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Contents

1 Acknowledgments

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2 Executive summary

The demand for beef cattle has been increasing strongly in Indonesia. This provides a potential opportunity for smallholder farmers who are the main producers of Bali cattle in Indonesia to improve their economic welfare. However, figures indicate that Bali cattle numbers have actually been declining across most regions of Indonesia over the past decade, leading to a supply deficit that is largely being serviced by imports of beef and live cattle from Australia. There is an opportunity to develop and implement strategies at the smallholder level to increase the number and quality of Bali cattle.

This project has identified a range of factors that are constraining livestock production in the smallholder farming systems of eastern Indonesia including: availability and quality of forages, especially during the dry season; poor knowledge and/or capacity to implement optimum feed management practices; limited supplies of readily accessible stock water; bull availability; inadequate cattle housing; labour availability; extended and sub-optimal breeding cycles; diseases; marketing constraints and limited access of smallholders to the formal credit sector for acquiring cattle and livestock handling materials. Most of the technologies needed to address these constraints have already been developed in Indonesia or elsewhere, but have yet to be adopted by local farmers.

This project explores the merits of an approach for improving livestock production that combines the principles and tools of farming systems analysis and farmer participation. The process begins with an extensive benchmarking process to understand and quantify how the current system functions and the constraints to livestock production. Potential strategies for addressing these constraints are identified and their economic, social and environmental viability is assessed using a customised whole farm model. These simulated results are then ‘workshopped’ with farmers to come up with a shortlist of feasible, best-bet strategies for subsequent on-farm trialling. The on-farm trials then become an important extension platform for subsequent extension and communication to other farmers within and beyond the target village.

The feedback from farmers and the results from monitoring the on-farm trials indicate that the participatory, farming systems approach was successful. There is a range of evidence to support this including: quantifiable gains in forage and livestock production, labour savings and gains in household income; the intention of most farmers to continue successful strategies; and evidence of significant adoption/adaption of the livestock improvement technologies by other (non-project) farmers.

The pathways to adoption of livestock improvement strategies varied with the region and the technology concerned. Strategies requiring more skill and knowledge to implement, and for which the implications are more complex and less predictable (e.g. changing feed availability or breeding cycle) required greater input from the project team and benefitted most from the modelling analysis. The involvement of village ‘champions’ was instrumental in fostering uptake in two of the focus sites. Typically, an incremental approach was taken to the rollout of best-bet strategies. The initial focus was to address forage supply and quality constraints through modest plantings of selected forages. The confidence and trust arising from successful adoption of these comparatively simple technologies was then used as an entry point for more complex animal management strategies which require long-term planning and investment.

The Integrated Analysis Tool (IAT) was found to be exceptionally useful in a number of ways: a) as a communication tool to inform/underpin the dialogue between the project team and the farmers; b) enabling rapid analysis of the financial, resource and production impacts of livestock improvement strategies and their sensitivity to key climate, soil, management and farm design variables; c) screening out less desirable strategies and identifying a shortlist of best-bet options for subsequent on-farm testing, thus ensuring a more efficient and targeted use of limited project resources; d) providing a degree of

confidence to both project staff and farmers that the strategies to be tested on-farm are likely to have a beneficial effect, and; e) for some farmers providing motivation about the potential impacts of proposed livestock improvement strategies.

The apparent success of the approaches developed and tested in this project provides support for wider adoption in other regions of Indonesia.

3 Background

Bali cattle (Bos javanicus) account for ~ 25% of the total cattle population in Indonesia and are particularly important in the smallholder farming enterprises of the eastern islands where they make up ~ 80% of the cattle population (Talib et al. 2003). The demand in Indonesia for beef cattle, both for meat (increasing at 6-8% per annum, Talib et al. 2003) and live cattle for resettlement areas currently exceeds the local capacity to supply these animals, with the deficit largely met by imports of beef and live cattle from Australia (189,000 head in 2005-6, MLA 2006). As a consequence, Bali cattle numbers have declined in most areas of eastern Indonesia over the past decade although the extent of the decline is highly variable across provinces. The increased demand is also reported to be encouraging farmers to sell bulls at a younger age and is leading to village-level shortages of mature bulls. The decline is further exacerbated by increasing slaughter rates for pregnant cows (Talib et al. 2003).

In recognition of the declining cattle population and the potential threat this poses to the economic wellbeing of many Indonesian smallholders, some Government of Indonesia initiatives have been developed to arrest the decline. For example, the Provincial government of East Nusa Tenggara (NTT) has banned the export of the some categories of bulls and heifers. Females that are still capable of breeding are also being purchased from slaughterhouses for redistribution to selected smallholders (Talib et al. 2003).

