Case study 2: Developing an integrated production system for Bali cattle in the eastern islands of Indonesia

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The low weight of Bali cattle for sale was a major issue related to smallholder farmer poverty and an impediment to the development of a cattle industry in the eastern islands of Indonesia. An ACIAR-funded project team[7] established that the low weight was due to poor management, particularly nutrition, which led to low reproductive efficiency, and poor survival and growth of the calf.

The ACIAR research team worked with villagers to introduce a simple management system aimed at increasing pregnancy rates in lactating cows, reducing calf mortality, reducing the bull cost per calf, and increasing average post-weaning growth rates and survival. These strategies should minimise costs, increase turn-off rates, reduce average turn-off age and increase net financial returns.

This case study outlines the approach taken in developing an integrated management system for Bali cattle, with emphasis on both successes and failures.

Rationale for the project

Smallholder farmers in eastern Indonesia have been major suppliers of beef cattle to the local markets and to the large market in Java for decades. However, the growth in the market has outstripped the local capacity to supply, with imported live cattle meeting 20–25% of the beef market in Indonesia. Two of the important elements for the potential successful introduction of new ideas and technologies were in place—a strong market demand for the product and a demonstrated willingness by farmers to use their cattle to generate income. ACIAR commissioned this project to develop strategies to deal with the shortage of Bali cattle for the Java markets and the low liveweight of the cattle sold into the market.

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Typical farming conditions and systems

In eastern Indonesia there are two contrasting environments—the wet tropics as characterised by Central Lombok and Bali, and the dry tropics as characterised by parts of Lombok, Sumbawa, Sumba and West Timor. The project focused on two locations in East Nusa Tenggara province: Central Lombok and Sumbawa. Annual rainfall, typically 1,500 mm and 1,100 mm respectively, falls predominantly between November and May. The minimum and maximum ambient temperatures of 23 °C and 33 °C are relatively constant throughout the year and similar for both locations.

Central Lombok consists mostly of lowland areas, 100–500 m above sea level. Farmers grow one or two rice crops under irrigation, followed by a cash crop such as soybean or vegetables. Sumbawa is hillier than Central Lombok, and up to 1,700 m above sea level. Here, one crop of either rice or mungbean is grown in upland rainfed conditions or, where irrigation is available, one or two rice crops are followed by a mungbean crop.

The main cattle species in both areas is Bali cattle. In Central Lombok, animals are tethered in either stalls (wet season) or in the fields (dry season) during the day and at night are confined in a communal pen (kandang), and fed mainly cut-and-carry feeds of shrubs and grasses. In Sumbawa, cattle spend a larger portion of their time free-grazing during the day, including rice straw on fallow paddy fields, but are confined to communal pens at night. Cattle are used for draught in both locations, with peak requirements from November to January. Animals older than 2 years are used for an average of 4 hours/day.

Approximately 80% of household members contribute to farm production in some way, with no external labour used. Labour requirements are highest during cropping activities, with cattle raising the only farm activity between crops. In Central Lombok, male household members typically seek external employment during the dry season, while females of the household produce woven handcrafts. Cattle management becomes the responsibility of the women of the household when the men are involved in other activities.

Bali cattle in a communal village kandang in Central Lombok.

Bali cattle grazing communal land in the dry tropics of Sumbawa.

Perceived and real problems

The low weight of Bali cattle for market sale was thought to be due to genetic regression for growth rate and mature size, and an inherently low reproductive output. The genetic merit of the cattle was seen to be declining as a consequence of the regular sale and removal of the better quality Bali cattle bulls for slaughter or for sale to Java. As evidence, it was often quoted that in the past bulls around 350 kg liveweight were regularly sold; in contrast, the industry currently accepted bulls as low as 250 kg liveweight to meet market demands from Java.

An ACIAR-funded project,[8] involving geneticists from various Indonesian agencies, concluded that there was no evidence of genetic regression—bulls of mature size up to 750 kg were seen, most Bali cattle were in good body condition reflecting adaptation to their environment and their inherent fertility appeared high (Lindsay and Entwistle 2003). Indeed, the random mating in practice was likely to result in stable genetic merit. Low turn-off weights and fertility rates appeared to be mostly a function of nutrition, an effect of available diets and management.

The specific problem identified by the project team was an inappropriate matching of feed supply with animal requirements, resulting in inappropriate calving patterns (a high proportion of calves born in the peak of the dry season) leading to reduced calf birth weight, high calf mortality rates, and low growth rates of suckling calves and other juvenile cattle (i.e. poor reproductive efficiency). Also, many females did not calve until 3–4 years of age, and this was followed by a long inter-calving interval.

In addition, during the past decade, there had been an emphasis on the expansion of cropping enterprises, to the detriment of the livestock component of the mixed crop–livestock farming system. Farmers were forced to sell cattle at younger ages and lower weights to alleviate cash-flow problems experienced with various cropping activities and the general economic downturn.

This situation, coupled with increasing demand for beef from Java, resulted in younger turn-off ages and lighter turn-off liveweights. There had also been a purported decline in cattle numbers in the eastern islands of Indonesia during this period, but this may be an aberration in the method of data calculation.

Other social perceptions, cultural beliefs and regulatory issues were identified that also influenced the productivity of the beef industry, or at least the adoption of technology and innovation. These issues included:

- cattle viewed as a saving for expenditure when needed, with cattle ownership and management indicative of higher social standing

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- adult cattle required for draught associated with cropping activities, particularly during the early wet season, which meant that calving in the wet season to improve nutrition was not suitable and hence strategies were needed to cope with calving in the dry season
- calves not weaned, and a perception that cows spontaneously stopped lactating after 6 months
- bulls rarely kept specifically for natural mating and no existing commercial bull-producing sector; farmers thought that bulls were unable to impregnate more than 10–20 females/year, and bulls were more likely to be traded as they returned a higher price than females and were considered difficult to manage
- cattle penned or tethered during the wet season, meaning feedstuffs were cut and carried, water access was limited and conditions may have been unhygienic
- villagers generally eager to adopt low-risk, low-investment strategies that had a high probability of increasing return on their capital and labour investment—apparently because most villagers have financial constraints
- cattle theft as a major problem in some areas, resulting in continual guarding of cattle, facilitated by communal penning at night
- most cattle sold to visiting traders, with villagers apparently having very low bargaining power—this was exacerbated by a low ability to accurately estimate animal liveweight and a lack of information on market prices
- local regulations in many areas requiring artificial breeding be used in preference to natural mating—as a consequence, crossbred cattle (such as Bali cattle crossed with *Bos indicus* or *B. taurus* breeds) caused specific problems with fertility and mature size of the crossbred cow (hence an increase in feed requirement).

