Case study 1: Crop–livestock farming systems in eastern Indonesia

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All household members contribute to the management of farm, non-farm and household activities.

Research to improve Bali cattle production for the smallholder households of eastern Indonesia was funded by three ACIAR projects.[3]

The project teams initially developed, tested and modified a project methodology that combined a process of participatory, on-farm engagement with farmers and the principles of farming systems analysis and modelling. This approach initially helped to identify specific economic, social and technical constraints that hindered the farmers' ability to raise healthy, productive cattle. The next step was to involve individual farmers in the development of 'best-bet' options to improve cattle production in the context of their farming systems. Trials of these options took place over more than 2 years, involving 40 selected households from four sites in eastern Indonesia.

This case study describes the research and its outcomes. It demonstrates how the uptake of these technologies is starting to bring substantial benefit to the smallholders, their families and communities.

Rationale for the projects

Bali cattle (*Bos sondaicus*) comprise about 25% of the total cattle population in Indonesia, but about 80% of the cattle population in the eastern islands (Talib et al. 2003). These cattle have traditionally provided draught and served as a source of accumulated capital to finance larger purchases and meet contingencies. Hence, most smallholder households with cattle would fall within the categories of livestock 'users' and 'keepers', rather than 'producers' (Neidhardt et al. 1996).

Major structural changes in the livestock economy across Indonesia may change this relatively utilitarian role of Bali cattle. The demand in Indonesia for beef cattle—both for meat (increasing at 6–8% per year, Talib et al. 2003) and live cattle for resettlement areas—currently exceeds the local supply. Imports of beef and live cattle from Australia (515,016 animals in 2007–08, MLA 2008) largely meet this deficit.

This buoyant market environment has created strong opportunities to increase smallholder household welfare by further integrating cattle 'production' activities into the traditional crop farming systems. However, Bali cattle numbers have purportedly declined in most areas of eastern Indonesia over the past decade. One reason cited is that farmers feel encouraged to sell bulls at a younger age, leading to village-level shortages of mature bulls. There are also reports of increasing numbers of young cows being slaughtered (Talib et al. 2003).

3 ACIAR project AS2/2000/124: Prospects for improved integration of high-quality forages in the crop–livestock systems of Sulawesi, Indonesia; ACIAR project AS2/2000/125: Optimising crop–livestock systems in West Nusa Tenggara province, Indonesia; ACIAR project AS2/2004/005: Improving smallholder crop–livestock systems in eastern Indonesia

A significant increase in the number and quality of Bali cattle will help meet the expanding demand. However, farmers need effective strategies to address the key constraints on cattle production of availability and quality of forages, especially during the long dry season (Wirdahayati 1994; Mastika 2003; Talib et al. 2003). The farmers depend heavily on locally available natural feed resources, but there is a shortfall due to limited land availability and uncertain local climatic patterns; moreover, Bali cattle do not thrive under these circumstances.

As with people in many developing countries, farmers in Indonesia have been slow to adopt improved grass and legume forages into mixed crop–livestock farming systems despite the availability of cultivars for most tropical environmental niches (Ivory 1986; Schultze-Kraft 1986; Horne and Stür 1999). Smallholders either have not sufficiently tested the various forage options, or they are unconvinced of the merits of improved forages in their livestock enterprises. However, there are examples in South-East Asia of smallholder farmers benefiting from introducing improved forage technology into mixed smallholder farming systems (Paris 2002; Horne and Stür 2003).

When the projects described in this case study began, the extension of 'proven' new technologies (e.g. artificial insemination) in eastern Indonesia typically occurred via large groups of smallholders in a 'one-size-fits-all' approach. In many instances, this is still the prevailing extension system. Contact with individual smallholders remains infrequent, especially in the more remote regions, reflecting the need to reach many smallholders with limited extension resources. This may be appropriate and effective for some 'generic' technologies, where the impact is typically positive and predictable. But processes designed to improve animal production may have both negative and unexpected outcomes, due to interdependencies between the crop, forage, livestock and human elements of the system. For example, the displacement of food crops with forage crops will invariably affect household food supply and labour usage.

In the more marginal and low-rainfall cropping areas of eastern Indonesia, where there is occasional crop failure, some smallholder households will see the purchase of food using the proceeds of increased cattle production as a lower risk food security strategy. Conversely, households in less marginal areas may reject this approach, even if it makes greater financial sense, on the grounds that they feel more secure producing their own food and having the required skills and experience to do so.

Successful forage adoption

The key to the successful forage adoption approach developed by Horne and Stür (2003) was the strong emphasis on farmer participation. Smallholder households in selected villages are engaged to diagnose and prioritise issues of interest. Potential solutions are identified and discussed with smallholder focus groups and a shortlist made of appropriate technology options for testing. This approach recognises the pre-existing knowledge relating to the most appropriate forage species for different environments in South-East Asia.

Preliminary trials are typically small, and results from monitoring and evaluating them are reported back to the rest of the community. Promising technology is likely to be expanded and integrated permanently into the activities of households. Other smallholders within the community and neighbouring communities are then influenced through extension techniques such as 'local champions', smallholder learning groups and field days.

Carberry et al. (2004) reported the potential value of using a farming systems approach and tools in the selection, analysis and communication of alternative practices on smallholder farms. Their study reflected the tight integration between the various biophysical elements (i.e. livestock, crops and forage), resources (i.e. land area and quality, feed supply, labour resources, cash availability) and social context (i.e. religion, cultural practice, risk attitudes) of smallholder households. They noted the additional complexity that arises from the impact of temporal climate variability and fluctuations on commodity prices and input costs.

It is therefore important when evaluating potential options for improving cattle production to consider the impact of such component changes on the overall farming system and the sensitivity of these system responses to fluctuations in climate and other factors. Simulation models that capture the key system processes and their interactions and response to change offer a good means for exploring these complex interactions. However, there are few examples of the successful application of simulation models actually leading to demonstrable impacts on smallholder farmer practice. The outcomes have had more effect on research direction or on the training of local researchers (Castelan-Ortega et al. 2003a, b; Carberry et al. 2004; Herrero et al. 2007).