While actions such as these may help to stem the decline in the Bali cattle population, additional strategies are required to significantly increase the number and quality of Bali cattle to meet the expanding demand. These strategies need to address the key constraints to cattle production that have been identified by this and other studies (Talib et al. 2003, Wirdahayati 1994, Mastika et al. 2003). These include: availability and quality of forages, especially during the dry season; poor knowledge and/or capacity to implement optimum feeding management practices; extended and sub-optimal breeding cycles; diseases; marketing constraints and limited access of smallholders to the formal credit sector for acquiring cattle and livestock handling materials. Issues relating to capital access and the livestock market are largely beyond the control of farmers. The focus in this research is on constraints that the farmer can have a direct influence on, namely feed availability, feed quality and animal management.

As with most developing countries, the adoption of improved grass and legume forages into mixed crop-livestock farming systems has been slow in Indonesia. This is not due to a lack of available and adapted forage species. A plethora of local and international work has identified cultivars for the majority of tropical environmental niches, but their adoption has been poor (Ivory 1986, Schultze-Kraft 1986, Horne and Stur 1999). Farmers have either not been sufficiently exposed to forage options, or are not convinced that improved forages provide significant benefits to their livestock enterprises. However, there are examples in southeast Asia where smallholder farmers have successfully introduced forages into the cropping systems (Horne and Stür 2003, Shelton et al 2005, Paris 2002) and these successes, despite being rare, demonstrate the potential benefits from adoption of improved forage technology in mixed smallholder farming systems.

Benefits of a whole-of-system, participatory approach

Norman and Collinson (1985) define the farming systems research (FSR) process as having four distinct stages. The first stage involves determining constraints that farmers face and the potential flexibility within the farming system to adopt change. The second step advances potential strategies to address these constraints. Historically this step has involved researcher managed and implemented trials on research farms, subsequently evaluated for technical feasibility, economic viability and social acceptability. In the third stage, the most promising strategies are evaluated on-farm in farmer-implemented trials.

The fourth and final stage involves the broader implementation and dissemination of successful strategies.

The key to the successful approach adopted by Horne and Stür (2003) was the strong emphasis on farmer participation. At the start of the process, farmers in selected villages were engaged to diagnose and prioritise issues of interest. Potential solutions were identified and discussed with farmer focus groups and a shortlist made of appropriate technology options for on-farm testing. Their approach recognises the vast amount of pre-existing knowledge relating to the most appropriate forage species for different environments in southeast Asia. This essentially negates the need for extensive trials on experimental farms as proposed by Norman and Collinson (1985). Preliminary on-farm trials are typically small in extent. Results from the monitoring and evaluation of these trials are then reported back to the rest of the village. Promising technology is likely to be expanded and integrated permanently into the activities of farms. Other farmers within the village and neighbouring villages are then influenced through a variety of extension techniques including supporting 'local champions', working with farmer groups, conducting field days etc

Benefits of whole-farm simulation tools

A key feature of the smallholder farming systems of eastern Indonesia is the tight integration between various biophysical elements (i.e. livestock, crops and forage), resource endowments (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. Additional complexity arises from the impact of temporal climate variability and fluctuations in commodity prices and input costs. It is, therefore, important when evaluating any of the potential options for improving cattle production that consideration be given to 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.

Whole-farm simulation models have developed to such an extent that they can reliably simulate the key processes and interactions within smallholder, crop-livestock farming systems. As such, they can be used to help explore the technical feasibility, economic viability and social acceptability of various welfare improvement strategies for smallholder farmers and the associated tradeoffs between different system components. For example, Castelan-Ortega et al (2003a and b) describe a decision support system comprised of integrated biophysical models for maize and cattle production and a socio-economic model, developed for the purpose of identifying the optimum allocation of resources that maximise farmers' income. Herrero et al (2002) describe a platform that integrates a variety of databases and component biophysical modelling tools to enable comprehensive systems analysis of crop-livestock systems in developing countries.

However, examples of successful application of simulation models actually leading to demonstrable impacts on smallholder farmer practice are rare. The impact has more often been on research direction or in the training of local researchers (Carberry et al 2004, Matthews and Stephens 2002, Matthews et al. 2002). Carberry et al. (2004) states:

"In the past, modelling applications (in smallholder farms) have generally meant abstract analyses whereby researcher-designed management scenarios are tested under hypothetical situations, and recommended actions are suggested on what managers should do, generally without any reference to real world testing".

The approach adopted in this project combines the principles of FSR analysis (Norman and Collinson 1985, Horne and Stür 2003) and whole-farm modelling in considering the social, economic and biophysical impacts of change, with strong farmer participation in all steps from benchmarking, identification of cattle/forage improvement options and the on-farm testing and communication of findings.

Building on previous work

The present research strategy is built on the considerable advances that were made in projects AS2/2000/124 and 125 working in mixed crop-livestock smallholder farming systems in rainfed lowland and upland areas of eastern Indonesia. The objectives of these earlier projects were: to build relationships with the key stakeholders; to develop an understanding of the crop-livestock production systems through various benchmarking, surveying, monitoring and general observation and; to develop the tools necessary to assess the production, economic, environmental and social benefits and risks at the smallholder farm level that would flow from a greater emphasis on beef production by increasing forage quantity and quality.