Project objectives

The main objective of the project was to evaluate animal management and nutritional strategies and devise ways of improving the productivity of cattle in the eastern islands of Indonesia. Simple management systems and limited, targeted feed supplementation, with the specific aim of manipulating feed supply, were needed to:

- increase pregnancy rates in lactating cows
- reduce calf mortality
- reduce the bull cost per calf
- increase average post-weaning growth rates and survival.

Rural scene in Sumbawa, Indonesia

The aims were to minimise costs, increase turn-off rates, reduce average turn-off age and increase net financial returns. Fordyce (1998) demonstrated the efficacy of such a system in the dry tropics of northern Australia, achieving an average weaning rate of 83% for a *Bos indicus* × *Bos taurus* herd, using very low but strategic inputs.

The project team determined that an integrated system of tools encompassing aspects of animal nutrition, reproduction and health was needed to improve farm productivity and that establishing the system at two demonstration sites would be a key to the success of the project.

Project operations

The researchers' approach was to use existing information to provide the most likely solutions and then to test these within a village scenario. The project occurred in three phases:

- development of an integrated management system for Bali cattle in the eastern islands of Indonesia
- development of a technical extension package in reproduction and nutrition, with an emphasis on system development
- evaluation of some low-cost supplementation strategies.

Phase 1: Integrated management system

The project team adopted a systems approach, applying the technology most appropriate to the situation and making modifications as results came in. This approach works at a range of scales, and its success can be gauged by a marked improvement in weaning rates and growth rates, and a rise in the number of cattle sold from a stable herd size. However, the strategy had not previously been tested at the village level in Indonesia.

Research in Indonesia had looked at ways of improving cattle productivity but these had not been put into an integrated management system that would take into account the farming system context. The project team expected that development of such a system, comprising a simple set of management rules, could easily be applied and would quickly change the economic outcome for farmers through sale of cattle. Using this approach, the team established a best management system, using information gathered from around the world. The system was implemented at the village level with careful monitoring, and outcomes from each year were the basis for modifications in subsequent years.

Success relied on three components:

- knowledge of the reproductive and nutritional requirement of cows
- controlled mating, bull management and weaning of the calf

- development of low-cost supplementation strategies for the cow and weaned calf, depending on the feed supply profile for the year.

Initial meetings developed the best system for each of the two regions, taking account of the biological requirements of the animals and the availability of forage and other nutrient resources. One outcome sought was to train people in how to put systems together and thus use the vast amount of component research knowledge already available.

Sites from the wet tropics and the dry tropics were selected in 2001. Criteria for selecting the villages included having a representative climate, a predominance of Bali cattle, breeding cattle as a significant part of the village cattle business, accessibility by project staff, and villagers willing to participate in a 3-year monitoring program and prepared to adopt different cattle management practices. Two villages on Lombok (cut-and-carry systems) and two on Sumbawa (grazing) participated in a comparison of Bali cattle management.

One 'control' village on each island (Tandek, Lombok and Village S, Sumbawa) maintained prevailing management. The second 'intervention' village from each island implemented either all (Kelebuh, Lombok) or components of (Village B, Sumbawa) a new management system. The components of the system included:

- selection of a bull to meet breeding objectives
- natural mating over a period that suited seasonal conditions, cropping activities, draught power requirements and social constraints. Discussions were held in each village to determine the optimum time for mating, and it was agreed that the seasonal mating period would only be reduced from the initial (conservative) period of 12 weeks set by the villagers if conception patterns indicated no risk of reduced fertility
- weaning of calves at 6 months of age or younger. To achieve permanent separation of the calf from the cow, a weaning pen was introduced, and it was suggested that cows stay near the pen for up to 3 days after separation from the calf, and that calves be penned for 2 weeks on full hand feeding and managed separately from their dams after weaning
- strategic diet management, such as the growing of tree legumes and feeding them to calves
- composting of animal waste, which was introduced as a method of producing a fertiliser; it also assisted in the control of parasites and improved the sanitation of animal housing, particularly during the wet season.

Each 'intervention' village nominated a team to purchase a breeding bull (using project funds) and then nominated a villager as the bull manager. The manager was compensated by retaining funds surplus to purchase costs when the bull was sold, and accepting mating fees as arranged within the village. The manager was

Controlled weaning of Bali calves occurs at approximately 6 months of age as part of the integrated village management system established on Lombok.

*Higher quality feeds such as tree legumes (*Sesbania *spp.) are established (top) and used (bottom) as part of the integrated village management system established on Lombok.*

Bull mating pen and natural mating of Bali cattle as part of the integrated village management system established on Lombok

expected to prepare suitable housing for the bull and provide infrastructure, such as a mating pen and methods to achieve mating when cows were in oestrus during the mating period. The project initiated a bull competition, in collaboration with Dinas Peternakan in Central Lombok and Sumbawa, which proved to be a successful extension tool. It identified 'good' bulls and this strategy, despite criticism from a quantitative genetic perspective, has a role in the social and technical aspects of bull selection.

A support technical officer was assigned to each island to assist with data records and to provide assistance when a new management system was introduced. A book-based data-recording and management system was introduced to record all production parameters. Each animal was identified. Recorded data was primarily descriptive, with a focus on:

- growth—weight, girth, height and body condition, and changes in these in relation to season, year and animal sex, and age
- fertility—conception of heifers and lactating cows, gestation length, calf loss, calf output, and distribution in relation to female age, bull matings and calving date
- other—weather patterns, management descriptions, diet descriptions and costs, and inputs for economic modelling.

Phase 2: Technical extension package

The aim was to identify what villagers wanted to hear about and, while delivering that information, provide the information needed to develop the integrated management package. The project team surveyed practices and perceptions as well as social issues relating to Bali cattle production, and then identified the needs for future training. Project members used village demonstrations as an important means of gaining information. They determined that farmers did not make effective use of government advisers, nor did they regard overseas experts as very relevant.

Young people and women had different perceptions to men on various issues; they were interested in information but, depending on the island, had variable roles in cattle production. All were averse to risk and reluctant to spend money or adopt a practice that might delay mating and production of a calf.

The villagers deemed that the main focuses of future extension were disease management, improving dry season nutrition and improving cattle fertility. The team considered these needs in developing the extension material. However, these

factors were the symptoms of the larger problem of inappropriate management rather than problems in their own right. It was improbable that the villagers or the discipline-oriented extension services could see the problems and potential solutions in the wider context. This made the acceptability of the potential solution, provided mainly be external sources, more problematic.

Phase 3: Feeding and supplementation evaluation

The success of the integrated management system for Bali cattle in eastern Indonesia relied on the more efficient use of scarce feed resources. A potential solution was to provide high-quality forages to lactating cows or newly weaned calves while allocating low-quality roughages for non-lactating cows.