Project objectives

This case study reports the findings from three ACIAR-funded projects conducted between 2001 and 2008. Overall aims were to:

- develop, test and apply tools and knowledge-sharing techniques for evaluating strategies to improve Bali cattle production for the smallholder households of eastern Indonesia
- communicate the outputs of the project to smallholders, both in the immediate vicinity of the case study sites and more broadly across eastern Indonesia (and also to other providers of research and extension services).

The approach combined the principles of farming systems analysis (Norman and Collinson 1985; Horne and Stür 2003) and whole-farm modelling. It considered the social, economic and biophysical impacts of change, with strong smallholder participation in all steps—benchmarking, identification of cattle/forage improvement options, in-field testing and communication of findings. The work involved a multidisciplinary team comprising forage, livestock and farming systems scientists, social scientists, resource economists and extension specialists who came from a range of Indonesian and Australian Government agricultural research, development and extension agencies.

Project operations

Project activities occurred at four sites in eastern Indonesia: Satuan Pemukiman A (SPA) village in Central Sumbawa; Lompo Tenggah, Pattappa and Harapan villages located within Barru Regency in South Sulawesi; Mertak village in Central Lombok; and Lemoa and Manyampa villages in the Parangloe subdistrict of the Gowa Regency in South Sulawesi.

Typical smallholder farming conditions and systems

Smallholder crop–livestock farming enterprises in eastern Indonesia are typically less than 2 hectares in area and support an integrated mix of crop, forage, livestock and human activities. The two basic land types are cropland and upland.

'Cropland', located close to the main residence, is used to grow a range of annual crops such as rice, maize, peanut and soybean. Usually this land is naturally flat or formed into terraces, with deeper, more fertile soils and access to simple irrigation. It may be bunded to retain overland flow. The length of the wet season (typically November–May) and accessibility to irrigation determine the selection, extent and number of crop cycles in one year.

'Upland', located farther away from the house, is larger in area and usually less accessible. This land, which often includes sloping ground with shallow and less fertile soils and with no access to irrigation, is used to grow perennial fruit (e.g. mango, coconut, cashew), fibre (e.g. kapok) and timber crops (e.g. teak, bamboo).

Although farmers also keep other livestock, including buffaloes, goats, ducks, chickens and geese, Bali cattle play a central and multifunctional role in these farming systems. Most significantly, they are a readily saleable store of capital to meet major household needs. Depending on the time of year, cattle either free-graze crop stubble, 'native' pasture or forages, are tether grazed, or are penned and hand-fed various mixtures of 'cut-and-carry' forage. Forage production tends to follow the seasonal climate pattern; maximum biomass production occurs during the wet season and declines to almost zero by the end of the dry season.

All household members contribute to the management and operation of farm, non-farm and household activities. Key farm activities include land preparation (e.g. ploughing); sowing and transplanting the crop; fertilising; chemical application; weeding; harvesting, threshing, bagging and transportation of the harvested product; cattle tending; forage gathering; and water gathering. Farmers often hire additional labour to assist with harvesting and land preparation activities. They may also seek supplementary income from off-farm activities—both agricultural (e.g. weeding) and non-agricultural (e.g. crafts).

The approach adopted in these projects comprised four key steps:

A significant increase in the numbers of Bali cattle will help to meet the expanding demand.

Step 1: Quantify and understand the farming system, and build relationships

At the outset, the teams sought to understand the functioning of the smallholder farming systems at the selected sites, and to quantify the associated resource flows and farm productivity. The information was used to identify participants for the study, to develop and parameterise a farming system simulation model (described in step 2) so the teams could explore and compare alternative management options, and to establish a baseline for comparing and evaluating the performance of alternative practices.

Participants in the study were selected based on the following selection criteria: Bali cattle were already part of the farming system; there was both on-farm capacity (e.g. feed/land resource availability) and willingness by households to improve cattle production; there was support from village leaders and district extension agency staff; and the sites were accessible and representative of activity at a broader scale.

The team sourced social and economic information from a combination of historical village records (i.e. secondary sources), semi-structured interviews with smallholder groups and individual smallholders, and the 'expert knowledge' of staff from the collaborating RD&E agencies. These socioeconomic data complemented other primary biophysical data relating to forage availability, feed management, cattle breeding cycles, cattle performance, soil characteristics and climate.

Local project staff familiar with village customs and language and with a history of activity in the target communities interviewed the farmers. Best results were achieved when two project staff were involved, one holding a 'guided' discussion with the interviewee/group and the other taking notes.

The benchmarking activities also served to develop sound relationships between the participating agencies and farming communities.

Step 2: Develop and parameterise desktop simulation tools

A smallholder household simulation model—the integrated analysis tool (IAT)—was developed, incorporating the key socioeconomic and biophysical processes and their interactions in smallholder farming systems. The IAT integrates three separate models: a pre-existing farming system model APSIM (Agricultural Production Systems Simulator), new models for Bali cattle growth and smallholder enterprise economics.

Model systems

The integrated analysis tool (IAT) allows users to define and calibrate a baseline case against which to 'design' and test alternative crop, forage and livestock management options. The output is presented as either a graph or table, describing biophysical characteristics of the system (i.e. crop and forage yield/biomass and animal liveweight gain), labour demand and supply details, and economic performance (available cash balances, gross margins and net income) over a 5-year period (a limit set by the animal production module).

The IAT also enables rapid assessment of potential production and socioeconomic impacts of changes in the system state (i.e. management, climate, soil, prices and costs). Less desirable strategies can be identified and discarded, leaving a shortlist of 'best-bet' options that households can then assess. This provides both project staff and smallholders with some confidence that the effects of actions they are about to undertake are unlikely to be adverse, and also enables a more efficient and targeted use of limited project resources. The user interface, in both English and Indonesian, is meant for easy operation by development or extension professionals working interactively with smallholders (not directly by, or in isolation from them).

The IAT has three component models:

- APSIM simulates the growth and development of many crop and forage types in response to site-specific soil, climate and management data (Keating et al. 2003).
- The Bali cattle model predicts liveweight gain and reproduction cycles over 5 years for cattle under local feeding and husbandry practices (including grazing and cut-and-carry systems for feeding forages and crop residues).
- The household economic model accounts for the key resource pools of labour, finance, land, household consumption needs and opportunities, forage and draught. It was developed to identify production, consumption and economic returns, and resource constraints associated with exploiting new forage–livestock opportunities.