Both AS2/2000/124 and 125 took a systems approach to study crop-livestock farming in smallholder systems. AS2/2000/124 was based in South Sulawesi (Sulsel) where the main objective was to explore whether forages could be introduced into higher rainfall rice-based farming systems where land availability for forages was a constraint. AS2/2000/125 was based in the semi-arid area of eastern Indonesia (Sumbawa) where land for forages was not as much of a constraint as the long-dry season where forage quantity and quality severely limits animal productivity.

The two projects worked closely in model development, with the AS2/2000/124 team concentrating on the crop and forage models, and the AS2/2000/125 team focussing on developing a household socio-economic model and a simple livestock model for Bali cattle and an integration tool (Integrated Analysis Tool, IAT) that linked crops, forages, animals and household economics in a way that various scenarios could be tested.

The IAT is now fully functional and operational and gives the operator the ability to choose a number of cropping, forage and livestock options. The model is sufficiently detailed to represent the effects of important drivers (e.g. precipitation, soil fertility, interest rates, market prices, economic consequences), yet is sufficiently simple that it can be used by local staff with relatively little training.

These two projects were reviewed, along with three other AS2 projects, in mid-2003. The following excerpt from that review has guided the development of this project.

"Farmers are keen to increase cattle production, particularly as the relative prices of cattle and grains have changed so rapidly, but they face a constant problem of balancing the crop and livestock components of their systems. The feed supply per se and the quality of that feed becomes a real problem during the dry season. However, production of forages on-farm to meet that demand has trade-offs against crop production. Conducting conventional field research to explore the variety of options has serious limitations because of the significant year-to year differences in rainfall and its pattern, which constrain the ability to extrapolate results to other times.

Experience in Northern Australia has demonstrated the value of generating simulation models that accommodate these constraints and can link the components of the system. This capacity enables the development and evaluation of numerous production options, taking account of price differentials and individual farmers' circumstances. The CSIRO Sustainable Ecosystems team (CSE), and their collaborators, have such systems in place and have considerable experience in the humid and semi-arid tropics. This project used that experience to address this problem, with livestock added to that system.

There have been substantial increases in capacity in the modelling of crop-livestock systems in both Australia and Indonesia and significant progress towards a functional model based on data collected at the sites in both Sumbawa and South Sulawesi. This is the first time that such an integrated model has been developed. Sustaining the research effort and its application as an extension training tool will require commitment within Indonesia to retain capacity and with providers of model support."

While these two earlier projects were successful in developing the models and building capacity in systems approaches within the partner agencies in Indonesia, they did not reach the stage of directly testing these tools with farmers or testing the best-bet scenarios on the ground via on-farm trials.

4 Objectives

1. To develop, test and apply tools, information and knowledge-sharing techniques appropriate for use at both farmer and extension levels to evaluate the impacts of management interventions into tropical rainfed crop-livestock systems.

- Undertake desktop studies to develop and test crop-forage-livestock options in partnership with groups of local farmers in a range of case study settings (Sulawesi, Lombok, Sumbawa) to identify `best-bet' options to profitably increase livestock production on smallholder farms;
- Undertake on-farm trials of the `best-bet' options over a range of regional sites to test their technical efficacy under realistic field conditions and to monitor their impact in terms of improving household welfare, the natural resource base and their social acceptance viz a viz, existing smallholder practices.
- To refine the existing simulation models to more closely mimic (1) the growth and yield performance of rainfed crops, multi-purpose fodder trees, forages and livestock production; and (2) the consequences for household welfare for a wide range of smallholder settings in eastern Indonesia.

2. To communicate the outputs of the project to smallholder farmers, 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.

- Use the on-farm trial sites as ongoing extension platforms, plus other more conventional extension methods to demonstrate, raise awareness and promote acceptance of the farming systems approach to management and of the risks and benefits of the best-bet options identified in partnership with the collaborating farmers.
- Promote the expansion of local capacity to undertake farming systems research and extension activities by supporting the establishment of the ‘Centre for Simulation and Modelling in Agricultural Systems’ within the Faculty of Agriculture and Forestry at Hassanuddin University.

5 Methodology

Project site selection

Project activity was conducted at four sites: 1) SPA village in Sumbawa; 2) Lompo Tenggah, Pattappa and Harapan villages near Barru in Sulsel; 3) Mertak village in southern Lombok and; 4) Lemoa and Manyampa villages in the Parangloe subdistrict of the Gowa Regency in Sulsel. The original intention was for the principle, co-ordinated project activity to take place at the Barru and Mertak sites. Activity at the Lemoa, Manyampa and SPA sites was to be conducted by, and be the responsibility of, the Indonesian contingent with minimal input from the Australians.