In developing a weaning strategy for Bali calves and finding a feed source for non-lactating cows, the project team evaluated the suitability of a range of forages and supplements as feedstuffs. Experiments were held at the University of Mataram, Lombok, and the University of Nusa Cendana, West Timor. Commonly available forages (king grass, sorghum grass and rice straw) were fed as basal diets to young Bali heifers and non-lactating cows, and supplemented with a range of locally available by-products (copra meal, rice bran and corn meal) or alternative feed sources (leucaena and palm pith). A metabolism study and a fasting study (to estimate endogenous purine derivative excretion—a means of establishing the efficiency of protein supply) were also held on both Lombok and Sumbawa using heifers and cows. In addition, a heifer growth study was conducted on Lombok.

Development of relationships

The key factor in the development of good communication and relationships within this project was for the project members to cultivate an understanding of both the Indonesian and Australian cultures and an appreciation of the differences between them. These connections improved when an Australian Youth Ambassador[9] for Development was deployed in Lombok to work on the project—there was an enthusiastic exchange of information. Team members adjusted themselves well into the new teamwork environment, and the trust and confidence gained fostered an appropriate approach for working with the support agencies and the farmers.

Farmers have concentrated on expansion of their cropping enterprises to the detriment of the livestock component of the system.

9 Australian Youth Ambassadors are volunteers jointly sponsored by the Australian Government and the host agency; they spend 6–12 months on location providing assistance in a range of activities. There are numerous examples of the multiple benefits when they are involved in ACIAR-supported projects.

Results and observations

Village selection

The selection of villages was a key determinant of the success of the project. On Lombok, Kelebuh (intervention) successfully implemented all management practices and received excellent technical support, while Tandek (control) successfully maintained its existing management practices and production levels, which were similar to the level at Kelebuh before the new management practices were implemented.

By contrast, both villages on Sumbawa essentially remained control villages. The Sumbawa 'intervention' village (Village B) did not change management sufficiently to elicit a change in production due to a combination of the individuals involved, a lack of appreciation by the project staff of exactly what would be optimum for this situation, and irregular technical support. Data collection for cattle at the Sumbawa sites was much less complete than at the Lombok sites, reinforcing the concept that significant time must be devoted to establishing good working relationships with support staff and villagers. The key to the success on Lombok was having an enthusiastic local person employed by the project working closely with villagers on a daily basis. This realisation was the backbone of two projects mentioned in Case study 1.

Cattle control and diets

In Kelebuh, animals are usually kept in their stalls during the wet season. During the dry season, animals are tethered away from the stalls during the day, but in busy periods some animals may be held in the stalls during the day. The cattle are fed in stalls with the feed available in bunks. Throughout the year, cut-and-carry forage provided the bulk of the animals' diet. Approximately 80% of the cut-and-carry diet for Kelebuh cattle is green grass during the wet season, with the balance being fresh forbs (broad-leaved herbs other than grass).

During the dry season, 70–90% of the diet is a mix of dead and mature grass and rice straw. The composition of the diet was the same for all ages of animals. The daily fresh weight of the diet was on average 30–35 kg/adult during the wet season, and approximately half that amount during the dry season. It took an average of 2.5–3.0 hours to collect the feed for one adult cow when grass made up most of the diet; the time taken was reduced to 1.5–2.0 hours when rice straw was a significant component of the diet. Estimates of the feed provided were approximately 50% above expected voluntary feed intake for these cattle. This arose largely because of wastage in the feeding process, with feed dropped and trampled by the cattle.

At Tandek, animals are tethered at all times; at night in the village collective, and during the day usually where a family member can guard the animal. Because of continuous cropping, all animals are hand-fed, with most of the diet being grass. During the wet season, approximately 35–40 kg of feed is provided to each adult daily, with this reducing to 20–25 kg during the dry season. The time taken to cut and carry the feed to each animal daily increased from an average of 1.5–2.0 hours in the wet season to 2.5–3.0 hours during the dry season.

These observations suggest that animals were being offered up to twice their expected voluntary feed intake. Feed wastage at Tandek was much higher than in Kelebuh, as fewer farmers fed from bunks. With feed valued at Rp1,000/hour taken to collect it, annual savings of up to Rp100,000/animal might be made if 10% less time was taken to collect 20% less feed. Some of this surplus money could be used to improve housing and feeding facilities for the cattle and thus enable more efficient feeding.

Management of Sumbawa Village B cattle differed markedly from that on Lombok. During the day about 70% of the cattle were tethered, with the remaining 30% free-ranging. At night one group of villagers (subvillage A), either tethered or penned their cattle, while in another group (subvillage B) about 10% of the cattle were not controlled at night. Most of the diet during the wet season is grass harvested by the tethered or free-ranging animals. During the dry season, the estimated proportion of rice straw in the diet rose from 0% to 50%. The time taken to manage feeding each animal daily was estimated at 0.3 hours, irrespective of age and season.

Cattle from Sumbawa Village S received a similar diet to cattle from Sumbawa Village B—mostly grass and forbs, with the quality deteriorating as the seasons progressed from wet to dry. As the cattle in this village are mostly free-ranging, a maximum of 20% of their diet is rice straw, mostly from grazing fallow rice paddies. The time taken to manage feeding and its valuation was the same as for Sumbawa Village B between December 2001 and May 2002, but thereafter the reported time taken was 30% less.

Cattle fertility

The adoption of the integrated management system in Kelebuh, Lombok, in late 2001 and early 2002 shifted the calving and weaning patterns for calves born in 2002 and 2003 (Figure 9). In both years, calving started in late March but was 75% complete in June 2003, in contrast to only 50% complete in the previous year at the same time. The average calving date moved from mid July to mid June.

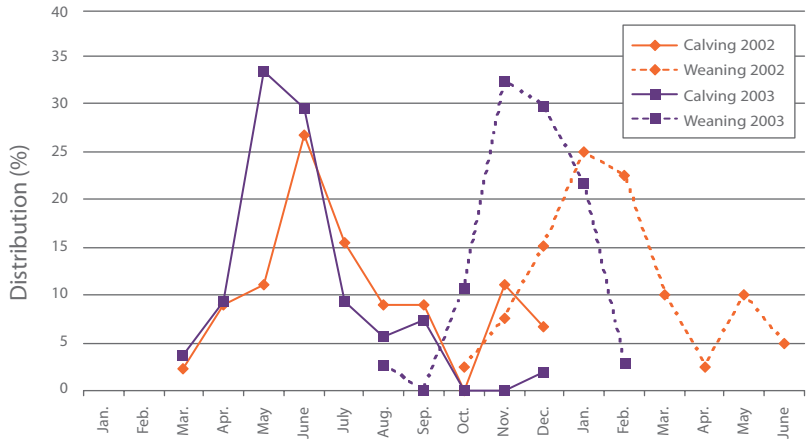

Figure 9. Calving and weaning in Kelebuh before and after the introduction of the new integrated management system, January 2002 to June 2003

Calf mortality rate was 4% in 2002 and 2% in 2003. By January 2004, almost all new-management calves were weaned, whereas weaning continued for several months past this point in the previous year. Figure 10 demonstrates that, after the management changes were implemented, the calving to conception interval averaged 70 days (30–120 days for 95% of cows) and that 80% of first-lactation cows and 90% of mature cows reconceived by the end of mating. This enables a high proportion of cows to wean a calf annually, with an average gestation of 287 days.

