, did not differ between crossbreds and Ongole cattle in Central Java. The indicators for the additional functions of cattle show identical scores for local breed and crossbred cattle, just as in the Madura case study. The ranking results do not capture the expected higher manure production of crossbreds due to their size, nor the expected higher ranking for the financing and insurance function due to their higher financial value.

Environmental indicators (GWP and land use) were not significantly different between crossbred and Ongole cattle in Central Java (Table 5.4. and Figure 5.3.). The indicators for weight and meat yield in the Central Java case study express the positive effect of crossbreeding and the expected increase in meat production. However the labour productivity shows a negative effect for the crossbred farms. Farmers are not able to change the farming system to suit improved feeding through more land use, buying feeds or growing forages instead of food crops. Farmers still prefer crossbreds; they are attracted by the higher selling prices of crossbreds compared with Ongole.

5.6. Conclusions

This GIA is based to a large extent on data from two case studies. The literature, for example Ripoll-Bosch *et al*. (2012), states that if case studies are selected properly it is possible to generalise the results, at least if the case studies create an understanding of the underlying principles and patterns. The large number of representatives of different stakeholders who participated in the two workshops should ensure that underlying principles and patterns are reflected in the issues raised. However, the values of the indicators can still be misinterpreted by farmers and other stakeholders. In our case studies and in the development of the GIA, we focused mainly on farm level, because there is a lack of accessible data available at other levels. This limits the assessment of the aggregate impact of crossbreeding across all relevant levels. This is the major limitation of the GIA model we developed. However, the advantage of focusing on farm level is that we obtained an in-depth understanding of the critical factors that affect the farming system and the livelihoods of farmers.

The approach used to develop the GIA model is similar to the assessment of sustainability at farm level. For now we have a model that focuses on the most important stakeholder, the smallholder mixed farmer. The Madura case shows that even this category is complex; in Madura farmers keep many types of cattle with different breeding goals: *sonok, karapan,* non-cultural Madura and *madrasin* cattle. A thorough identification of stakeholders can prevent putting all farmers in a single category. The GIA results at this stage of crossbreeding in Java and Madura can contribute to an evaluation for future strategies and planning, both at governmental level and farmers (breeders and users of breeding stock) level. However, so far no precise population genetic data for breeds, crossbreds and subpopulations in Java and Madura are available.

A GIA should ideally be performed before the introduction of exotic breeds. Some countries require permission for the importation of new exotic livestock breeds before the importation takes place (Pilling, 2007). A GIA beforehand helps to fulfil this requirement. No such assessment is currently available for the Indonesian situation. The impact of exotic farm animal genetic resources at animal, livelihood and agro-ecosystem levels is hardly ever done beforehand, despite the literature indicating that importation of exotic breeds is not always evaluated as a success and can have devastating effects on the conservation of biodiversity (FAO, 2007). A GIA before the introduction of exotic breeds can help to ensure that the full benefits of such imports are realised and to avoid unforeseen investments and disappointments among stakeholders.

As the case study on the crossbreeding of Ongole and Simmental in Java shows, meat production has increased with crossbreeding, but income generation was negatively affected and environmental performance not improved. In addition, fertility problems can be caused by continuous upgrading. In Madura, there is a genetic resource available for increasing meat production, the sub-population of large-sized Madura cattle used for cultural events, the *sonok.* Knowledge of this trait could have provided an alternative for Limousin crossbreeding, when it began in 2001.

The outcome of the GIA emphasizes that joint discussions among all stakeholders for the final decision making are needed. Different views on breeding goals as shown between the government's goal for meat yield and the Madura farmers' goal for cultural values can be decisive for the import of exotic breeds. Moreover the GIA showed that crossbreeding per se did not guarantee that GMs and environmental performances are improved. Breeding strategies therefore should be participatory, systems based and the results should be monitored as the application of the GIA model for crossbreeding in Java and Madura has shown.

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Chapter 6

General Discussion

Ongole and crossbred animals in front of farmer's houses

6.1. Introduction

Crossbreeding is rapidly changing several of the local cattle populations in Indonesia. The Indonesian government started with the importation of semen from exotic beef breeds about 30 years ago. Farmers initially disliked crossbred animals, but this gradually changed and crossbreds currently account for about 40% of the total number of 12.8 million cattle. Crossbreeding is supported by a wide range of stakeholders, varying from policy makers, extension workers and traders to large-scale slaughter operations. More than 90% of the cattle are kept by smallholder farmers. Smallholders keep cattle not only for meat production, but also for financial security, manure for cropping, social-cultural reasons and draught power. The primary objective of the crossbreeding policy is to increase beef production for the growing urban population. The wider implications of crossbreeding are rarely discussed. There is a lack of reliable field data that can be used to assess the advantages and disadvantages of crossbreeding. This chapter discusses the impacts of crossbreeding on rural livelihoods, the environment and the future of local breeds. It critically reviews the methodologies used in this study and the diversity in cattle breeds in Indonesia, and explores feasible breeding strategies and policies for local and crossbred cattle in smallholder farming systems in Madura and Central Java, Indonesia.

6.2. Reflection on methodology

Information on cattle breeding systems and breeding decisions in Indonesia is difficult to access both within and outside governmental institutions. The research questions in this study were answered by gathering data from different sources: studying grey literature, organising focus group discussions and SWOT analysis, interviewing farmers and key persons, field observations, monitoring feeding practices and reproduction performance, and measuring animal performances. Secondary data were taken from a statistical database published by the government. Data on the size of the populations of local cattle and crossbreds and their contribution to meat production in Indonesia are not available. There is also no information about the specific crossbreeding generations of crossbred cattle, because no systematic pedigree registration exists. As Marshal (2014) suggested, the impact of the introduction of new breed types on indigenous populations should be monitored by regular census.