Livestock yield and other animal data (e.g. projected temporal liveweight gain, calving dates) are exchanged directly between the livestock and economic models within the same spreadsheet. APSIM forage yield and quality data (from sources such as crop stover and forage crops) are inputs to the livestock model, and the simulated crop yield data are also inputs to the economic budgets embedded within the IAT.

Step 3: Identify strategies for Bali cattle improvement

Once the benchmarking was completed and the IAT developed, group meetings were held in each focus village where team members presented and discussed benchmark results to ensure their validity. Smallholder participants were asked to identify constraints on livestock production and nominate potential options to address them. Their constraints fell into three broad categories: those largely beyond the control of the individual farmer (e.g. access to finance); those for which the solutions were quite obvious and did not require detailed analysis (e.g. disease, stock water supply); and those for which the solutions and the implications were more complex (e.g. feed availability, breeding cycle). The team used the IAT to analyse potential solutions for this third group of constraints by using a single, representative farm–household configuration (for each village) and by comparing current practice with practice based on the potential solutions that had arisen from the smallholder workshop.

The team presented the results to the smallholders at a second workshop held 1 day later, to identify a shortlist of both feasible (i.e. practically and culturally) and viable (i.e. economically and environmentally) 'best-bet' strategies for improving Bali cattle production in the region. Approximately five households involved in the original benchmarking activity were then chosen from each village to participate in trials of selected best-bet strategies. The strategies were adapted to fit the specific physical, cultural and social circumstances of each household and its available farm resources.

Step 4: Test strategies in the field

Having reached agreement on these best-bet strategies, the next step was to test them in the field. These in-field trials provided:

- an opportunity for smallholders to experience and test the performance of the chosen strategies on their farms
- data for validating the IAT and related assumptions (both biophysical and economic)
- opportunities to demonstrate and communicate project findings and methods.

The trial sites were located in accessible, highly visible locations to facilitate extension activities. They served as a centrepiece for several field days that gave smallholders from neighbouring villages and other project villages the opportunity to view the technology on offer, view performance data from the monitoring activities, and hear firsthand the views and experiences of the best-bet households. To facilitate less formal, incidental exchanges between households and within smallholder groups before, during and after the field days, the team

Perennial legume cut-and-carry, Satuan Pemukiman A village, Central Sumbawa

Paspalum *and* Stylosanthes *at Harapan village, Barru, South Sulawesi*

erected permanent signs at each trial site detailing the objectives and methods of each trial. All materials were presented in Bahasa Indonesia and, where possible, the local language.

Impacts on forage availability and cattle performance were monitored using the same techniques adopted during the benchmarking activities and the results were regularly discussed with the participating smallholders. Team members periodically interviewed householders to evaluate their experiences and impressions of the technology, and held a comprehensive exit interview with each best-bet household at the end of the project.

Results, outcomes and impacts

Factors constraining livestock production, and potential solutions

Feed availability, quality and management: A shortfall in feed was identified as a major constraint on households at the Barru, Lemoa, Manyampa and Mertak sites, especially in the latter part of the dry season when cut-and-carry feed sources were severely limited. It also became clear to the project team that the farmers' knowledge of optimal feed management practices (i.e. when, how much and what to feed animals of different age and condition) was limited.

Strategies for improving the quantity and quality of feed options on-farm fell into three main categories: improved use and management of existing fresh forages and crops (especially tree legumes such as *Gliricidia* and leucaena, and elephant grass), introduction of new forage grasses and legumes to increase fresh forage supply options, and better use and improvement of crop residues (e.g. peanut, rice). The households were also advised on the correct amount and composition of feed required by animals of different age, condition and activity.

Breeding cycle: In most villages, the cows were not producing a calf every year due to the stress imposed on them by a suboptimal breeding cycle and delayed weaning. Mating occurred from late in the dry season to early in the wet season with calving (9.5 months later) during the following dry season. A lengthy weaning period followed, where the cow's milk was supplemented with cut-and-carry material. The lactation period coincided with the dry season when high-quality feed was in short supply.

Household labour focused on field preparation and planting of rice when the wet season began; consequently, the cutting and carrying of forages as supplements for tethered or housed animals became a relatively low priority. Furthermore, in the early wet season there was often an overlap between lactation and draught activities, with fields being ploughed in preparation for rice planting. Cows ploughing the field were often being followed by suckling calves. Additional stress can occur at this time of year when the diet changes primarily from dry forage to green forage as the wet season advances.

Bags of conserved crop residue, Satuan Pemukiman A village, Central Sumbawa

This cycle led to declines in the condition of lactating cows, calf growth rates and the reproductive ability of cows. To help address these constraints, households were encouraged to calve late in the wet season (March–April) and then mate no longer than 3 months later to encourage a 12-month cycle.

With this schedule, the cow was being used for draught at a safe time of the pregnancy (avoiding the final 2 months of gestation) and was not raising a calf at the same time. Furthermore, the calf was born at the end of the wet season when plenty of feed was available and the cow was in good condition. The households were also encouraged to wean their calves at a younger age (c. 6 months) and to preferentially feed them thereafter. Panjaitan et al. (2008) found this practice maximised calf growth rates and reduced the stress on the cow, especially during the dry season. More details on this strategy are provided in Case study 2.

Bull access: Limited access to a bull for mating was listed as a constraint in a number of the project villages. The bull shortage is attributed to the sale of most male cattle before breeding age to provide cash for large expenses such as schooling, house renovations, travel and, during a recent drought, for the purchase of food. Smallholder households typically pay for the services of another household's bull, but delays in availability severely reduce the efficiency of mating and conception. As the success of best-bet strategies relating to cattle breeding require ready access to a bull, a decision was made at Mertak and SPA to purchase bulls to service the cows of the best-bet farmers (and through negotiation, by other farmers). One of the best-bet farmers managed the bulls.

Recycling of household grey water, Satuan Pemukiman A village, Barru, Sumbawa

Improved cattle housing and feeding troughs, Lompo Tengah village, Barru, South Sulawesi

Stock drinking water: Sources of drinking water for stock are usually community wells, dams or individual household wells. Some households also capture rooftop water, but this is primarily used for family consumption. Typically, a member of the household spends part of the day (more during the dry season) collecting water from the communal source, although in some cases (e.g. SPA) water is trucked in from outside the village and delivered (at cost) to individual households.