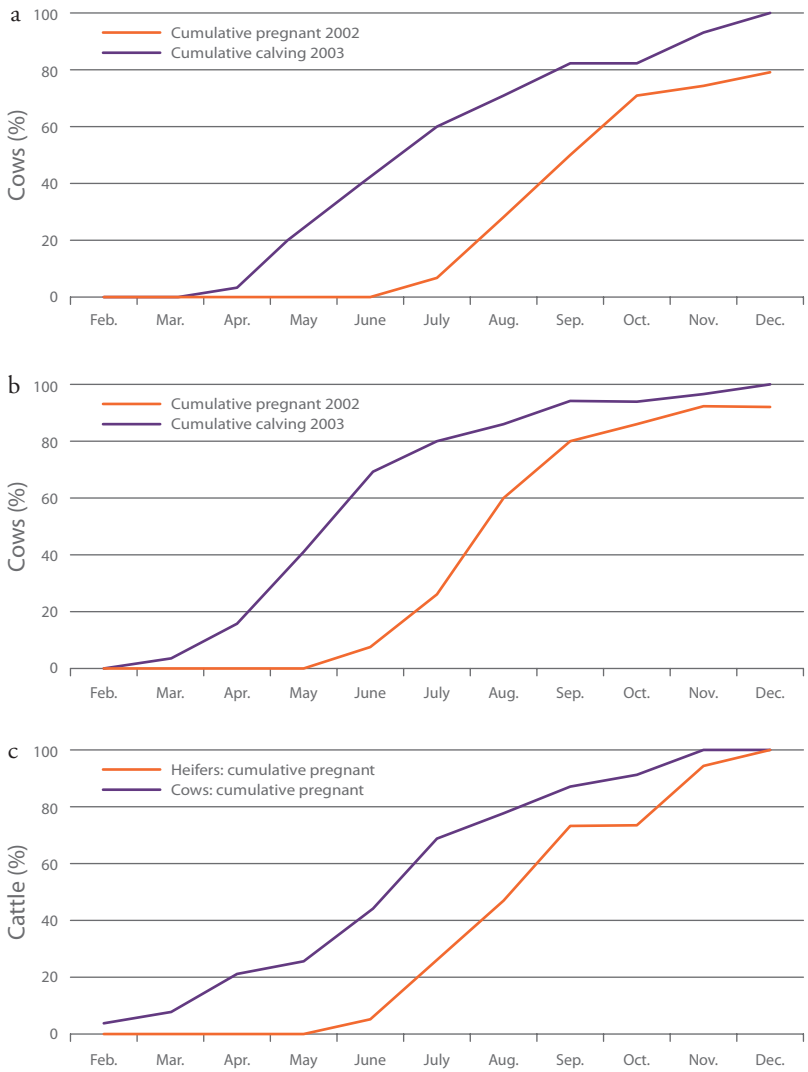

Figure 10. Cumulative calving and reconception patterns for (a) first-lactation cows, (b) mature lactating cows and (c) dry cattle in Kelebuh, 2002 and 2003

First conception was achieved in 80% of heifers within 3 months of the start of mating, and 100% within 6 months. The available data do not reflect the full impact of new management, as the early births of 2003 calves would result in heavier heifers by the start of mating in 2005 and a more compact conception period.

The villagers at Kelebuh showed that one bull could handle the mating requirements of 4–5 females/day under the mating management system used (oestrus females introduced to a penned bull) and achieve a very high number of conceptions in one mating season (Figure 11). Available data indicated that pregnancy rate per mating was 70–80% (i.e. there was a 20–30% pregnancy failure per mating). This is within the normal range expected for cattle.

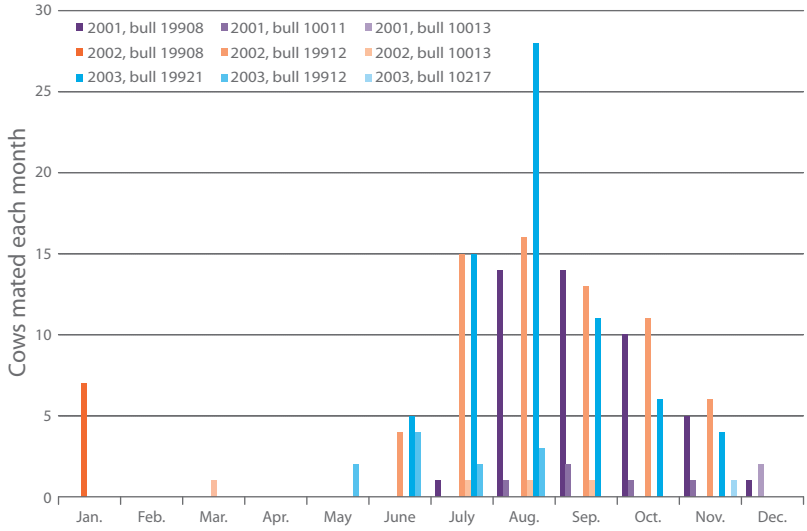

Figure 11. Monthly mating activities of selected bulls for 2001–03 in Kelebuh

Cattle growth

Pre-weaning calf growth averaged about 0.3 kg/day before the new management system, but has since risen to more than 0.4 kg/day. One outcome of the new management system was the significant increase in the average size of progeny (by 20–40 kg) by December when the average age was approximately 6 months. Post-weaning, growth in yearling female cattle was approximately 0.2 kg/day, but increased by 0.1 kg/day in heifers aged 1.5–2.5 years (Figure 12). The average growth rate of yearling bulls increased from 0.25 kg/day to 0.3 kg/day (Figure 13).

Since implementation of the new management system at Kelebuh, a combination of better calving and weaning times and improved growth rates has indicated that males would reach target weights approximately 6 months earlier than previously, and that females would reach mature size up to one year earlier (i.e. at 3 rather than 4 years of age). This has substantially improved the value of cattle and resultant cash flow. The regular monitoring of animal growth and condition, through liveweight and body dimension measurements, has demonstrated that girth was predictive of liveweight (Figure 14). Farmers at Kelebuh have found this relationship a valuable tool in valuing cattle at sale.