Obtaining accurate data at farm level was complicated and time consuming (Chapters 2, 3 and 4). Our farm level data on animal weights and feed intakes may lack accuracy, as detailed measurements are not possible for large numbers of animals in the field and for such a large research area. The Gross Margins calculations used in Chapters 2 and 3 only included the financial flows on farms, the additional benefits of cattle in terms of the use of manure on own crop land and the security function of the cattle were not included in this figure. In Chapter 4 we also quantified additional benefits of keeping cattle: manure, insurance and financing. For Central Java these additional benefits accounted for approximately 30% of the total economic value of cattle keeping. Our very low estimation of the economic value of manure (1% of total economic value) seemed to underestimate its real value, as it was only based on the synthetic fertiliser N-equivalent. It excluded the P and K values of manure, and the positive effects manure has on the organic matter and water holding capacity of soil. Farmers valued manure as one of the most important assets, in addition to capital saving and additional income (Tables 2.2. and 3.4.). As cattle are part of the cropping system, the impact of local and crossbred cattle on crop production has to be further investigated. Finding accurate methods to value these functions remains a challenge. The methods used to value insurance and finance, likely underestimate the true values of these functions in Indonesia. Farmers regarded ‘saving’ as the most important motive for keeping cattle, but our estimations showed that insurance and financing accounted for only 30% of the total economic value of cattle keeping. So, the economic analysis of the additional functions was not in line with the ranking of motives of the farmers (Tables 2.2. and 3.4.).

The impact assessment of crossbreeding on the environment (Chapter 4) only focused on GWP and land use. Other aspects of environmental impact, such as eutrophication, acidification and water use, also need to be assessed to understand the total impact of smallholder cattle production on the environment. For example, in Central Java, the storage of manure of small ruminants caused high contamination with total and faecal coliform in the water sources adjacent to small ruminant houses (Budisatria *et al*., 2007). The impact of cattle manure storage systems on water sources is not known, but it will not differ between crossbred and local cattle farms.

Chapters 2, 3 and 4 and the resulting GIA were mainly focused on assessing the consequences of crossbreeding at farm level. Indicators at higher aggregation levels were not assessed because a lot of the required information was not available. However, farmers and other stakeholders mentioned some of the important issues at higher aggregation levels in the focus group discussions. Finding methods to assess the impacts at the higher levels is a great challenge. This challenge arises mainly because of the poor availability of baseline data of all actors in the cattle value chain.

The field data from Madura and Central Java were collected during a period of 1 to 1.5 years. Variation between years was therefore not included. The monitoring years 2010-2012 were, however, average years in terms of climate and price developments.

6.3. Impact of crossbreeding on mixed farming systems

In Indonesia, the initial reluctance of farmers to switch to crossbreeding has been replaced by high expectations of crossbreeding (Table 5.2.). Crossbreeding practices differ between areas. The differences in importance of cultural traditions are a main reason for the differences crossbreeding practices. The variation in cultural values of cattle does not only occur between Java and Madura; Chapter 2 shows that cultural values also differ between areas in Madura, which results in sub-populations of Madura cattle and different management and breeding practices within the island. Since 2001, crossbreeding with Limousin has been promoted in Madura. Prior to 2001, crossbreeding was prohibited to protect the local Madura cattle breed. Crossbreeding using Simmental semen is practised for a much longer period in Java. It is implemented in Central Java irrespective of the existing farming systems.

Crossbreeding and cultural values

Understanding and assessing cultural values of livestock are important in the implementation of interventions aimed at the conservation and utilisation of animal genetic resources (Gandini and Villa, 2003; FAO, 2012). Although the cultural value of local breeds is much discussed, very few studies have actually assessed this value. Chapter 2 was motivated by the concern that crossbreeding would have a negative effect on the preservation of local traditions involving cattle in Madura, an area with strong cultural ties between cattle and people (De Jonge, 1990). Chapter 2 assessed cultural values using the following methods: observation of cultural events, interviews with stakeholders who participated in cultural events and on-farm recording of cattle performance and management practices on farms. On-farm recording was conducted for farms that participated in cultural events and also for farms that did not participate in these events. The assessment showed that the two cultural traditions involving cattle, *sonok (*cow contests) and *karapan* (bull racing), are found in different areas and that Madura cattle in these areas are bred specifically for these events. Management practices, in terms of caring and feeding, are also focused on the cultural events. This has resulted in marked differences in body measurements and live weights between these two sub-populations. The cultural events are a strong driver for the preservation of the two sub-populations of Madura cattle in these areas, but the populations are relatively small (45 000-50 000 in each sub-population). In the *sonok* area, inbreeding is controlled by circulating bulls between villages; no efforts are made to control inbreeding in the *karapan* area. Farmers in the *sonok* area select bulls on the basis of their pedigree or they use semen from the nine *sonok* bulls in the AI centre. Inseminators in the *sonok* area are very motivated to improve *sonok* cattle keeping. To avoid inbreeding, inseminators record the distribution of semen and the use of natural mating. In Sapudi Island, the centre of *karapan,* only four bulls were used for breeding during the period of the field observations. Farmers in Sapudi Island perceive AI as unnatural. The AI centre had only two *karapan* bulls. Farmers from areas outside Sapudi usually buy young promising bulls from Sapudi farmers for racing events all over Madura.

*C*rossbreeding is not a threat to the two cultural events nor to the Madura cattle sub-populations in the specific areas where these events are organised. Both *sonok* and *karapan* farmers are very proud of their cattle and cattle that perform well in cultural events have a high market value. Therefore *sonok* and *karapan* farmers will not switch to crossbreeding with Limousin. Crossbreeding is, however, a threat to the majority of conventional Madura cattle outside the areas where the cultural events are organised.

In Central Java, there is no strong link between cattle keeping and specific cultural traditions. However, farmers do have traditional motives, like the Madurese farmers, for keeping cattle, such as cattle as security, providers of manure and social status. There was no difference in the motives for keeping cattle between farmers who kept Ongole and crossbred cattle (Tables 3.4.). Hence, culture is not a main driver for maintaining the Ongole breed in Java.