Some households already captured water from their roof into the house mandi (water reservoir for domestic water supply) using simple guttering (e.g. bamboo). Rooftop water capture was promoted during the smallholder workshops as an efficient means for collecting water for both household and stock needs. Selected best-bet households were also provided with bags of concrete and plans to construct troughs for the capture and retention of household greywater (post-washing) for use as stock water. The team also recommended how much water to provide to cattle of different age, size, sex and condition (e.g. lactating, pregnant).

Cattle housing: In most of the project villages, cattle housing and feed troughs were either non-existent or poorly designed and maintained. This resulted in significant feed spoilage and may have promoted the incidence of cattle diseases and parasitic conditions. Advice on the potential benefits and optimum design of cattle housing and feed troughs was provided to each participating household.

Cattle health: Some of the smallholders at the workshops mentioned cattle disease and parasites as potential production constraints. However, these appeared to be relatively isolated and could be controlled by the existing drenching and immunisation programs of Dinas Peternakan.

Labour availability: Smallholders in the Mertak, Lemoa, Manyampa and Barru sites mentioned labour availability, especially during the dry season, as a constraint on increasing their commitment to cattle production. During this period, when there is no crop-related activity, adult males often work off-farm to generate additional income and leave tending the cattle to the rest of the family.

Access to capital: Another consistent constraint on increasing livestock production is access to capital. Smallholder households typically lack the cash reserves or access to loans to buy a bull or more cows for breeding. Hence, they must build up their herd independently through cow-sharing arrangements and breeding, and buy the services of bulls from others in often distant communities. Building up a herd is made even more difficult because smallholders frequently need to sell some cattle to release cash for other household expenses.

Modelling the potential impacts of these strategies

The teams used the IAT to explore and quantify how these strategies would impact on the whole-farm feed, labour and cash balances of a 'typical' household. They considered current farming system design, and then worked with the participants of the smallholder workshops to identify a series of changes. The model results were presented back to the smallholders in a simple table. An example from the Barru workshop is shown in Tables 1 and 2. Table 1 details the farm structure upon which the simulations were based, and Table 2 demonstrates the outcomes of some options.

Table 1. Structure of a 'baseline' farm used to simulate strategies to improve smallholder production using the integrated analysis tool

Farm structure	
Family	4 (2 adults, 2 children)
Land	0.6 ha lowland, 1 ha upland, 0.1 ha backyard
Living costs	500,000 Rp/month
Rainy season crops	0.54 ha rice lowland, 0.3 ha groundnut upland
Dry season 1 crops	None
Dry season 2 crops	None
Forage crops	None
Crop retention	None
Cattle at start	2 cows, 1 calf, 1 weaner
Cut-and-carry	30 kg/day
Plantation crops	None
Tree legumes	None
Commodity prices	
Rice	1,000 Rp/kg
Groundnut	3,500 Rp/kg
Beef (weaners)	10,000 Rp/kg
Beef (2-year-olds)	14,000 Rp/kg
Beef (old animals)	12,000 Rp/kg

ha = hectare; kg = kilogram; Rp = rupiah

Table 2. Outcomes for selected intervention options from the integrated analysis tool model

Case scenario	No. cattle sold over 5 years	Annual fodder surplus/deficit (kg)	Dry season surplus/ deficit of labour (days)	Final cash balance after 5 years (Rp million)
Option 1: baseline	6	–3,000	–10	14
Option 2: baseline + retaining 80% of groundnut residue	7	–1,000	+50	15
Option 3: option 2 plus 0.3 ha elephant grass on upland, 40% of dry season rice straw fermented	8	+5,000	+90	23
Option 4: option 3 plus increase number of breeding cows to 4, increase cut-and-carry to 40 kg/day	14	–1,500	+40	41
Option 5: option 4 but reduce beef prices by 20%	14	–1,500	+40	36

ha = hectare; kg = kilogram; Rp = rupiah

Over a 5-year period under current practice (baseline), the modelled household sells six animals, has a labour shortage for cut-and-carry in the dry season and a fodder supply deficit. It accumulates only Rp14 million.[4] Options 2 and 3 indicate how the household might address the fodder deficit by growing elephant grass on underused upland, retaining 40% of rice crop residue and fermenting it, retaining 80% of peanut crop residue, and growing tree legumes along bunds and fence lines.

Using these strategies, the farmer can increase offtake to eight animals, generate a surplus in both fodder supply and dry-season labour and increase the accumulated funds to Rp23 million over a 5-year period, all without interfering with the primary activity of growing rice. The surplus fodder then allows the farmer to keep more animals, with the potential for offtake to increase to 14 animals and funds of Rp41 million to accumulate. Naturally these projected outcomes will vary depending on the sequence of seasons that are actually experienced. Also, the households may be unable to implement all the interventions simultaneously; they are more likely to implement them in a step-wise fashion with subsequent incremental gains in animal offtake.

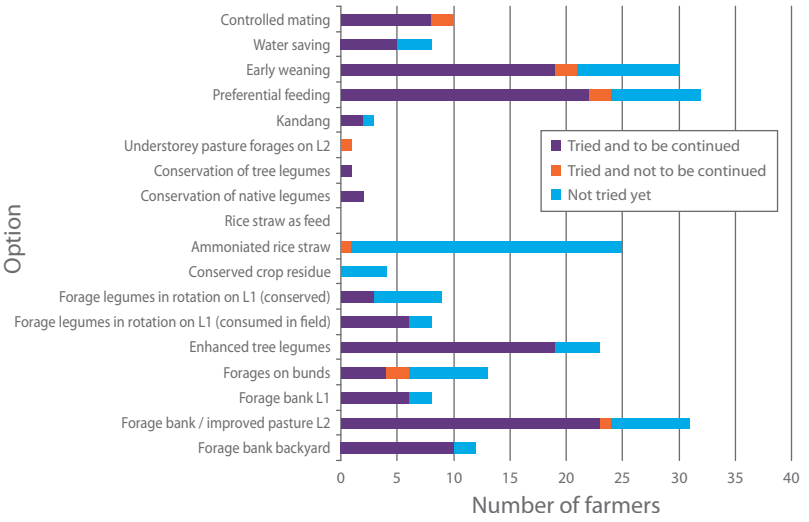
4 At the time of writing A$100 ~ Indonesian Rp850,000

Uptake of options by smallholder households

Figure 2 summarises the type, occurrence and status of best-bet activities across all sites, based on exit interviews held with the participating households in February 2008 (and other project records).