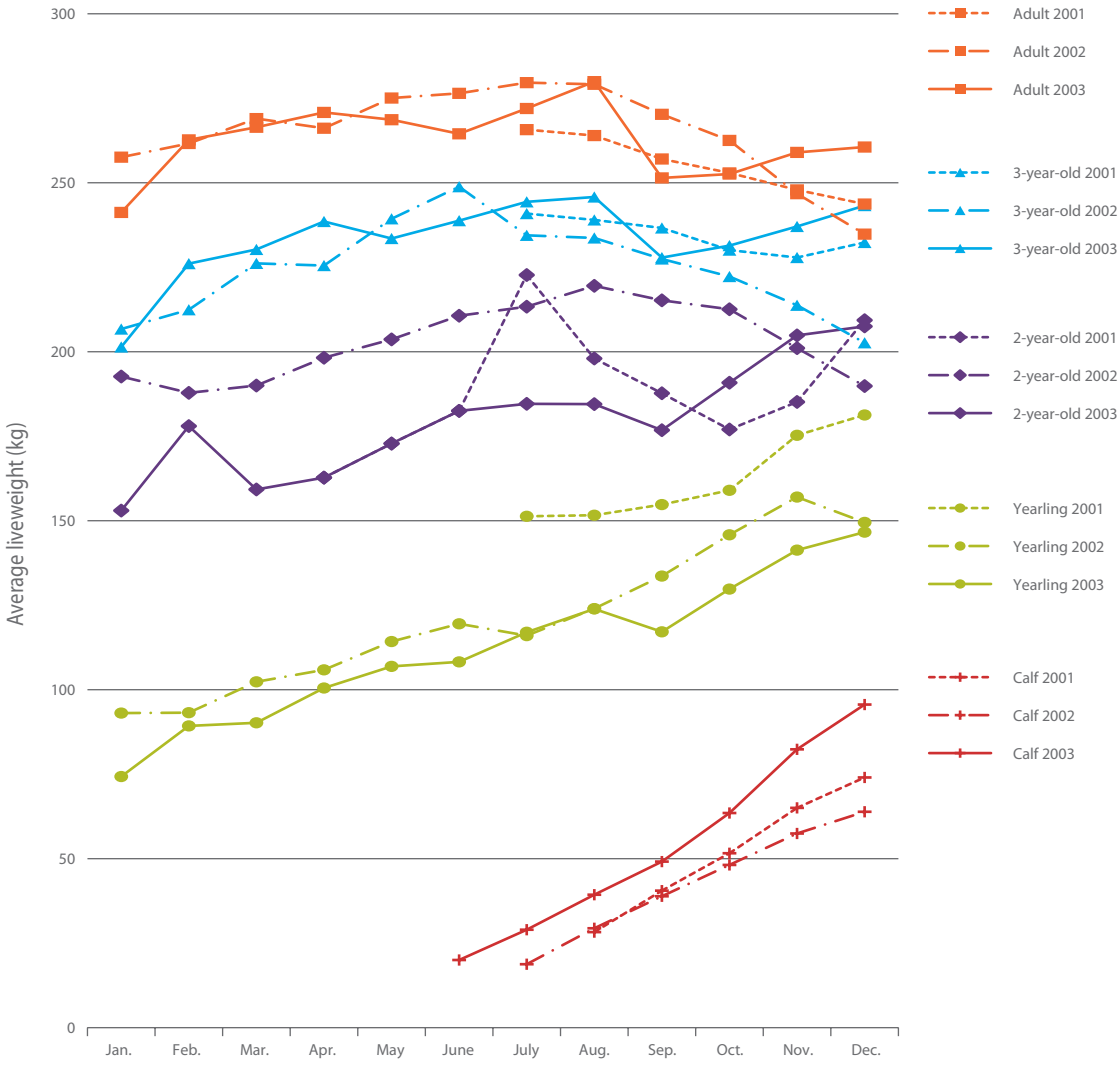

Figure 12. Monthly liveweight of various classes of female cattle in Kelebuh before and after the introduction of the new integrated management system

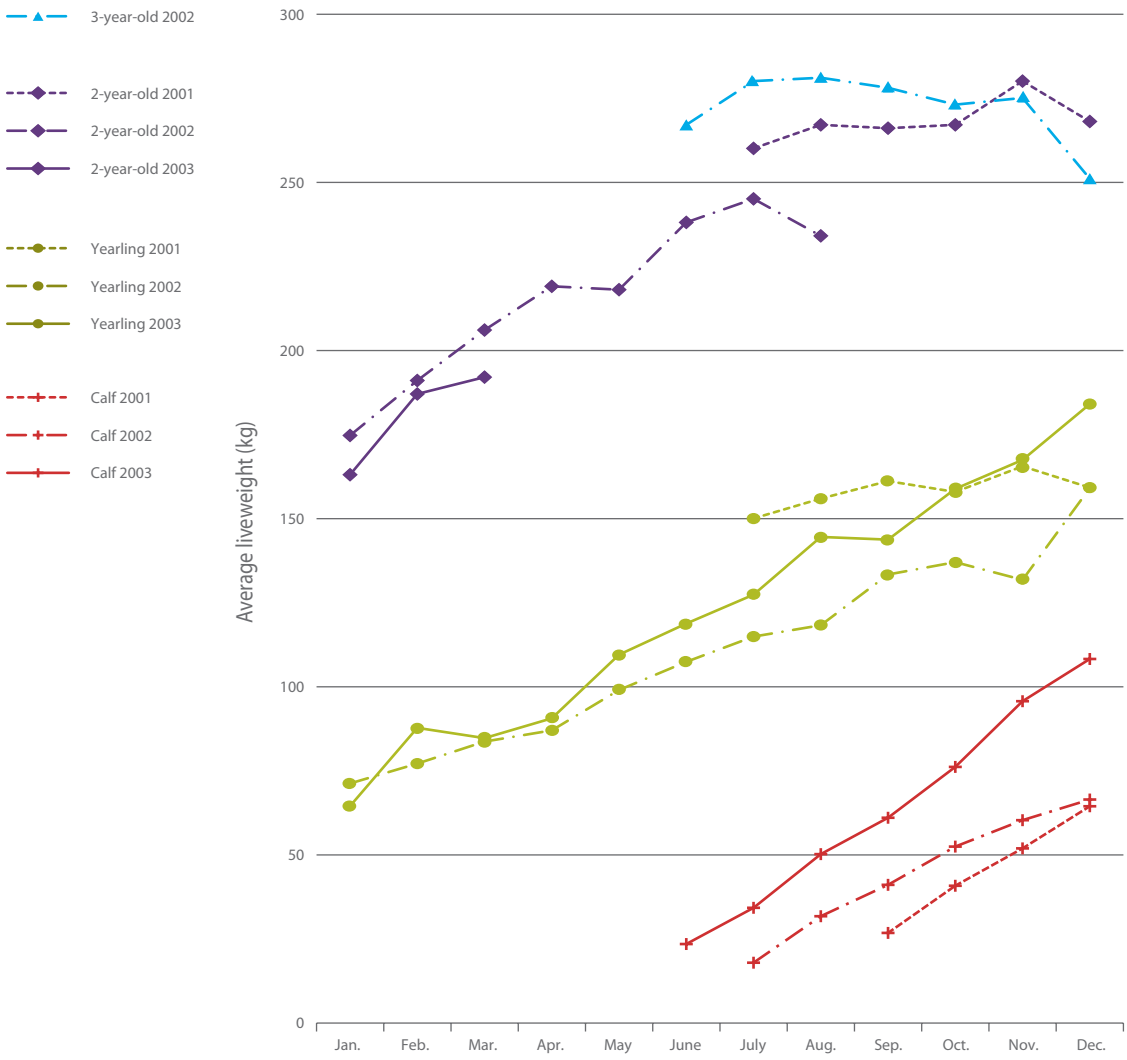

Figure 13. Monthly liveweight of various classes of male cattle in Kelebuh before and after the introduction of the new integrated management system