Keeping crossbreds also has positive social-cultural implications. Farmers in Java prefer crossbreeding with Simmental, not only because of their higher growth rates but also because of their red shiny coats, yellow lips and their unselective feeding habits (Sutresniwati, 2006). In Madura, crossbred cattle that perform well are the pride of their owners. The local government in Madura makes use of this by organising the *madrasin* contest, in which crossbred cows are judged for their body conformation, weight and conformation of their calves. This contest, like the *sonok* contest and *karapan* races, contributes to a high market value for stock. So, cultural values represent an economic value (Gandini and Villa, 2003). *Karapan* is a main tourist attraction for Madura. This justifies attention to solve the risk of inbreeding in the *karapan* population.

Is crossbreeding beneficial for farmers?

Chapter 3 addressed whether crossbreeding is beneficial for the mixed farming systems in Central Java. The results show that crossbreeding has not changed the farming systems, in terms of herd size, farm types and experience in cattle keeping, and this finding was consistent across different agro-ecological zones. No difference was found in the motives for keeping cattle between farms keeping crossbred cattle and farms with Ongole cattle. Although the agro-ecological zones differed in cropping patterns and feed sources, they did not differ in the amounts of dry matter (DM) and crude protein (CP) fed to individual animals. Crossbred cows were about 25% heavier than Ongole cows and their progeny were 16 to 24% heavier than Ongole progeny. Farmers appreciated the resulting higher market prices for crossbred stock. The FDGs (focus group discussions) showed that farmers were aware of the higher feed requirements of crossbreds (Table 5.2.), but were less aware that crossbreeding does not necessarily bring financial gains (Table 3.10.). In the lowlands of Madura, the financial results tended to be slightly higher for crossbred farms than for conventional Madura cattle farms, but the differences were not significant.

In smallholder dairying, crossbreeding has proved to be a good means to increase household incomes in various countries (Udo *et al*, 2011). A main advantage of dairying is that milk sales give a regular income, whereas beef type cattle are an irregular cash source, in particular in farms with only 2-3 cattle. The present results show that crossbreeding for beef production is not reducing rural poverty for smallholders. This leaves a question open. If it is not the smallholders, who actually is gaining from crossbreeding in the cattle production value chain in Indonesia (Figure 1.2.)? Answering this question will require research at different aggregation levels than was done in this study.

Is crossbreeding beneficial for the environment?

Increasing productivity is generally seen as an efficient strategy to reduce the climate impact of livestock and to reduce the land use for livestock in densely populated areas, such as Java and Madura (Steinfeld *et al.*, 2006; Herrero *et al.*, 2009; Gerber *et al.*, 2013; Herrero and Thornton, 2013). Chapter 4 addressed whether intensification through crossbreeding is beneficial for the environment in a smallholder setting.

The main finding is that there were no differences in global warming potential (GWP) and land use per kilogram live weight produced between local and crossbred cattle production systems in the four study areas in Central Java. This is in line with the finding that the financial results of crossbred farms were not different from Ongole farms in Central Java. Crossbreds were fed more fresh forages, either home-produced or bought, and supplements (Table 3.7.). This resulted in extra emissions, extra land use, just as extra costs compared to Ongole. The results show that crossbreeding has led to increased production but not to more efficient use of resources.

Keeping fewer but more productive cattle is a paradigm within the intensification approach to reducing environmental impact. Keeping fewer cattle is expected to lead to lower greenhouse gas emissions, as the biggest contribution to climate impact is from enteric fermentation (Steinfeld *et al.*, 2006; Gerber *et al.*, 2013). Reducing the number of animals and feeding only the better feeds available is theoretically beneficial for productivity, animal growth rates and environmental impact per unit of production. However, this will interfere with the multiple objectives of keeping cattle (Zemmelink *et al*., 2003; Oosting *et al*., 2014). Tables 2.1 and 3.3 show that farms with crossbred cattle in Madura and Central Java have not reduced the numbers of animals held. Farmers kept an average of 2.5 cows, with a range of 1 to 13; the number of animals they keep is related to their resources of feed, cash and family labour. Farmers use all their land for cropping activities and the animals have to rely on crop by-products, which are usually of low quality. Possibilities to improve the feed situation, and so, to intensify cattle production, are limited. In Java, farmers do not have sufficient resources to invest in better feeding. Farmers have no access to land for forage production, and they lack cash to buy good quality supplements or concentrates. Although there appear to be few options available for improvement, large differences were observed among farmers. The 25^{th}percentile of farms with the lowest GWP per kilogram live weight produced, fed their animals more in terms of DM and CP and had better performance (calving intervals, body condition scores and live weight produced) compared to the other farms. Farmers' groups are an appropriate tool to implement changes in farming practices in Indonesia. In such groups, farmers could learn how to improve the management of their cattle from farmers that have better cattle management practices.

6.4. Genetic Impact Assessment

In literature on farm animal genetic resources, the call for genetic impact assessments (GIA) arises primarily because of concerns about the potential loss of genetic diversity through crossbreeding or upgrading (Hiemstra, 2003). Marshall (2014), however, states that the impact of using different breed types in livestock systems in developing countries requires assessments from a number of viewpoints and at different levels. In Chapter 5, an integrative assessment (GIA) was conducted by identifying relevant technical, economic, ecological and societal issues using participatory techniques and involving various stakeholder groups. This type of approach makes farmers a partner in assessing the consequences of crossbreeding by valuing their knowledge and experience (Mollenhorst, 2005).

The main users of a GIA are policy makers and farmers. These users need a certain level of aggregation of the results. The amoeba diagrams summarized the main results at farm level. This showed that crossbreeding in Central Java was negative in terms of labour productivity and positive for live weight with no change for the carbon footprint and land use. The Madura case showed that crossbreeding for increase in body weight may not be competitive with cultural values of Madura sub-populations. Focus group discussions were held in 2012 with the aim of obtaining feedback on the integrative assessments of consequences of crossbreeding from farmers and other stakeholders in Central Java and Madura. These FGDs were attended by 64 persons: farmers, policy makers, local government representatives, a representative of a breeding centre and scientists. Local representatives of governmental institutions in Madura were still not very concerned with different breeding requirements of sub-populations of Madura cattle. Avoiding crossbreeding in Sapudi Island was considered sufficient in maintaining cultural traditions. From the farmers' perspective, the most important issue was the financial impact of the higher market prices for crossbred cattle. Farmers also emphasized the stability of cattle prices. Farmers often face the dilemma of selling young stock for a low price or keeping the young stock and waiting until prices increase again. Farmers were of the opinion that they lose much more when they decide to sell crossbred cattle in a low price situation. On the other hand, keeping crossbred cattle is costly due to the higher feed costs. Scientists were concerned about maintaining sufficient good quality cattle of local breeds for crossbreeding. This is particularly important in order to be able to back-cross higher generations of crossbred cows. Policy makers were still concerned with increasing meat production, but were also required to recognise the global concern about conserving the diversity of animal genetic resources. Policy makers opted for zonation for local breeds, such as the '*Return to Ongole'* programme in Central Java (Chapter 3).