Activity in the earlier AS2/2000/124 and 125 projects was focused on the villages at Barru in Sulsel and at SPA. Over the course of these projects we developed strong relationships with the local farmers and Dinas staff and there was a strong level of expectation that we would return and complete the work that we started in these earlier projects. The large amount of data already gathered from these sites enabled us to launch directly into the workshopping and testing of various options with farmers. Furthermore, preliminary workshops had already been conducted at the Barru site.

Mertak is just a two hour drive from Mataram, Lombok where some of the Indonesian project staff are based. Mertak was visited during the course of a project development trip to Lombok in July 2004. We met with a group of farmers to discuss the nature of their farming activity, to gauge the nature and extent of constraints to livestock production, and their level of interest in exploring options to overcome those constraints. Mertak has a total population of 7400 (2100 households), half of whom are illiterate and many of the remainder have very low levels of formal education. The village covers an area of 2700ha comprised of rainfed lowland (280ha), upland (750ha), grazing land (360ha) and forest. In the lowland areas, farmers typically grow rice during the wet season and soybean as a first dry season crop, although many crops fail or give very poor yields due to the unreliable rainfall in the region. It has the largest cattle population in its sub-district, with each household having about two cattle fed on a combination of crop residues, pasture and cut and carry. Feed typically runs out in September/October and rice straw has to be trucked in from neighbouring areas. The farmers we spoke to want to increase cattle numbers and identified access to capital and feed availability as the primary constraints to livestock production. They expressed interest in exploring the incorporation of high quality forage species into the system, and the improvement in feed quality via rice fermentation.

At the specific request of the Vice Governor of Sulawesi, two villages were chosen in the Parangloe subdistrict of the Gowa Regency, as the preferred second site in Sulsel. This subdistrict is about 35km from Makassar and has the highest cattle population in the Gowa Regency. This subdistrict is one of the major suppliers of fresh vegetable produce for the city of Makassar and also supplies Makassar with drinking water from the Bili-Bili dam on the Jeneberang River. High rainfall combined with a steep undulating landscape and poor land management practices has resulted in extensive soil erosion and a major landslide event in early 2004 with substantial loss of life. These events have led to declines in agricultural productivity and the contamination of dam water, incurring substantial expenses for water purification. Siltation of the Makassar Harbour downstream of the dam has created a navigational hazard to local shipping. There is a growing awareness that farming and soil conservation practices in this subdistrict will need to be modified to make them more sustainable and that research needs to be conducted in order to help farmers come up with the best solutions.

Key steps in the process

Step 1. Quantify and understand the farming system

The first step involved developing a clear understanding of how the farming systems in these sites function, and quantifying the associated resource flows and farm productivity. The information/data is used in a number of ways:

- To identify appropriate / representative case study villages, sub-villages and farmers by alignment with defined selection criteria. Participation is based on whether Bali cattle are already part of the farming system; there is both on-farm capacity (e.g. feed / land resource availability) and willingness by farmers to improve cattle production; there is support from village leaders and district extension agency staff; the sites are accessible and representative of activity at a broader scale.
- To develop and parameterise the farming system model so that alternative management options can be explored and compared.
- As a baseline against which the performance of alternative practices can be compared and evaluated.

The social and economic information for this study was sourced from a combination of historical village records (i.e. secondary sources), semi-structured interviews with farmer groups and individual farmers, and the ‘expert knowledge’ of staff from the collaborating research, development and extension agencies. These socio-economic data were complemented by the collection of primary biophysical data relating to forage availability, feed management, cattle breeding cycles, cattle performance, soil characteristics and climate.

All interviews were conducted by local project staff who were familiar with village custom and language, and who had a history of activity in the target villages. Interviews were conducted at a convenient time for the interviewee, often in the evening so as not to disrupt the daily on-farm work schedule. Best results were achieved when interviews were conducted by a team of two with one of the team having a ‘guided’ discussion with the interviewee/group while the other took notes and ensured that the required information was collected. The Australian members of the project team participated in many of these interview sessions.

Step 2. Develop and parameterise desktop simulation tools

The second step involved the refinement and parameterisation of the Integrated Analysis Tool (IAT), developed in projects AS2/2000/124 & 125. The IAT is a smallholder household simulation model that integrates three separate models: the farming system model (APSIM, Keating et al 2003), a model for Bali cattle growth and a smallholder enterprise economic model. Key attributes of the IAT include:

- Incorporates key socio-economic and biophysical processes and their interactions in smallholder farming systems
- Capable of accommodating the diversity of current and potential farming systems (i.e. management, soil and climate) as well as variation in commodity prices and seasonal climate
- Transparent in terms of the model assumptions and caveats of use
- Easy to operate by development or extension professionals in an interactive way with farmers (not directly by, or in isolation from farmers)
- Enables rapid assessment of the potential production and socio-economic impacts of changes in the system state (i.e. management, climate, soil, prices, costs)
- Able to be readily updated to accommodate the specifics of new regions, changes in farming practice etc.