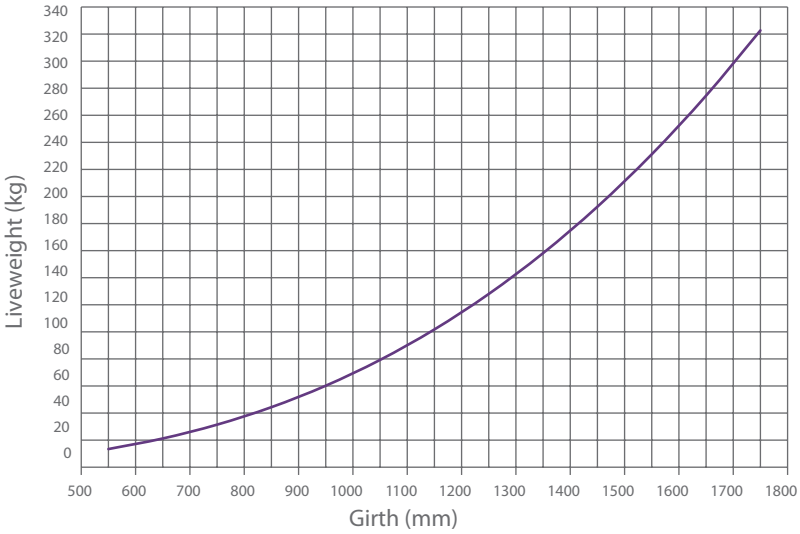

Figure 14. Relationship between liveweight and girth of Bali cattle in Kelebuh

Draught power

Draught power is still a major use of cattle, with cattle usually working for up to 4 hours/day, but occasionally up to 6 hours. Its importance was high in Lombok and low in Sumbawa, where buffaloes are preferred to cattle for draught (when available).

At Kelebuh, yearling bulls and females of all ages were used for draught power, with the peak month being December when animals were used for between 30 and 40 hours. In November, the average work time per animal was approximately 10 hours. Draught power requirements were much less over the remainder of the wet season, with no requirements during the dry season.

This feature of the farming system meant that the calving pattern had to fit in with the draught requirements; hence, contrary to biological requirements, calving was timed to occur in the early dry season. This also reinforced the need for weaning at around 6 months of age, as nutrient demand on the cow needs to be reduced as soon as possible.

At Tandek, draught requirements of cattle peaked in December and January, when approximately two-thirds of the available animals were used for between 20 and 90 hours/month. Very few animals less than 2 years of age were used. As cropping is continuous at Tandek, draught power is used throughout the year, with timing of crops dependent on seasons. Outside the peak period, each animal worked up to 30 hours/month.

The early wet season was also the peak draught period at Sumbawa Village B, where only females over 2 years of age were used for between 20 and 60 hours per month. There was also limited use of draught power for the second and third crops each year. In Sumbawa Village S, cattle were used for trampling rather than draught in preparing fields for crops.

Feeding and supplementation of young Bali heifers

In the development of a weaning strategy for Bali cattle, pen studies at Lombok and West Timor were used to evaluate feedstuffs. Each experiment involved eight Bali heifers weighing 77 ± 3.7 kg.

In Lombok, copra meal, rice bran and corn meal were evaluated as supplements to either king grass or rice straw forage. All supplements increased digestible organic matter intake (DOMI), with corn meal producing the largest increase. All king grass diets had approximately double the DOMI of rice straw-based diets. Microbial protein production increased markedly with king grass compared with rice straw, and with supplements on both forage types—primarily as a result of the extra DOMI but also in response to an increase in efficiency of microbial crude protein (MCP) production.

In West Timor, the control diet was wet- or dry-season sorghum grass with supplements of rice bran, palm pith or leucaena. All supplements increased DOMI, with leucaena producing the largest increase. Wet season grass diets were approximately 38% higher in DOMI than dry season grass diets. Microbial protein production increased markedly with all wet season grass diets.

The project team concluded that choosing high-quality forage was a more effective strategy than providing supplements for improving nutrition of weaned Bali heifers. Subsequently, a fasting experiment to estimate endogenous purine derivative excretion was conducted, working with the same eight Bali heifers, with the endogenous purine derivative excretion determined to be 277 ± 92 μmol/kg $W^{0.75}$/day.

Feeding and supplementation of non-lactating Bali cows

Experiments at Lombok and West Timor compared supplements with a rice straw basal diet, using five Bali cows allocated to five treatments.

The dietary treatments (dry matter basis) at Lombok were:

- RS (rice straw ad libitum)
- US–RS (urea or sulfate of ammonia at 2% weight/weight + rice straw)
- UMMB–RS (urea molasses multinutrient block at 0.2% weight/weight + rice straw)

- RB-US–RS (rice bran at 0.5% body weight + urea or sulfate of ammonia at 2% weight/weight + rice straw)
- Sesbania–RS (fresh *Sesbania grandiflora* at 0.5% body weight + rice straw).

The treatments in West Timor were:

- dry season sorghum grass, alone or supplemented with US or UMMB
- leucaena alone or supplemented with palm pith.

At Lombok, US supplementation increased rumen ammonia (NH_3-N) concentration but did not significantly improve dry matter intake (DMI) or digestibility (DMD), or MCP. UMMB did improve DMI but did not provide sufficient degradable nitrogen in the rumen due to its low urea content. Both RB-US and *Sesbania* significantly improved DMI, DMD and NH_3-N but did not significantly improve MCP. The results indicate that RB-US is a good supplement for the rice straw basal diet but only when the price is low. *Sesbania* appeared to be the best among the supplements evaluated.

In West Timor, the leucaena diets had much greater DOMI and digestibility, while supplementation of dry season sorghum with US or UMMB increased DOMI. Similar differences were found with MCP. Leucaena was by far the better forage, but sorghum grass could be improved to provide approximate maintenance levels of DOMI with the addition of simple nitrogen supplements.