The focus in the case studies and the development of the GIA was mainly on farm level because there was a lack of accessible data at other levels. Relevant issues at regional level mentioned by various stakeholders were reproduction and health services, facilities (slaughter house, market building and presence of a research centre), certification of products, recording and identification by breeding organisations, organisation of the marketing system and value chain, and the presence of a breeding programme. Facilities were assumed to be improved automatically when crossbred animals are used (Table 5.2.). But these improvements require serious investments and should also be considered beforehand.

6.5. Genetic diversity in Indonesian cattle

Genetic diversity is a prerequisite for the survival of the different breeds and for breeding opportunities in the future. According to the CBD (Convention on Biological Diversity) regulations, the national government is responsible for farm animal genetic resources in Indonesia. Many countries have developed national strategies and policies addressing the conservation and sustainable use of farm animal genetic resources. Such policies and strategies require indicators to monitor their effects. For agrobiodiversity, the genetic level (the genetic diversity within the relevant species) is the most relevant level (Hiemstra *et al*., 2006). Initiatives and policies of the Indonesian governments determine which (male) breeding material is available for individual farmers and the extent to which this breeding material fits with the farmer's breeding goals. It is difficult to assess the genetic diversity of cattle, as suggested by Hiemstra *et al*. (2006), because much of the information (e.g. population sizes, share of different breeds, use of breeding strategies) needed for the assessment at country level is not currently available. Another obstacle is the lack of knowledge and awareness about differences in breeding goals. In this situation, unlimited and non-systematic crossing with exotics can easily lead to upgrading with exotic breeds and the extinction of a locally adapted native breed (locally adapted native breed is the official definition for local breeds; Martyniuk *et al*., 2010). This all enhances the risk that a valuable locally adapted native breed will disappear without being noticed by the responsible authorities. Thus, the development and implementation of a monitoring system, including controls on the level of upgrading, for cattle populations in Indonesia is strongly advised.

Deptan (2003) and Astuti *et al*. (2007) approximated the population sizes of locally adapted native breeds (Bali, Madura, Sumba Ongole, Ongole (*Peranakan Ongole*), Brahman, Hissar, Pesisir, Aceh, Rambon, Katingan and Sahiwal) and crossbred cattle at nine million and five million, respectively. Bali, Madura and Ongole are the three main locally adapted native cattle breeds. Given these approximations, it seems that the three major locally adapted native breeds are still safe according to FAO standards. The share of these three breeds decreased from 80 percent in 1980-1990 to 50 percent at present. In the meantime, the share of crossbred cattle has increased towards 50 percent (Deptan, 2003; Astuti *et al*., 2007). Given the speed at which the number of animals of locally adapted native breeds is decreasing and the crossbreeding policy, almost all locally adapted native breeds will be threatened in their existence within 10 to 15 years. Then, the opportunities for using heterosis in systematic crossbreeding programs will be lost. Breeding programmes using highly selective breeding methods for beef production are needed for the locally adapted native breeds as well as for crossbreeding. Structured breeding programmes, involving the recording of performance traits, estimation of breeding values and a programme for the selection of potential parents (FAO, 2013), do not exist in Indonesia. Such breeding programmes require organisational efforts of farmers and government to enable systematic performance recording, planned mating and genetic evaluation.

6.6. Future breeding systems

The higher market value of crossbred stock is the main reason for the euphoria of farmers about crossbreeding. Crossbreeding will inevitably continue, but the lack of a systematic approach poses risks for its sustainability. Added to this, most farmers do not want to completely upgrade their cattle to Simmental or Limousine. The two basic requirements to prevent a complete upgrading of local cattle are 1) an efficient identification and registration (I&R) system so that farmers know the crossbred generation of their cows and can decide to back-cross with a local breed; and 2) an efficient breeding programme for local breeds, so that bulls will be available for pure breeding and for back-crossing. A more straightforward alternative could be to stop using semen from Simmental or Limousin bulls on crossbred cows and start using crossbred bulls or semen for breeding. Syrstad (1996) suggested this 'new breed' formation as the most simple breeding strategy for smallholder dairy farming. Crossbreeding, however, is not only an issue of applying logical breeding decisions, it is also a psychological issue. Farmers nor AI centres might be willing to use semen of crossbred bulls.

In Indonesia, breeding programmes are limited to promotion of crossbreeding and selection programmes in governmental breeding stations for Bali, Aceh, Madura and Ongole breeds. The breeding station programmes aim to conserve these local breeds; they produce certified breeding stock for farmers interested in these animals. The '*Return to Ongole'* programme is an example of a nucleus breeding programme. It uses village breeding centres. This programme is carried out in the Wet lowlands II and Dry uplands study sites in Central Java. The selection goal is the growth rate from weaning until one year. Participating farmers get a subsidy for a pregnant cow. The best yearling calves are reared in a central test station. There are no data on how effective this programme is. Collection of data should be supported by scientists in order to be able to monitor the programme and to evaluate the perceptions of the participating farmers.

The cultural values of Madura cattle are being maintained by the farmers. The breeding goals of these farmers are defined by the requirements of the cultural events, which are body conformation traits in *sonok* cattle and the racing speed of bulls in *karapan* cattle. The national breeding strategies and conservation efforts for local breeds do not concern the differences in traditions across areas and therefore the differences in sub-populations of Madura cattle. The only conservation strategy is for Sapudi Island, where crossbreeding is prohibited. The national database, Indonesia's contribution to the National Report on Animal Genetic Resources for FAO (Deptan, 2003), should also include data at the sub-population level. So, there is an urgent need for reliable data on the numbers and performances of different types of cattle in Madura.