The project team identified 142 best-bet options relating to forage and cattle management for the 40 households; 85 were trialled between November 2005 and February 2008. Exit interviews with households at the end of the project confirmed that the main forage improvement practices—establishing mixed forage banks and either enhancing existing tree legumes or establishing new trees—were at some stage of adoption or would be introduced in the coming season.

Relatively few households reported that they had tried these practices and then decided to abandon them. The East Nusa Tenggara villages of Mertak and SPA were familiar with tree legumes, especially *Gliricidia*, and were more interested in using them than were the South Sulawesi villages of Barru, Lemoa and Manyampa. Only a few households had undertaken any form of conservation of forages or crop residues, preferring to use the material when it was available in the field immediately after harvest, or to burn it.



kandang = communal cattle housing overnight; L = lowland

Figure 2. Outcomes of 'best-best' activities at all sites in eastern Indonesia

Of the three main cattle management practices—controlled mating, early weaning and preferential feeding—more than half the households had applied the latter two. Most of the other households recognised the potential benefit of both practices and intended to use them when they had an appropriate calf. The timing and extent of household uptake of early weaning and preferential feeding depend on the availability of calves and (simultaneously) high-quality forage.

Active farmer participation is the key element for ensuring successful adaptation and adoption of forage technologies.

Although these options were identified in the original household interviews and canvassed with all households throughout the program, the farmers tended to tackle them once forage constraints had been addressed (in line with the step-wise approach described earlier). This mainly occurred in the second wet season, when the farmers had calves aged 6–7 months and high-quality forages were available.

Less than one-quarter of the households had practised controlled mating of their cattle. Most were mated independently, and failure to mate was largely due either to inability to confine cattle or difficulties in finding suitable bulls at the appropriate mating time. The highest rate of adoption of improved cattle management strategies was in SPA. With the exception of Pattappa, at least some best-bet farmers in each study village had begun some form of controlled mating by February 2008.

All best-bet households in SPA constructed a trough for recycling greywater in the dry season and used it successfully during the course of the project. Some of this uptake may be due to the current project but at least one of the best-bet households was already recycling greywater before the project began. The approach was actively encouraged during the workshop and helped by the provision of cement to some of the households. Each of the best-bet households in Desa Mertak also received cement, but no troughs had been built by the time of the exit interviews, apparently due to problems in obtaining suitable local sand for concrete.

The work of the project team and interactions with other households (via field days and less formal interactions), together with the legacy of previous ACIAR-funded projects, influenced and motivated smallholder households. Hence, while most households adopted the initial best-bet strategies, there were some deviations over the course of the project. All of the householders who attended field days at one of the other established sites commented that these visits were important in terms of providing knowledge, ideas and motivation.

Forage production

Since the start of the program, many households have significantly expanded their original forage introduction best-bet areas. For example, Amaq Warni from SPA stated that he planned to plant up to 1 ha of new grasses and legumes in his upland and relocate all of his cattle operations to that site, while Bella from Lemoa had more than doubled his forage area under cashews from 0.2 to 0.5 ha. Saiful from Lemoa and Jufri from Lompo Tenggah are developing significant new areas of forages in their upland, while Amaq Adul from Mertak planned to double his *Stylosanthes*/grass/*Gliricidia* hedge grazing and cut-and-carry system in 2008.

Many farmers have also expanded plantings of pre-existing elephant grass and *Gliricidia*. For example, Sudding from Harapan now has 1 ha of elephant grass in addition to an area of new forages, while Mahmud from Lompo Tenggah has planted 600 m of *Gliricidia* hedges for forage. Finally Amaq Ahyar, Amaq Saekoni and Mamiq Anti of SPA have together planted up to 1 km of additional *Gliricidia* fences over the project period.

Cattle production

Households participating in exit interviews strongly agreed that the strategies used during the project were already leading to improved cattle productivity (Figure 3).

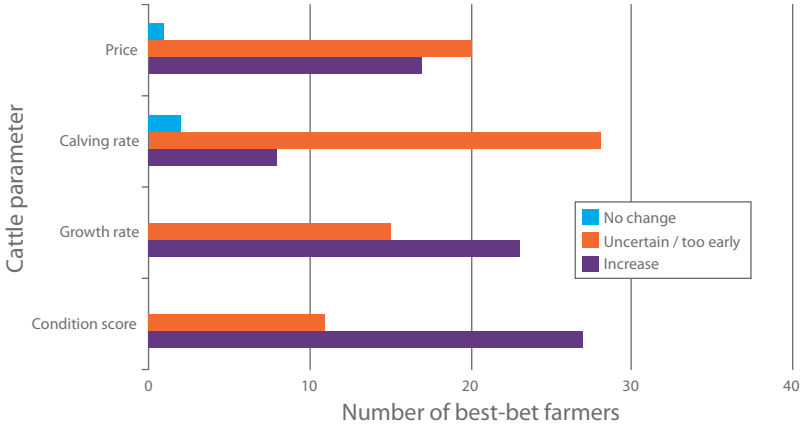


Figure 3. Impact on cattle parameters from best-bet practices at all sites in eastern Indonesia

According to the farmers, the availability of forages was already lifting animal performance—particularly in terms of the body condition of all classes of animals and the growth rate of young cattle. While less than one-quarter of households thought that the reproductive performance of their cows had improved, almost half were sure that their cattle were much more valuable than those of similar age and sex owned by other households in their communities. Margins in the order of 33–50% or greater were commonly suggested. Nevertheless, a significant number of households were undecided about any difference in animal performance, or still thought it was too early to be definite—particularly with respect to calving performance and cattle prices.

Isolating the impact of individual best-bet activities through in-field monitoring is difficult, especially in the early stages of new forage introductions. This is because the contribution to total forage supply is often relatively small, and the households often choose to save their forage banks for late dry-season cut-and-carry use or as planting material. The difficulty is compounded by the relatively long intervals between monitoring.