A full description of the IAT is given in Appendix A. In this project, model development work involved:

- The creation of new APSIM datasets for each of the four villages
- The calibration of a new APSIM model for Elephant Grass
- Improvements to the IAT interface
- The addition of new capacity to the cattle and economic models.

Step 3. Identify strategies for Bali cattle improvement

Once the benchmarking was completed, farmer group meetings were held in each focus village. At these meetings, the benchmark results were presented and discussed to ensure their validity. Small group discussions followed in which farmers were asked to identify constraints to livestock production and to nominate potential options to address those constraints. These constraints fell into three broad categories: (i) those beyond the control of the individual farmer (e.g. access to finance); (ii) those for which the solutions are obvious and do not require detailed analysis (e.g. disease, stock water supply); and (iii) those for which the solutions and the implications are more complex (e.g. feed availability, breeding cycle). Potential solutions to this third group of constraints were analysed with the IAT, using a single, representative farm configuration (for each village) and by comparing current practice with practice based on the potential solutions that arose from the farmer workshop.

The results were presented to the farmers for discussion and refinement at a second workshop (one day later), so as to identify a shortlist of feasible and viable best-bet options for improving Bali cattle production in the region.

Approximately five of the farmers that participated in the original benchmarking activity were then chosen from each village to participate in on-farm trials of selected best-bet strategies. The selection of these farmers was based on the following criteria:

- Currently own/manage cattle
- Have capacity/desire to improve/expand cattle production
- Willing to adopt/trial agreed best-bet strategies
- Willing to establish and manage trial activity with guidance and necessary consumables provided by the project
- Willing to allow other farmers to view activity (field days etc)
- Willing to provide seed and cuttings to other farmers
- Acceptance of signage describing activity and key results
- Willing to participate in monitoring activities (interviews etc).

Given that the IAT analysis was based on a representative, generic farm, not all of these options were appropriate for every farmer. The strategies had to be customised or adapted to fit the specific physical, cultural and social circumstances of each farm and farmer. With this in mind, separate discussions were held with each of the selected best-bet farmers to identify farm-specific livestock improvement strategies that were then trialled on-farm.

These interviews were conducted at the farmers' house and were followed by a walk around the farm in order to help 'visualise' the management practices, constraints and opportunities that arose during the interview. A key part of the process involved the completion of a 'typical' annual activity calendar with the farmer. This calendar summarised the timing (e.g. sow and harvest time), area and location (e.g. cropland, upland, backyard) of food crop, grazing and cut and carry activities; the timing of cattle breeding activity (i.e. mating, calving and weaning); the source and composition of off-farm feed sources (i.e. crop residue or cut and carry); the composition and period of use of on-farm conserved crop residue; and the timing and nature of peak labour periods. Other baseline information was collected relating to herd size and age profile, historical crop yields, perceived constraints to livestock production, maximum manageable herd size, family details (size, age distribution, education level) and so on. The activity calendar enabled the project team to rapidly identify farm-specific livestock production constraints and potentially feasible options for addressing these constraints (from the list of strategies arising from the earlier workshop and incorporating the farmers' own suggestions). The calendar also enabled the farmer to check and reflect upon the answers he provided. The potential livestock improvement options were then added to the calendar for discussion and an agreed set of best-bet options were then selected for subsequent trialling on each farm. Activity calendars for each of the 40 best-bet farms are included in the farm summaries shown in Appendix F. An example activity calendar is shown in Figure 1.

Land type	Area (ha)		J	F	M	A	M	J	J	A	S	O	N	D
Lowland	0.6ha	Food crop	Rice					Other crop: legumes (cowpea, mungbean, soybean)						
		Grazing										Tethered grazing		
		Cut and Carry	Sesbania on bunds											
Upland	1.4ha	Food crop	Maize											
		Grazing	Tethered									Free grazing		
		Cut and Carry	Perennial forage 'garden' fenced with Gliricidia to control stock. Introduce more legumes into upland to complement E.G. (e.g. Arachis)											
Backyard	0.17ha	Grazing												
		Cut and Carry												
Cattle breeding			Weaning and preferential feeding					Calving			Mating			
Off-farm residue / cut and carry												Peanut from neighbour		
Conserved feed (period of use)			Ammoniate rice straw and conserve. Store peanut residue for weaners and late dry.											
Peak labour periods			Rice planting				Harvest + prep./planting				Harvest			Rice prep.

Figure 1. Activity calendar for farmer Muhammad, Harapan, Sulsel. Current activities are shown in green. Potential best-bet activities are shown in red.