In Madura, *sonok* cows were comparable with *madrasin* cows in body weight and body condition scores. This shows that the AI organisation could also have used bulls from the *sonok* area to improve the meat production of Madura cattle in the major part of Madura, instead of propagating crossbreeding. Unfortunately, performance data from the different sub-populations were not known at the start of the crossbreeding programme. It should also be noted that farmers in the *sonok* area are very passionate about managing their cattle and participating in the *sonok* event. Therefore, the *sonok* farmers represent a specific sub-group of dedicated cattle breeders. Their cattle performance results may not be achieved by *madrasin* farmers. *Madrasin* farmers give priority to their cropping. Nevertheless, the AI organisation could promote the use of semen of *sonok* bulls, also for the farmers in the *madrasin* area. The first priority for the *karapan* area is the control of inbreeding. There are two requirements to achieve the control of inbreeding, an accurate recording of the use of bulls for breeding and the use of more breeding bulls than is currently practised.

6.7. Policy implications

Crossbreeding is increasing in Indonesia, but it has not yet been able to reduce the gap between the supply and demand of meat (Agus *et al*., 2014). In the last decade meat production has increased by 49%. Crossbreeding has probably contributed to this remarkable increase, as Chapter 3 shows that the amount of weaned weight per farm was about 20 % higher on crossbred farms than on Ongole farms. Crossbreeding is therefore beneficial for increasing meat production at the national level. Despite this, the national cattle production was still only able to satisfy 51% of meat demand in 2014; this is predicted to decrease to 43% in 2024 (Agus *et al*., 2014). The Indonesian government plans to import breeding cows from Australia in the next five years to increase the cattle population. Fattened cattle and frozen meat will still be imported to fulfil the deficit. The expansion of livestock production to other islands, such as Kalimantan, Sumatera, Sulawesi and Papua, is also a major policy objective. In the outer islands, extensive large-scale beef production systems are propagated (Agus *et al*., 2014). The 'road map' towards increased beef production in Indonesia proposes cow-calf operations outside Java and fattening in feedlots near the major cities (Agus *et al*., 2014). Cow-calf operations outside Java are suggested to be integrated systems, with food crops, palm oil plantations and other plantations, and belonging to big private companies (Agus *et al*., 2014). The major problems for cattle production in other islands are the lack of human resources, regulations from companies that do not support integration with livestock, and the large distances from livestock source areas to the markets (Java) for final products. To support the distribution of live cattle and cattle products across islands, the infrastructure needs to be improved or developed. This infrastructure includes harbours, ships, roads, refrigerator containers in the harbours and cold storages.

Local cattle, such as Bali, Madura and Ongole, seem the most appropriate breeds to be kept in areas outside of Java (Baliarti, personal communication), considering their good fertility and ability to cope with harsh conditions and poor management (Hardjosubroto, personal communication). Crossbreds and Brahman crosses from Australia are also possible for experienced farmers. Java is the biggest market for cattle production. In the past several feedlots existed in Java. Such feedlots rented or bought marginal lands for growing forages. Supplements and concentrates were bought from local suppliers. Many of feedlots collapsed because of the economic crisis in the late 1990s, long distances to markets, and long and risky marketing systems. The future perspective of feedlots depends to a large extent on the macro-economic conditions in Indonesia.

Genetic improvement and intensification remain high on the policy agenda for smallholders in Java. The GIA developed on base of the two case studies give clear indications for the Indonesian farmers and the Indonesian government. At Madura, the Madura sub-populations should be conserved for their high cultural value and, in particular the *sonok* Madura cattle still has opportunities to be improved in beef production traits. This is valuable for farmers and government. At Java the GIA shows that crossbreeding with exotics has limited possibilities to improve cattle production and environmental performances at farm level.

Intensification implies the increased use of external inputs and services to increase the output quantity and/or the value per unit (Bebe *et al*., 2002). Crossbreeding as tool of intensification has to be supported by better feeding and management and requires a package of innovations on the basis of external inputs, such as feeds, health and breeding services, credits and marketing (Udo *et al*., 2011). In practice, crossbreeding has been limited to providing exotic semen. Consequently the cattle keeping systems have not become more efficient through crossbreeding.

Nevertheless, crossbreeding will be continuing. The higher market value of crossbred cattle encourages farmers to produce crossbreds. However, farmers do not want to completely upgrade their Ongole cattle to Simmental or Limousine (Chapters 2 and 3). This means that breeding activities for Ongole cattle have to be supported by the necessary institutions and facilities (section 6.6.). A first priority is a I&R system. Farmers need to know the crossbred generation of their breeding cows, so they can plan the use of semen from exotic or local bulls.

In Indonesia, the current top-down approach, which is focused on increasing meat production has to be adjusted towards breeding activities that support the objectives of the farmers themselves. The gap between governments' objectives and farmers' practices calls for participatory methodological approaches involving the key stakeholders, the farmers, to understand their perceptions about sustainable livestock development strategies for their farming systems. Monitoring of cattle production performance and trends in numbers per breed and sub-populations and area is needed to conduct impact assessments. Such information can be used by policy makers for decision making about future breeding strategies. Information should flow to stakeholders through training, education and extension. Policy makers should actively support the collection of such information by providing funding and setting up appropriate infrastructure. Research institutes and national universities could play an important role in the communication of research results. Without these changes, unstructured crossbreeding will continue.

6.8. Conclusions

1. In Indonesia, cattle fulfil livelihood needs in smallholder mixed farming systems; they provide security, support cropping activities, contribute to social status, and are involved in cultural events in specific areas.
2. The Madura cattle breed and the cattle production systems in Madura are not homogenous. Crossbreeding is not a threat to the two cultural events

involving cattle, *sonok* (cow conformation contest) and *karapan* (bull racing), nor to the sub-populations of Madura cattle in the specific areas where these events are organised. The future of *sonok* cattle is brighter than for *karapan* cattle in terms of performance and the future perspective of the cultural event. Farmers outside the *sonok* and *karapan* areas, prefer Limousin crossbreds (*madrasin*) to conventional Madura cattle.