As these were snapshots of forage use at that time, they occasionally missed the feeding of smaller areas of new forages. Furthermore, the utility of cattle-monitoring data for assessing impacts arising from individual household best-bet activities is often compromised by the small numbers of stock involved and relatively short turnover times for some classes of animals. This particularly applies to young males that are sold off to meet planned or unplanned household cash needs, or are share-farmed out to other households.

Nevertheless, there were many examples where the individual or combined impacts of a household's best-bet activities led to measurable improvements in both forage supply and cattle condition. For example, in Lompo Tenggah, Pak Jufri established a 0.05-ha forage bank of *Clitoria ternatea*, *Setaria sphacelata*, *Gliricidia sepium* and later *Paspalum atratum*. The bank provided up to 40% of fresh forage requirements for three yearling males for most of 2006, and resulted in his cattle growing at twice the rate (0.30 kg/animal/day) of the Lompo Tenggah average of 0.14 kg/animal/day.

In SPA, the widespread adoption of tree legumes provided the platform for the rapid introduction of improved livestock reproduction and feed-management strategies. The cattle showed significant gains in late dry-season liveweight. Young male cattle belonging to Amaq Ahyar stood out, recording a higher liveweight change than the average across all other SPA trials. He achieved this through better management of tree legumes to optimise green leaf production, conservation and feeding of legume crop residues and newly introduced forages, early weaning and preferential feeding of young males in a backyard kandang (communal pen; Figure 4).

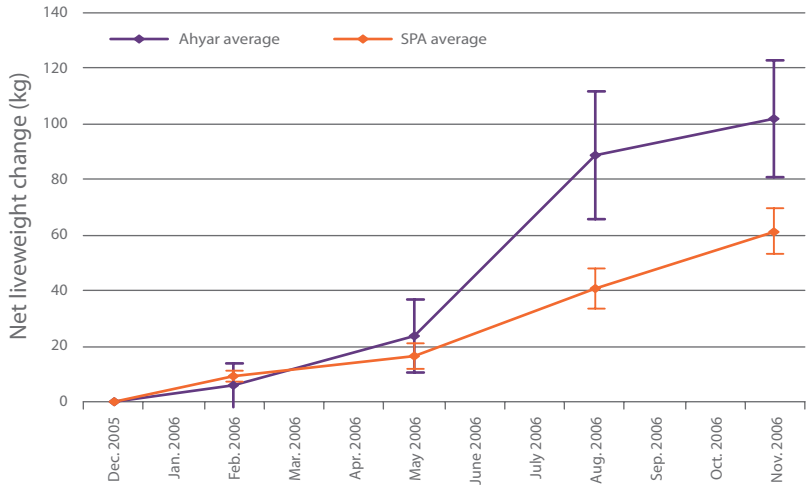


Figure 4. Comparison of average liveweight between Amaq Ahyar's young male cattle and other best-bet farmers at Satuan Pemukiman A (SPA) village, Central Sumbawa, December 2005 to November 2006

Crop production

Results from the exit interviews show that only 6 of the 40 households had decreased the area planted to food and cash crops, while another 2 had made some direct change to the mix of cropping activities in their farming systems (Figure 5). Most households in this small group had made a significant commitment to planting forages on their available land. None of the 40 households suggested that their commitment to trialling forages and livestock had any adverse impact on the performance of their cropping activities, and a small number reported an improvement in their crop yields. The cases of increased crop areas and/or improved yields appear to have come about through labour savings in cut-and-carry tasks resulting from more ready access to forage sources closer to their house yards.

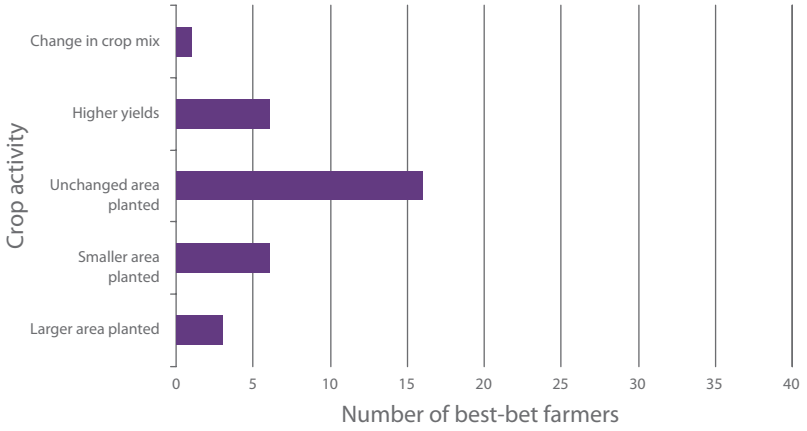


Figure 5. Impact on crop activities from best-bet practices at all sites in eastern Indonesia

Labour

Sourcing forages and water for livestock is typically a time-consuming activity for smallholder households, particularly in the dry season. Therefore, the impact of trialling the forages and animal husbandry practices on household labour demands was of particular interest to the project (Figure 6).

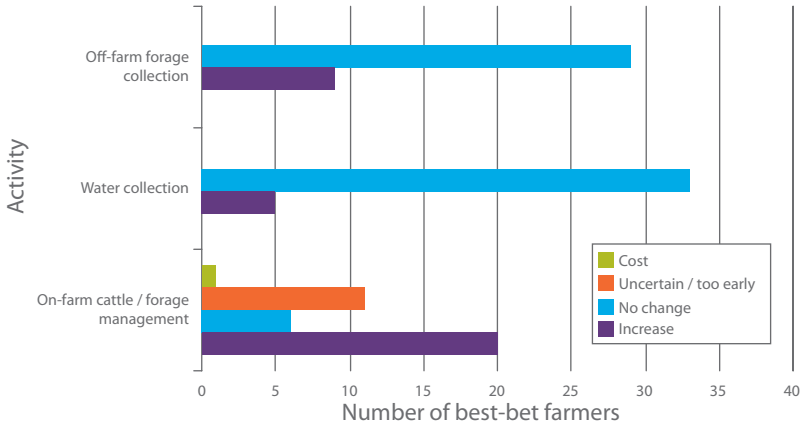


Figure 6. Impact on labour activities from best-bet practices at all sites in eastern Indonesia

The majority of households reported no change in the labour needed to source forages from beyond the boundaries of the immediate community. The nine households that did experience a saving in labour were all from SPA and Mertak (and represented most of the best-bet households). These are particularly dry locations, and hiring trucks to collect residues and straws from other regions during the dry season had been a common and expensive practice. In most cases, the new forage access had entirely eliminated this activity and its financial cost.