A fasting experiment to estimate endogenous purine derivative excretion, using the same five Bali cows and another cow with similar body weight and condition, determined their endogenous purine derivative excretion to be 276 ± 142 µmol/kg $W^{0.75}$/day. This is significantly lower than levels reported for *Bos taurus* cattle (414 ± 37 µmol/kg $W^{0.75}$/day) but comparable to *Bos indicus* cattle (190 ± 37 µmol/kg $W^{0.75}$/day) using a similar fasting technique (Bowen et al. 2006). This suggests that it may be inappropriate to use the generic endogenous purine production value (385 µmol/kg $W^{0.75}$/day) proposed by Chen and Gomes (1995) when estimating microbial protein production in Bali cattle.

The project team on a site visit in Indonesia

Outcomes and impacts

Integrated village management system

The project resulted in the development of an integrated management system on Lombok (Figure 15) based on an understanding of management practices, seasonal conditions, other activities, and social and cultural beliefs. The outcomes after implementation of the integrated management system in the intervention village are listed in the adjacent box.

Outcomes of implementing the integrated management system

The village herd structure moved towards the earlier mating of heifers, an improved reproductive rate, concentrated calving and higher growth rates of calves, with a better cash flow and market opportunities. Outcomes of the new strategies were:

- 75% of all calving occurring between March and June
- increased weight of progeny by December (at an average age of 6 months, calves were 20–40 kg heavier)
- average calving to conception period of 70 days
- 80% of first lactation cows and 90% of mature cows conceiving in a defined mating period
- increased pre-weaning growth rate (from 0.3 kg/day previously to more than 0.4 kg/day)
- bulls reaching target weights about 6 months earlier and heifers reaching mature size 1 year earlier (at 3 years rather than 4 years previously)
- calf mortality of 2–4%
- determining that a single bull can mate with 4–5 cows/day over an extended period
- acceptance of weaning and the advantages it gives the cow.

Other benefits include:

- a 25% better cash flow compared with pre-existing conditions
- the introduction of measures in the village to keep the management system in operation
- new members involved in the management system
- a shift from manager status (share farmer) to owner–manager status.

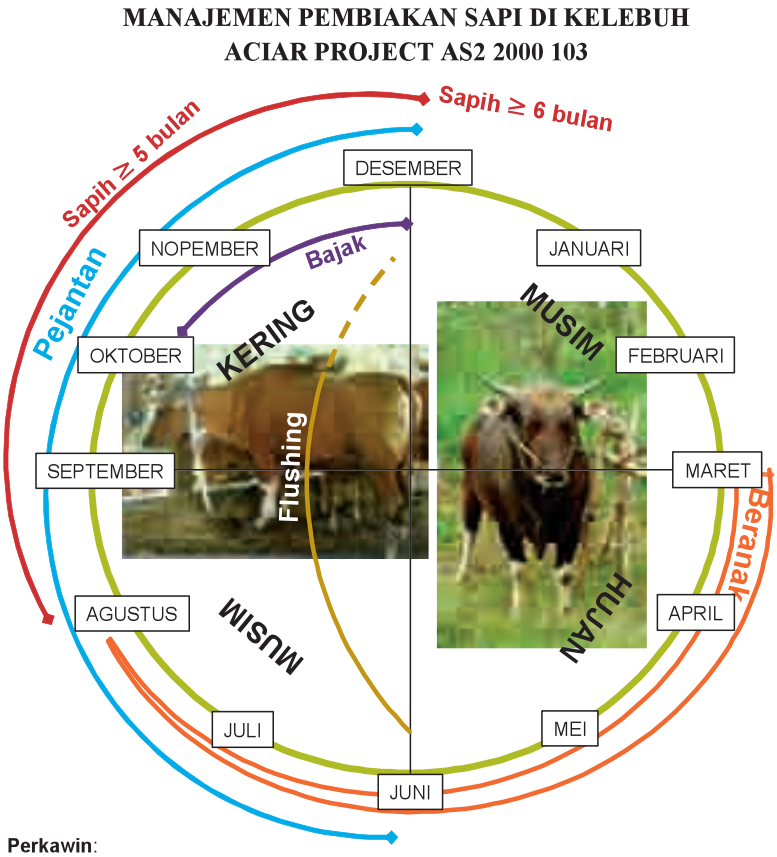

Figure 15. The management system described to farmers in Kelebuh

Technical extension package

There were two major outputs:

- annual cattle activity calendars
- a technical extension package.

The calendars listed the management activities for Bali cattle (e.g. mating periods, weaning) and were displayed in each village. Separate calendars were developed for Lombok and Sumbawa based on interviews with the villagers about the

timing of various events (e.g. wet and dry season) and activities (e.g. cropping, draught requirement, feed supply, religious or cultural observations, cash flow). For example, the best time biologically for cows to calve coincided with draught requirements, and it was not possible to use a cow in late gestation or early lactation for draught. This coincidence dictated the timing of mating and calving.

The technical extension package for smallholder cattle farmers was developed after detailed consultation with cattle owners in Lombok and Sumbawa. These consultations identified the owners' priority needs, and provided insights into the social systems and farmers' perceptions and practices, all of which influenced the style and content of the package. The package contains modules covering how to manage disease, manage dry season feeding and improve calf output using results from the demonstration sites together with other available information.

Feed and supplement evaluation

Feeding good-quality forages (i.e. fresh native grasses or tree legumes) to calves was better than using low-quality feeds with supplements. The low-quality forages such as rice straw are better fed to non-lactating cows, but require strategic supplementation to improve nutrient supply to the animals. Limited quantities of better quality forages should be used preferentially; recently weaned calves should have the highest priority, followed by lactating cows and then non-lactating cows.

As the availability of native grass is declining rapidly with the extensive land conversions to non-agricultural purposes, the use of abundantly available rice straw for non-lactating cows is highly recommended to reduce the cost of feeding.

In this high-humidity region, rice straw needs to be dried and stored properly before feeding. To meet the requirement for rumen-digestible nitrogen and sulfur when feeding rice straw, supplements of urea plus sulfur are used, but the increase in nutrient supply cannot meet the requirements, especially for cows in late pregnancy or lactating, nor for weaned calves. Supplementation of rice straw with *Sesbania* or leucaena, the tree legumes most acceptable to local farmers, is the best option both economically and practically.

Capacity development

The team developed capacity at multiple levels—the village, local project staff and associated agency colleagues, and students—to ensure the sustainability of the project and the ability of all stakeholders to conduct future projects.

Villages: Project members held meetings, workshops and study tours throughout the project involving farmers and agency support staff. All people directly associated with this project, especially in Kelebuh and to a lesser extent at Village B, substantially improved their knowledge and skills in the implementation of the

key management practices being used. Participating farmers are now able to better monitor their system and assess and modify management practices in response to changing conditions. Major developments for the Kelebuh villagers were the use of a calendar to record birth dates, mating dates and management activities as a means to manage and anticipate required husbandry, and the use of measuring tapes to estimate liveweight.