3. Madura cattle participating in the cultural events had a market price 2 to 3.5 times higher than Madura cattle not participating in these events. *Sonok* and *madrasin* cows were heavier and had higher body condition scores than *karapan* cows and conventional Madura cows in the *madrasin* area.
4. In Madura, the current breeding and conservation approaches do not distinguish between different Madura cattle types and do not consider the specific needs of the farmers in the *sonok* and *karapan* areas.
5. Monitoring and characterisation of animal genetic resources with well-identified cultural values can be used to quantify these cultural values and should consider the interaction of cultural values with management practices, animal performance and economic benefits.
6. In Java, farmers perceive that crossbreeding is beneficial for them. Crossbreeding is not changing the farming systems in terms of household and farm characteristics and management. Crossbred cattle reached a higher body size and weight and therefore had a higher market price, but they also required more feed. This resulted in comparable GM for farms with crossbred and Ongole stock. Although the financial benefits were not higher for crossbreds compared to Ongole, farmers preferred the crossbreds because of their nice appearance, high growth rate and the higher market price for progeny compared to Ongole.
7. Crossbreeding contributes to increased meat production at the national level. The amount of weaned weight per farm was 20% higher on crossbred farms than on Ongole farms.
8. The expectation that crossbreeding would reduce the carbon footprint and land use per kilogram of beef was not confirmed in Central Java. The advantage for GWP and land use per kilogram live weight produced arising from the faster growth of crossbreds was counteracted by the higher emissions and land use from feed production for crossbreds. The biggest contribution to GWP was from enteric fermentation, which is closely related to lower quality feeds.
9. Better feeding is generally advised to reduce the environmental impact of livestock. Smallholder mixed farmers do not have sufficient cash to buy more forages and supplements. Growing more feed crops is restricted by the limited land availability in Java. Keeping fewer cattle and feeding them the

better quality feeds available contradicts with the multi-functionality of cattle.

10. The dualism in crossbreeding is that policy makers promote crossbreeding to meet the increasing demand for beef, whereas farmers are concerned with their livelihoods and the multi-functionality of cattle.
11. Participatory approaches can ensure that farmers' views are considered in crossbreeding policies and practices. In Madura and Central Java, farmers identified economic benefits, feed availability, cattle management, animal performances, additional functions of cattle, and health and fertility as issues to be considered in a genetic impact assessment of crossbreeding. Other stakeholders mentioned meat production, environmental quality and diversity in farm animal genetic resources as important issues.
12. Crossbreeding will inevitably continue in Java, as farmers are satisfied with the performance and appearance of crossbred cattle, and the higher market value. Breeding strategies have to be adjusted, however, as farmers do not want to completely upgrade their Ongole cattle to Simmental or Limousin.
13. Viable populations of local cattle are needed to ensure sustainable crossbreeding strategies. Farmers need continuous support and encouragement from policy makers and scientists to conserve local breeds.

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SUMMARY

In response to increasing demand for meat, Indonesia's government has been implementing crossbreeding with European beef breeds to improve the performance of local cattle. Starting in the 1980's, the Indonesian government started with importations of semen of exotic beef breeds. About 90% of the 12.8 million cattle are in hands of smallholder farmers. They keep cattle not only for meat production, but also for financial security, manure for cropping, social-cultural reasons, and draught power. At first, crossbreeding was not very successful, but the preference of farmers for crossbreds has changed over time. Nowadays, farmers have high expectations of crossbred cattle. Crossbreeding is supported by a wide range of stakeholders, varying from policy makers, extension workers and traders to butchers ranged from small-large scale. The primary objective of the crossbreeding policy is to increase beef production. Major concerns are the impact of crossbreeding on rural livelihoods, the environment, the viability of the local breeds, and the organization of breeding strategies. There is a lack of reliable field data that can be used to support or deny cattle crossbreeding. Crossbreeding may influence not only the future availability of local farm animal genetic resources but also (for better or worse) the farming systems and livelihoods of livestock keepers. The main objective of the present study was to evaluate the benefits and consequences of crossbreeding in smallholder cattle farming systems, in order to develop a genetic impact assessment (GIA) of exotic cattle breeds on cattle farming systems in Indonesia.

This study used different research methodologies, including literature review, participatory observations and direct measurements of cattle performances, feeding practices and farm inputs and outputs. Important issues related to the impact of crossbreeding on smallholders farming systems were gathered through focus group discussions (FGDs) among stakeholders. These issues were selected, measured and assessed using semi-structured interviews and measurements of cattle and farm performance, inputs and outputs, and costs and benefits of cattle keeping. This study took place in Central Java Province, Yogyakarta Province and Madura. Central Java and Yogyakarta Provinces are located in Java, one of the largest islands and most populated island in Indonesia, whereas Madura is a small, densely populated island located off the northeast coast of Java. Madura was used to study the unique interaction between cattle and culture, and the potential impact of crossbreeding on this interaction, as Madura is famous for cultural events involving cattle. The study areas in Madura were determined by the use of cattle for different cultural events: *karapan* bull racing, *sonok* cow contests and crossbred (*madrasin:* LimousinxMadura) cattle contest. In Central Java, the study areas represent wet lowlands, wet uplands, and dry uplands. These have different topography, soil types, soil fertility and agro-climatic conditions, and consequently different cropping patterns, land use management and feed resources.

Summary

Chapter 2 was motivated by the concern that crossbreeding would have a negative effect on the preservation of local traditions in Madura. Quantitative and qualitative information was collected through participatory approaches involving farmers (n=97), government officials, community groups, key informants, and through direct observation of *sonok*, *karapan* and *madrasin* events. Phenotypic characteristics were collected from 184 cows. The Madura cattle breed and production systems are not homogenous. Four cattle types could be distinguished: *karapan*, *sonok*, *madrasin* and conventional Madura cattle. These cattle were found in three different areas: *karapan*, *sonok* and *madrasin* area. *Sonok* and *madrasin* cows were significantly bigger and had higher body condition scores than *karapan* cows and the conventional Madura cows. Madura cattle participating in cultural events were valued at prices that were 2-3.5 times higher than Madura cattle not participating in cultural events. Crossbreeding will not directly influence the cultural events or the management practices of Madura cattle in the *karapan* and *sonok* areas, however, outside the *karapan* and *sonok* areas, crossbreds are rapidly replacing conventional Madura cattle. It was concluded that cultural values of livestock can be a main driver for maintaining relatively small populations of local breeds.