Although the project recommended using household greywater, the majority of households also reported no change in labour committed to procuring water for their livestock. The five households that did report a saving in labour for this task were all from SPA, which had previously received rainwater tanks sponsored by Deutsche Gesellschaft für Technische Zusammenarbeit and where several of the best-bet households had successfully trialled greywater recycling. The households in Mertak were keen to trial greywater recycling, but had encountered delays in constructing troughs.

By far the largest impact on labour relates to on-farm labour use for both forage and cattle management. Almost half the households reported definite labour

savings, with most of these reporting that previous practices had involved one or two family members spending 6–8 hours/day for most of the dry season on feeding and managing cattle (either supervising cattle grazing away from their house yards or undertaking cut-and-carry or cut-and-drop activities). Only 1–2 hours/day were now spent on these activities. One-quarter of households were uncertain about the impact because most of these had only planted relatively small forage areas and felt that it was too early to determine if there was any labour saving; they stated their intentions to expand forage areas in the coming seasons, and anticipated similar savings.

Most households that freed up labour used it for crop management tasks—one half decided to further intensify their forage and cattle management practices, while the other half used it to support either non-farm or off-farm employment activities, or simply to rest.

Household finances

None of the best-bet households reported an income decrease as a direct result of trialling the forages and livestock management practices, and only two households were adamant that there had been no change so far. The majority had either experienced an increase in their income already or were not yet in a position to respond positively (Figure 7). Most of the income gain was the result of producing additional cattle that, at the time of interview, had already been sold. Most households that were uncertain or felt it too early to report financial success either had more cattle on hand already (e.g. live calves) or had pregnant cows, but had not yet sold any more cattle.

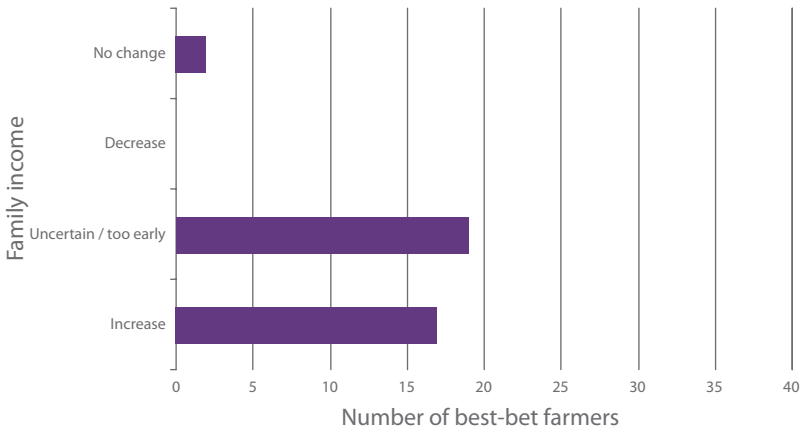


Figure 7. Impact on family income from best-bet practices at all sites in eastern Indonesia

Since many households had reported that their cattle were growing faster or were in much better condition than previously (see Case study 2, Figure 13), there was a clear expectation that they would enjoy higher incomes in the future as the cattle were sold. Many households that recorded increased incomes were reluctant to specifically state how much additional income had been generated from the livestock sales. However, the estimates that were provided were of the order of 50–300% gain, with young animals fetching around Rp2–3 million and typically involving the sale of one to two extra animals per year.

Most of the additional income from cattle sales went towards acquiring or improving major capital assets, which included house construction, or purchase of motor vehicles, land or more cattle. Several households also financed education and travel, mostly by supporting older children (school fees) and young adults (travel to distant work sites).

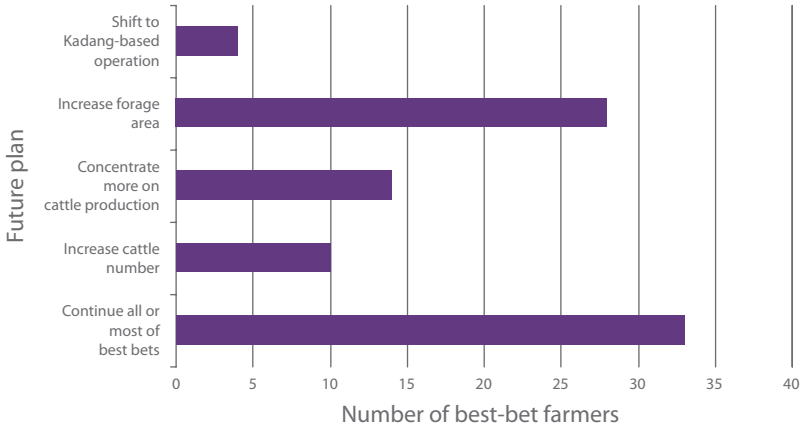
Although several households had previously constructed small kandangs to support their livestock activities, this was not a nominated use for any additional income. Also, while accumulation and the sale of cattle are long-recognised methods of financing travel associated with religious aspirations such as the Haj (and several of the best-bet households were headed by community-respected Haji), so far no household has allocated any of its additional income for this purpose.

The households with access to increased numbers of cattle and an ability to feed them year-round recognised that they held greater security against setbacks such as climatic shocks. Moreover, owning such collateral made them more creditworthy and thus able to access credit when needed on much more favourable terms than before.

Many households suggested that they were more confident to face the future—they felt more financially secure. As well, having overcome the hurdle of safeguarding their financial future through a major shift in their farming systems, they were confident about applying similar problem-solving capabilities to tackle any new challenges.

Future intentions

As the household exit interviews were held at a relatively early stage in the adoption of the new practices, the households were asked several questions relating to the future plans and aspirations for their farming enterprise (Figure 8).



kandang = communal cattle housing overnight

Figure 8. Future intentions with respect to employment of forage and livestock management practices at all sites

The majority of households planned to continue to use most, if not all, the best-bet practices that had been introduced. A couple of households that were not definitely proposing to continue the practices remained uncertain about their future plans. Of the practices that would proceed in the future, increasing forage areas was predominant, with a lesser commitment to either running more cattle or becoming increasingly specialised in cattle production.