Step 4. On-farm testing and extension of strategies

Having reached agreement on strategies that were both feasible from resource supply and social perspectives, and which were shown by the model to improve the financial welfare of the household, the next step was to test them on-farm.

These on-farm trials provided an opportunity for farmers to experience and test the best-bet strategies, provide data for validating the IAT and related assumptions (both biophysical and economic), and to demonstrate / communicate project findings and methods. So far as possible the trial sites were located in accessible, highly visible locations to facilitate extension activities. These trials served as a centrepiece for a number of field days at which farmers from neighbouring villages and other project villages were provided the opportunity to view the technology on offer, view performance data from the monitoring activities, and hear first hand, the views and experiences of the case study farmers (Figure 2 and 3).

Figure 2. Field day at Barru (July 2006)

Figure 3. Visit of Mertak farmers to SPA (October 2006)

To facilitate less formal, incidental exchanges between farmers and within farmer groups before, during and after the field days, permanent signs were established at each trial site detailing the objectives and methods of each trial (Figure 4). All materials were presented in Bahasa Indonesia and/or the local dialect.

Figure 4. Permanent sign detailing best-bet activity.

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 farmers.

Farmers were periodically interviewed to evaluate their experiences and impressions of the technology. A comprehensive exit interview was conducted with each best-bet farmer at the end of the project.

6 Achievements against activities and outputs/milestones

Objective 1: To develop, test and apply tools, information and knowledge-sharing techniques appropriate for use at both farmer and extension levels to evaluate the impacts of management interventions into tropical rainfed crop-livestock systems.

no.	activity	outputs/ milestones	comments
1.1	Workshop constraints and opportunities with Barru, SPA, Mertak and Lemoa / Manyampa farmer groups. Identify best-bets using IAT. Select focus farms. Design best-bet trials and monitoring procedures around preferred options from workshops.	Barru, SPA, Mertak Lemoa / Manyampa best-bet options finalised and trial sites identified. Trial designs and monitoring methods finalised.	A series of one-day workshops were conducted in early April 2005 for farmers from SPA and Barru; and in July 2006 for farmers from Mertak and Lemoa / Manyampa. Approximately 20-30 farmers attended each workshop. Two separate workshops were conducted over a three day period for each of the SPA, Mertak and Lemoa / Manyampa farmer groups. The purpose of the first workshop was to review and clarify village benchmarking results collected during the previous AS2/2000/125 project and to identify constraints and potential solutions for improving livestock production. The potential impact and viability of these solutions were then explored and quantified using the IAT on the following day by Cam McDonald and Shaun Lisson with the results presented and discussed with the farmers at the second workshop, one day later. The key output from this workshop was a suite of agreed and viable livestock improvement options to be tested on-farm. At Barru, the objectives outlined above for the first workshop were covered in a workshop held in August 2004 as part of a previous bridging project (to link AS2/2000/124 to AS2/2005/005). Hence, just the one workshop was held during this workshop at Barru in April 2005 to review IAT results and to agree on options to be tested on-farm. Each best-bet farmer was interviewed separately for 1-2 hours. Barru and SPA farmers were interviewed in October 2005, and Mertak and Lemoa / Manyampa farmers in July 2006. The interviews were conducted at the farmers' house and were followed by a walk around the farm in order to help 'visualise' the management practices, constraints and opportunities that arose during the interview. The interview was conducted as a discussion in local language by one of the Indonesian team members who received prompts from a small group of the Australian contingent.

1.2	Benchmark Lemoa / Manyampa and Mertak sites. Collect required soil, crop and climate data for modeling. Identify farmer groups.	Benchmarking completed for Lemoa / Manyampa and Mertak. Farmer groups identified. Weather stations established, key soils characterised.	The period from project commencement (April 2005) to July 2006 was used to collect benchmark data for Mertak and Lemoa / Manyampa. Benchmark data for SPA and Barru were collected during the previous AS2/2000/124 and 125 projects. A preliminary appraisal of soil characteristics at Mertak and Lemoa / Manyampa was conducted by Neal Dalgliesh, Lia Hadiawati, Ahmad Suriadi, Rakhmat Rachman and Syamsu Bahar in October 2005 (see Appendix B). This involved a coarse survey of the key soil types in each region and a textural description of each based on soil cores taken to a depth of 1.2m. This information was subsequently used to select representative, generic soil files for use in the IAT modelling studies mentioned below. Soil characteristics for Barru and SPA were collected during the course of the AS2/2000/124 and 125 projects and are described in the final reports for those projects. Automated climate stations were established in April 2005 at each site for the collection of daily temperature, rainfall and radiation data. Data from these stations were combined with longer term climate data collected from nearby Bureau of Meteorology stations to develop longer-term climate files for use in the IAT modelling studies. Benchmark data relating to forage and cattle production were collected from a group of representative farmers in both Mertak and Lemoa / Manyampa. This covered the composition, quantity and quality of forage, feed management characteristics (i.e. grazing, cut and carry, supplements), cattle breeding cycles (i.e. times of mating, calving and weaning) and cattle performance (i.e. liveweight gain, condition score, disease, dimensions). These data were collected at critical times (e.g. change of seasons) to cover at least one complete set of seasons.