Chapter 3 addressed whether SimmentalxOngole crossbreeding is beneficial for the mixed farming systems in four different agro-ecological zones in Central Java. Chapter 4 addressed whether intensification through crossbreeding is beneficial for the environment, in terms of the carbon footprint and land use. in Central Java. Both chapters used quantitative and qualitative information collected through participatory approaches involving 252 farmers in the four study areas. Phenotypic characteristics, reproductive performances, and carcass characteristics of Ongole and crossbred cattle were assessed, together with farmers' reasons for keeping Ongole or crossbred breeding stock, and the functions of cattle on the farms. All inputs and outputs of the cattle component on Ongole and crossbred farms were determined to calculate Gross Margins. In chapter 4 these inputs and outputs were used for a Life Cycle Assessment to compute emissions of the main greenhouse gases, and land use for the crossbred and Ongole farms.

Across different agro-ecological zones, crossbreeding was not changing the farming systems: herd sizes, farm types, experience in cattle keeping, and functions of cattle were about the same for Ongole and crossbred farms. Farmers were able to collect or buy extra forages and concentrates for crossbreds. Crossbred cows were approximately 25% heavier than Ongole cows. In terms of reproduction performances, both local and crossbred cows performed well with calf crops ranging between 73% and 86% per year in the different areas. Farmers are motivated to keep crossbred cattle as body weights and market prices were higher than for Ongole cattle, although crossbreds required more feed resulting in comparable Gross Margins for farmers with crossbred or Ongole breeding stock. So, crossbreeding is not bringing financial gains for the farmers.

At national level crossbreeding is contributing to increased meat production. The amount of weaned weight per farm was 20% higher on crossbred farms than on Ongole farms.

Chapter 4 showed that crossbreeding (as a tool for intensification) was not more efficient in mitigating GHG emissions and reducing land use per kg live weight produced than Ongole in the present smallholder farming systems in Central Java. Expressed per kg live weight of young stock produced, GWP and land use of Ongole and crossbred cattle were not different. The advantage of the faster growth of crossbreds in GWP and land use per kg live weight produced is counteracted by the higher emissions from feed production for crossbreds. The biggest contribution to GWP was from enteric fermentation, which is closely related with low quality of feeds available. Possibilities to improve the feed situation are limited. Farmers do not have sufficient resources to invest in better feeding. Farmers have no access to land for forage production, and they lack cash to buy good quality supplements or concentrates.

In literature on farm animal genetic resources, the call for genetic impact assessments (GIA) arises primarily because of concerns about the potential loss of genetic diversity through crossbreeding or upgrading. Chapters two, three and four show that the impact of crossbreeding has to be evaluated from a variety of issues. In Chapter 5, an integrative assessment (Genetic Impact Assessment, GIA) was conducted, including identification of stakeholders, identification of the issues, selection of indicators and development of GIA. Based on seven focus group discussions with in total 296 participants, farmers and other stakeholders mentioned relevant crossbreeding issues. Indicators at farm level were selected for these issues. The indicators were tested with data from the Madura and Central Java case-studies and with population size data of Indonesian breeds. Farmers identified economic benefits, feed availability, cattle management, animal performances, additional functions of cattle, and health and fertility as issues. Other stakeholders mentioned meat production, environmental quality and diversity in farm animal genetic resources as important issues. The GIA developed on base of the two case studies gives clear indications for the Indonesian farmers and the Indonesian government. At Madura, the Madura sub-populations should be conserved for their high cultural value and, in particular the *sonok* Madura cattle still have opportunities to be improved in beef production traits. This is valuable for farmers and government. At Java the GIA shows that crossbreeding with exotics has limited possibilities to improve cattle production at farm level. Crossbreeding is also not reducing rural poverty.

The dualism in crossbreeding is that policy makers promote crossbreeding to meet the increasing demand for beef, whereas farmers are concerned with their livelihoods and the multi-functionality of cattle. Participatory approaches can ensure that farmers' views are considered in crossbreeding policies and practices. Crossbreeding has led to increased beef production but not to more efficient use of resources. In practice, however, crossbreeding will continue. Crossbreeding is limited to supply of exotic semen and is done rather un-controlled. Breeding strategies have to be adjusted, however, as farmers do not want to completely upgrade their cattle to Simmental or Limousin. In Java, a viable Ongole population is needed to reduce the risk of upgrading to too high levels of Simmental. The cultural values of the different sub-populations of Madura cattle are being maintained by the farmers. The current breeding and conservation approaches do not consider the specific

needs of the farmers in the *karapan* and *sonok* areas. The future of *sonok* cattle is better than for *karapan* cattle in terms of the risk of inbreeding, performances and the future perspective of the cultural event. *Sonok* cows were comparable with *madrasin* cows in body weight and body condition scores. This shows that crossbreeding for meat yield may not be competitive with income from cultural values of *sonok* cattle and may not always be an automatic choice. Farmers need continuous support and encouragement from policy makers and scientists to conserve local breeds. There is an urgent need for reliable data on the numbers and performances of different types of cattle in Indonesia. Farmers need to know the crossbred generation of their breeding cows, so they can plan the use of semen from exotic or local bulls.

The locally adapted Indonesian cattle breeds, that have many well appreciated functions, deserve well designed and implemented conservation and breeding plans as a guarantee to maintain their functions and increase beef production.

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ABOUT THE AUTHOR

Widi was born on March 29th, 1975 in Wonosobo, Central Java, Indonesia. During the period 1980-1992 she completed her Elementary – High school in Ambarawa, a small old-town in Central Java. She entered the Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta and graduated in 1998. She worked in a livestock private company before continuing her studies to Master degree in Universitas Gadjah Mada in 2000 and finishing in 2002.