Local project staff and colleagues: Balai Pengkajan Teknologi Pertanian (BPTP) and University of Mataram (UNRAM) staff received training and developed significant capacity in all aspects of data collection and analysis, and improved their data management skills. Information being collated was highly diverse, including village biological data, survey data, and economic and market information data. Staff were also involved in the development of the technical extension package. For most local staff, this project provided the first opportunity to be involved in multidisciplinary research and to work collaboratively across institutions and with farmers. The lessons learned overcoming the constraints on operating in this mode have long-term benefits for the future development of the agricultural sector.

In addition, Dinas Peternakan staff members were involved in data collection, meetings and extension activities (e.g. the bull competition). The development of the extension package required both UNRAM and BPTP staff to conduct extensive survey work, which gave staff the opportunity to develop new skills, such as how to identify the needs of farmers, independent of any existing ideas (of their own or of the agencies). These processes clearly defined what smallholders in the region wanted to learn, and provided a wealth of information on social and cattle management practices—some of which some local team members had no prior knowledge of and of which the Australian team members had very limited understanding.

The international interaction also resulted in the recommendation of some team members for international training programs such as the 'IAEA training workshop on estimation of rumen microbial protein supply from urinary purine derivatives'. They then applied the newly learned techniques to the local problem.

All laboratory technicians received training in laboratory protocols.
The development of the economic model and the market analysis was a multidisciplinary team effort involving Indonesian and Australian staff.
This provided opportunity for exchange of information in economic principles, model development and use, and data management.

Students: The project enabled early career researchers to develop their capacity to conduct farmer-relevant research. Four postgraduate students, trained at the University of Queensland in Australia, and 20 undergraduate students, trained in Indonesia, were associated with this project. The PhD candidates, upon completion of their studies in Australia, returned to their home countries to conduct research in subsequent ACIAR-funded projects. The local Indonesian students studied aspects of nutrition at the University of Mataram and the University of Nusa Cendana. The students shared the materials and facilities provided by the project for their honours theses, gained valuable experience in conducting metabolism experiments to an international standard, and had the opportunity to interact with international scientists.

Learning from the project

This project allowed all participants to map a picture of the smallholder cattle farmer in the region. This included an understanding of the complexity of the whole farming system and the role of cattle production to support the livelihood of smallholders within that system. This knowledge was the platform for the participants to introduce a simple, low-risk management program that was acceptable to the whole system.

Communication played an important role in the success of this project, in terms of both delivery of the words and understanding of the messages from both sides. During the initial phases of the project, misunderstandings occurred when project participants did not understand the cultural differences in communicating responses. However, regular email and telephone correspondence, coupled with regular visits and meetings to refresh the project objectives, significantly improved the quality of communication. The maturity of personal relationships played an important part in developing trust and respect for each other's knowledge—which took time.

Summary of project impacts

Impact of the integrated village production system: This project was designed to develop an extension package through demonstration and evaluation of improved management, combined with evaluation of diet options for cattle.

Despite the limited output-oriented aims, the project achieved substantial impact, particularly in Kelebuh village where the villagers have stated that new practices would persist even if all agency support was withdrawn. The project also had a substantial impact on surrounding villages through the use of some of the management practices, including selection of superior Bali bulls, controlled natural mating, weaning (but there was high resistance to weaning young calves), and better nutritional and disease management. Further, an independent survey by UNRAM staff indicated that news of the benefits achieved at Kelebuh village

had reached more distant villagers (through family contacts), prompting the uptake of some of the management practices without any external incentives.

Better management has achieved astounding improvements in weaner output. Before the project, the annual weaning rate from cows in Kelebuh was approximately 60%, compared with approximately 90% with the new management system. In the first year of observations at Kelebuh, the pregnancy rate achieved in 2-year-old maiden heifers was 40% compared with up to 100% with the new management system. Calf mortality rate across other sites, and from anecdotal reports, appears to be at least 10%, which is far higher than seen in Kelebuh with the new system.

One advantage of the integrated management system was high calf output and calf survival. Another was concentrated calving, which highly impressed the Kelebuh villagers through its effect on ease of management and on integration of the cattle business with other enterprises. In Kelebuh, the project helped villagers develop simple weaning methods that resulted in no adverse effects on performance. This gave people the option to trade calves at much younger ages than most were previously traded or to retain calves to heavier weights at the same age as previously. Villagers have become more aware of achieving timely pregnancies and look to trade when it is apparent that pregnancy has not occurred. Both of these outcomes have required the development of new ownership, leasing or trading relationships.

Initial discussions with villagers indicated that most of them felt uncomfortable with using the bull for a limited period and weaning at the recommended young age. This is not surprising given that both strategies were foreign to villagers and local extension staff and researchers alike. However, these are essential features of the system and indicate impediments in attitude to expansion of the integrated project. Fortunately, the intervention village enthusiastically endorsed these strategies as they saw the benefit. This emphasises the need for demonstration or training villages as respondents in this survey and the extension surveys indicated that they rated information from other villagers more highly than from government agencies and visiting overseas consultants.

Economic analysis: An economic analysis, which took account of the specific production and social system, showed substantial benefits from using the improved management system. The analysis detected better cash flow (+25%) and higher gross margins at Kelebuh. If the weaned calf was kept for a further 6 months, until 12 months of age, then cash flow was increased by 65–120% depending on the growth rate. Owner–managers achieved greater returns than share farmers, and this appears to be leading many Kelebuh farmers to seek ownership. Access to credit schemes and better market information would accelerate this.

There has been a gradual change in the attitude and increasing acceptance of local staff to the new approach; this is even occurring in Sumbawa where the level of acceptance was initially very low. The support of local staff is vital in future incorporation of better management practices into smallholder Bali cattle operations. Further indications of impact and support come from the many senior official visits to Kelebuh, from agencies such as BPTP in Central Java and elsewhere, to see the new management system. The package forms the basis of a large project on Lombok to develop the system across the island.

Impact of the technical extension package: The technical extension package (management system and weight prediction) was made into a poster and calendar and distributed to Dinas Peternakan extension officers across the region and to collaborating farmers. The poster has been widely used by BPTP as part of an extension program to introduce this new management system into villages.

Impact of supplement evaluation: The initial benefit of this project component was mainly on the team members who received technical information that enabled them to assess village practices and make suggestions as to appropriate nutrition for different classes of cattle.

In particular, project survey data clearly demonstrated that weaning was contentious: farmers had reservations about weaning young and light animals. The demonstration of feeding lightweight calves was invaluable in convincing extension officers and a group of local farmers who saw firsthand the beneficial effects of the practice on the animals. Such demonstrations will be needed in the future to establish confidence in farmers that they can feed the animals properly with no long-term negative effects on the growth of the calf.