1.3	Establish trials on focus farms at Barru, SPA, Mertak and Lemoa / Manyampa and monitor the impacts on key resources	Trials successfully established and monitored according to accepted protocols. Data collated for analysis.	The establishment of best-bet trials commenced at Barru and SPA in late 2005 and at Mertak and Lemoa / Manyampa in late 2006. Trials were continued through until April 2008. Detailed schedules were developed for each best-bet activity. In the case of forage related strategies, the schedule included notes on the establishment and management of each trial and advice on how to use the resultant forage material. Consumables for best-bet implementation including seed and planting material, fertiliser, materials for constructing storages for crop residue or grey water conservation (where required) were provided by the project, with the farmer providing the necessary labour and land resources. These schedules are included in the individual farm summaries shown in Appendix F. The success or otherwise of best-bet implementation was regularly assessed by the project team. These assessments typically coincided with visits by the Australian team members; a total of nine visits were made by members of the Australian team to most study villages between July 2005 and February 2008. Suggested management adjustments arising from these reviews were identified in a “learning together” way with the best-bet farmers. In some cases this included decisions to re-plant or re-site forage trials which had failed or performed poorly due to seasonal conditions or unforseen site related issues. To help assess the performance and impacts of best-bet options, a program of regular forage and cattle monitoring was implemented for each best-bet farmer and study village. The frequency of monitoring was dictated by project resources but aimed to collect information at critical times through the season, such as early wet, late wet, early dry, mid dry and late dry seasons on forage supply, composition and quality, cattle performance and reproductive status. In both NTB and Sulsel, this averaged out to roughly 2-3 month intervals for both forage and cattle monitoring. Due to the low input nature and remoteness of the SPA site, monitoring was less frequent, while cattle monitoring at Mertak was conducted at roughly monthly intervals. These biophysical ‘snapshots’ were designed to compliment and calibrate regular farmer interview and evaluation data gathered as part of the best-bet impacts assessment process. Appendix C summarises the main forage and cattle variables monitored over the course of the project and the methods used. Data from these monitoring events (and from the climate stations) were sent to project data manager Lia Hadiawati, based at BPTP Mataram for collation into a central project database. During the course of the project, the local project teams undertook several rounds of visits to each of the best-bet farms involved in the project to check on their experiences to that point with the technologies that were being trialled in their systems - although less emphasis was placed on monitoring of the less intensive sites at SPA and Lemoa / Manyampa. Most of the household visits were conducted on a 4-6 weekly cycle to coincide with the forage and cattle monitoring activities and were generally of an informal nature. Records of purchases of inputs and sales of produce or revenue from non-farm sources were also included.

1.4	Develop and calibrate a new APSIM model for perennial legumes.	Draft APSIM model for perennial legumes completed and calibrated.	Plans to develop a component model for tree legumes were abandoned due to the early resignation of Jacqui Hill from the project (and CSIRO). In lieu of this, a simple, empirical biomass and feed quality model for Gliricidia was developed for use within the IAT model. Two Masters student projects were undertaken through Hasanuddin University to develop a component model within the APSIM framework for simulating the growth and development of Elephant Grass. A number of additions and changes were made to the IAT to improve the user interface and to simplify output interpretation. The main changes include: Replacement of village-based APSIM farming system output with output based on soil type X climate combinations. This makes the IAT more widely applicable without the requirement for detailed crop and forage modelling for individual villages; Language selection restructured to allow additional languages (e.g. Buginese, Sasak) to be added by the user if desired; The ability to save and reload parameter sets from previous analyses to ease comparison with new analyses; Allowance for seasonal variation in the amount of cut and carry fed to animals; Determination of manure production, economic value and labour requirement for collection and composting; Addition of costs and potential revenue from goats, chickens and other animals (this does not include full animal intake, liveweight gain and reproduction modelling as for Bali cattle); The addition of capability for the user to edit crop maintenance details, crop prices and labour requirements for planting, harvesting, etc. Other modifications were made to the cattle, fodder and socio-economic components of the IAT. These were tested and implemented as additional information became available on animal growth rates, pasture growth, and alternative farmer activities. Growth from native pasture is now included in the database of output from the APSIM model on introduced pastures (grasses and legumes). This simplifies the processing of the various sources of feed. Estimates of labour requirements for cut and carry material remain a highly variable component but, at the same time, an important aspect of intervention strategies. Increasing available on-farm forage can greatly reduce demand for labour for cut and carry both in the wet season, when farmers are busy with weeding of rice, and in the dry season when they often have to go long distances for forage. The IAT now has facilities for farmers to buy or collect fodder from other sources (e.g. rice straw from central Lombok) to offset their fodder shortage and reduce their labour demand. The labour and costs of obtaining this forage are incorporated into the socio-economic model. The display of model output has been updated to provide more complete visual representation of outcomes across the 10 year period of each model run. Detailed labour requirements/availability for each season for each family member and each farm activity can now be displayed for each of the 10 years rather than the overall summary provided previously. A graph of the monthly fodder requirements and availability highlights any periods of shortfall.