In 2002, she was awarded a Wageningen University scholarship to study an MSc in Animal Sciences at Wageningen University, and obtained the MSc degree in 2004. During her MSc study period, in 2003, she was formally admitted as a staff member in the Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia, where she has been working since. She is responsible for lecturing of subjects related to livestock production, primarily on meat, draught and companion animals. Apart from lecturing, she has research and public service obligations related to the aforementioned subjects.

She started her PhD program in September 2008, funded by Directorate of Higher Education (DGHE), Ministry of Research, Technology and Higher Education, Republic of Indonesia. She has been involved in farm animal genetic resources biodiversity research since 2004.

PUBLICATIONS

PEER REVIEWED

- **Widi**, **T.S.M**., H.M.J. Udo, K. Oldenbroek, I.G.S. Budisatria, E. Baliarti, A.J. van der Zijpp (2014). Unique cultural values of Madura cattle: is crossbreeding a threat? *Animal Genetic Resources* 54: 141-152.
- **Widi**, **T.S.M**., H.M.J. Udo, K. Oldenbroek, I.G.S. Budisatria, T. Viets, E. Baliarti, A.J. van der Zijpp (2015). Is crossbreeding of cattle beneficial for mixed farming systems in Central Java. *Animal Genetic Resources (in press).*
- **Widi**, **T.S.M**., H.M.J. Udo, K. Oldenbroek, I.G.S. Budisatria, E. Baliarti, A.J. van der Zijpp (2015, has been submitted to *Animal Genetic Resources*). Is crossbreeding of cattle beneficial for the environment? The case study of mixed farming systems in Central Java, Indonesia.
- **Widi**, **T.S.M**., H.M.J. Udo, K. Oldenbroek, I.G.S. Budisatria, E. Baliarti, A.J. van der Zijpp (2015, has been submitted to *Animal Genetic Resources*). Designing genetic impact methodology based on crossbreeding with exotic beef breeds in mixed farming systems in Indonesia.
- Hartatik, T., **T.S.M. Widi**, S.D. Volkandari, D. Maharani, Sumadi. 2014. Analysis of DNA polymorphism in SRY gene of Madura cattle populations. Procedia Environmental Sciences 20 (2014): 365-369.

ABSTRACTS IN SCIENTIFIC MEETINGS

- **Widi**, **T.S.M**., and T. Hartatik. The characteristics and performances of *sonok* compared to k*arapan* cows as important consideration for conservation of Madura cattle. *Tropentag 2009 Conference*. Hamburg, Germany, 6th – 8th October, 2009.
- **Widi**, **T.S.M**., T. Hartatik, and H.M.J. Udo. Traditional art contest of *sonok* as an alternative selection for Madura cattle. *Tropentag 2010 Conference*. Zurich, Switzerland, 14th – 16th September, 2010.
- **Widi**, **T.S.M**., I.G.S. Budisatria, E. Baliarti, H.M.J. Udo. Diversity on the exterior performance of crossbred cattle kept by farmers in Central Java. *The 5th International Seminar of Tropical Animal Production*. Yogyakarta, Indonesia, 19th – 21st October, 2010.
- **Widi, T.S.M.**, H.M.J. Udo, K. Oldenbroek, I.G.S. Budisatria, E. Baliarti, and A.J. van der Zijpp. Impact of crossbreeding on social and cultural values of Madura cattle; a unique case study on Madura Island. *Wageningen Institute of Animal Science* (*WIAS Science Day*). Wageningen, the Netherlands, 2nd February 2012.
- **Widi, T.S.M.**, H.M.J. Udo, K. Oldenbroek, I.G.S. Budisatria, T. Viets and A.J. van der Zijpp. Life cycle assessment of local and crossbred cattle production systems in Central Java, Indonesia. The 16th Asian Australasian Animal Production Congress. Yogyakarta, Indonesia, 10th -14th November, 2014.

PhD EDUCATION PLAN

With the educational activities listed below the PhD candidate has complied with the educational requirements set by the graduate school Wageningen Institute of Animal Science (WIAS) at Wageningen University, which comprises a minimum of 30 ECTS, which equals a workload of 21 weeks. Each ECTS (An European Credit Transfer and Accumulation System) equals a workload of 28 hours.

BASIC PACKAGE (3.0 ECTS)

- WIAS Introduction Course
- Course of philosophy of science and / or ethics

SCIENTIFIC EXPOSURE (11.0 ECTS)

- Four International conferences: (1) TROPENTAG 2009, (2) TROPENTAG 2010, (3) The 5th International Seminar on Tropical Animal Production (ISTAP 5), Yogyakarta (4) The 16th Asian-Australasian Association of Animal Production Societies Congress
- Four symposium and workshops
- Four oral / poster presentations at international conferences
- Two oral presentations at seminar and workshop

IN-DEPTH STUDIES (7.0 ECTS)

- Experimental methods in social science and inter-disciplinary research, 5th – 9th January 2009
- Advanced statistics, 11th – 13th February 2009
- Genetic resource policies and conservation strategies for plant and animal genetic resources, 12th – 30th April 2010
- Data analysis, 2nd – 8th June 2010

PROFESSIONAL SKILLS SUPPORT COURSES (4.0 ECTS)

- Techniques for writing and presenting scientific papers
- PhD competence assessment
- Project time management
- English course (CENTA), October 2008 – February 2009

RESEARCH SKILLS TRAINING (6.0 ECTS)

- Preparing own PhD research proposal, September 2008 – March 2009

DIDACTIC SKILLS TRAINING (11.0)

- Lecturing
- Supervising theses : Local supervisor for thesis of Marjon Schultinga, Wageningen University
- Supervision planned for students at Universitas Gadjah Mada: Aditya Kurniawan, Febri Ariyanti, Tesa Riatnawati and Adam Khoerul Anam

MANAGEMENT SKILLS TRAINING (1.0 ECTS)

- Official of Lustrum Seminar at Universitas Gadjah Mada

TOTAL ECTS 43.0

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