This order of priorities largely reflects the constraint that limited forage availability places on cattle raising and the fact that many of the best-bet households had only established relatively small areas of forages. It also implied that many of the households already had more cattle than they could realistically feed and that 'more cattle' is synonymous with 'poor cattle' until the feed restraint has been addressed. Four of the households were planning to concentrate on a kandang-based feeding system, in which animals would be held in specialist enclosures and fed entirely on forages grown and cut elsewhere on the owners' land.

Extension to other smallholder households

Beyond a major role in trialling and refining their best-bet practices, the participating households were also seen as important platforms for extending the practices to other households. The participating households were asked how much interest other households within the community showed in what they were doing. Most had fielded inquiries from other households about their involvement in the project or about some particular aspect of the practices they had trialled. The number of inquiries was generally higher at the more established sites of SPA (c. 130) and Barru (c. 120) compared with Lemoa and Manyampa (c. 17) and Mertak (c. 10).

A comprehensive assessment of the geographic extent and nature of scale-out of best-bet technologies was beyond the scope of this case study. In April 2008, a simple survey of 15 known scale-out households in the immediate vicinity of Lompo Tenggah showed that about 80% of these farmers had implemented improvement technologies, such as new forage introductions (sourced from the original best-bet households) and forage conservation. More than 50% had trialled preferential feeding and kandang-based feeding.

All of the smallholders interviewed commented that there had been a positive effect on the condition of their cattle. Most of the households interviewed were planning to continue some or all of the activities.

Capacity building

At the end of the projects, Indonesian members of the project teams identified new and improved skills as a major impact of their exposure to the project approach and its activities. This is borne out by their ability to successfully undertake many of the key project activities (workshops, field days etc.) with little and intermittent involvement from the Australian team members. Furthermore, most of the in-country staff have presented project summaries at internal agency conferences and collaborated with Australian team members in the preparation and delivery of a number of significant international conference papers (McDonald et al. 2004 a, b; MacLeod et al. 2007 a, b; Corfield et al. 2008). Many staff, although experienced in their own discipline (i.e. forage, cattle, soil or crop sciences, social science or economics), had to operate across disciplines to explore the interactions and inter-dependencies inherent in these smallholder farming systems. Their skills were improved mainly through regular contact with the Australian project team, but also through the considerable time spent in the field, talking with smallholders and discussing, reviewing and adjusting techniques.

Similarly, the results from the household exit interviews clearly show substantial gains in forage and livestock management knowledge by participating smallholder households. Virtually all nominated knowledge gain as the most important benefit

they had received from participating in the project. Many households made the comment that the knowledge was now 'part of them' and that they had greater confidence to go forward, try other options and expand their current activity.

Several respondents commented that they had experienced previous aid projects that had promised something of immediate value, but most had delivered little of lasting or tangible benefit. One householder eloquently summed this up by describing most previous projects as like 'pasar malam' (traditional night markets)—set up this afternoon and gone by tomorrow morning!

Respondents typically affirmed the ACIAR projects as having lasting benefit because they addressed problems of major significance, adapted solutions to individual capabilities and circumstances and, importantly, provided repetitive reinforcement and technical support.

Community and social impacts

The household exit interview feedback and the results from the monitoring of the field trials both show quantifiable gains in forage and livestock production, labour savings and gains in household income over the life of the project. It is reasonable to expect that this will continue, as most of the participating households intend to stay with, if not expand, the strategies. There is also evidence of significant adaptation and adoption of the livestock improvement technologies by other non-participating households, which should extend to other households over time.

Smallholder households at Lemoa and Manyampa (and the Kepala Dusun) in Gowa regency expressed the belief that the wider establishment of improved forages would ultimately enhance social harmony. This would occur by lessening the potential for inter-household conflicts over the limited forage supplies on communally held land, especially in the late dry season.

Other interviews revealed a community belief that forage material, even when grown on land recognised as belonging to an individual household, was generally available to all community members unless enclosed by a secure fence. Once a secure perimeter was established (e.g. by planting a tree legume fence around the parcel) exclusive ownership was generally respected—although some younger household heads noted that they had not yet earned sufficient respect to have their property rights entirely respected by some older community members.

There was also a high level of agreement among the best-bet households during the exit interviews that their successful participation in this project had given them confidence to seek solutions to other problems that were confronting their communities—not just issues related to forages or cattle management.

Several households stated that they had originally participated in the hope of getting something for free—especially cattle—and had initially become quite disillusioned when nothing material was immediately forthcoming. However, they came to realise that the project was offering valuable opportunities and information to support real welfare gains for both themselves and their community, and had subsequently become enthused about their participation—reinforced by a visit to another community where the results were not only impressive but which they quickly recognised they could accomplish themselves.

This sense of project value was often described in terms of 'confidence' and 'security'. In fact, when asked to name the most important impact of the best-bet practices on overall household welfare, many households stated that they felt less vulnerable to the sorts of crises that had beset them in past years. For example, when food and cash crops failed, or family members suddenly became ill, previously they quickly liquidated their limited reserves of wealth, often under unfavourable circumstances.

Future applications

The projects in this case study successfully developed and tested an approach that combined the principles of participatory, on-farm engagement with farmers, and farming system analysis and modelling. Their main purpose was to encourage the uptake of technologies that improve the productivity and welfare of smallholder households. Although the specific focus in this project has been on livestock improvement for smallholder households in eastern Indonesia, the approach and tools are generic in nature and can be readily adapted for application in other environments and to address other farming systems issues.

Two new projects began in 2007 deploying the tools, knowledge and skills developed through this work. They are tailored to the needs of their respective regions, but share the aim of generating wide-scale adoption of new farming practices, increased beef production and improved farmer welfare. The first is based in South Sulawesi[5] and the second in Lombok.[6]

5 ACIAR project SMAR/2006/061: Building capacity in the knowledge and adoption of Bali cattle improvement technology in South Sulawesi

6 ACIAR project SMAR/2006/096: Scaling up herd management strategies in crop–livestock systems in Lombok, Indonesia