PC = partner country, A = Australia

Objective 2): To communicate the outputs of the project to smallholder farmers, 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.

no.	activity	outputs/ milestones	comments
2.1	Project outputs disseminated / communicated via established channels.	Signage established at trial sites. Field days conducted at trial sites. Regular farmer bulletins prepared. Papers presented to regional and national conferences.	Field days were conducted at Barru in July 2006, at SPA in July 2007 and at Mertak and Lemoa / Manyampa in April 2008. These field days were attended by the best-bet farmers and other farmers from the focus village. Participants were taken on a guided tour of selected best-bet activities with commentary provided by both participating best-bet farmers and other members of the project research team. In addition to local farmers, best-bet farmers from Lemoa / Manyampa were bused to the Barru field day while Mertak farmers made a separate field visit to SPA in October 2006. These cross-site visits were particularly beneficial for Mertak and Lemoa / Manyampa farmers in providing knowledge, motivation and seed/cutting material. Prior to the field day, permanent (weather-proof) signs were installed at selected best-bet trial sites to promote the project and associated activities to passing farmers. These signs remained in place for the duration of the project and outlined the objectives and methods for each activity. The signs were prepared in Bahasa Indonesia. Brief (<1 page) fact sheets were prepared for many of the best-bet activities as handouts to participating and other farmers and for broader distribution by Dinas and staff from other agencies. These fact sheets were prepared in both English and Bahasa Indonesia (Appendix E). In addition to the more formal field days, best-bet farmers were regularly visited (at least once per month) by in-country project team members and less regularly (3-4 months) by Australian team members. The visits from in-country staff were typically for monitoring activities and staff would take the opportunity to discuss the progress of best-bet activities, provide additional advice and discuss cattle and forage monitoring results. A total of 8 conference papers relating to this project have been or will shortly be delivered to a range of Indonesian, southeast Asian, Australian and international conferences (see communication section for details). Authorship and delivery has been shared wherever possible by both Indonesian and Australian team members. A series of two seminal journal papers are currently being prepared for publication in Agricultural Systems Journal. The first is ready for submission and the second will be completed to submission stage by July 2008. A third journal paper has been prepared for submission to the Australian Journal of Tropical Forages. Two draft book chapters have also been prepared for an ACIAR monograph (yet to be published).

2.2	Evaluation of farmer, extension agent and researcher attitudes to project technology and extent of adoption of project outputs.	Evaluation plan developed and agreed upon at start of project. Cyclical evaluations conducted throughout project.	In order to obtain a broad overview of progress on the application of the best-bet practices by the participating households close to the point at which the project formally closed, a final series of interviews was undertaken at each study site in Sulsel, Lombok and Sumbawa in February 2008. This involved face to face interviews, conducted in the local language, with 39 of the households who had been participating in the trials. A semi-structured interview approach was used to canvass a series of issues associated with applying the forage and animal management technologies and practices; including the impact on household activities and welfare, the interest shown in the activities by other households within and beyond the immediate community, personal effectiveness for problem solving and future intentions with respect to employing the practices. The individual interviews involved 32 questions or issues and took approximately 2 hours to complete. Project staff were individually canvassed on two occasions (May 2005 and May 2007 coinciding with annual project meetings) on their understanding of the project objectives, their personal role in the project, their perception of the performance of the technologies and practices and whether they felt the project was delivering value to the smallholders. On both occasions there was a high level of satisfaction expressed with all facets of the project operation and team roles. There was universal agreement that the project was already delivering value to the smallholders. A major part of the high degree of concurrence is likely to be due to the outcome of similar exercises that were conducted for projects AS/2000/124 & 125 in which some serious problems of both a project and technology nature were identified and positive steps taken in this project to resolve them as part of the project team builiding and implementation strategy.
2.3	Prepare training manuals describing the theory and operation of component and integrated models.	Model training manuals (Bahasa Indonesia) completed.	A comprehensive manual describing the structure and operation of the IAT was produced to aid workshop participants and for future reference/support. The manual was originally written in English but is currently being translated into Bahasa Indonesia.

2.4	Conduct a training workshop in the theory and operation of component and integrated models and in extension and community engagement methods.	Workshop conducted and performance formally evaluated.	In August 2007 a 3-day training workshop was held BPTP Narmada, Lombok. This was attended by project participants from Lombok and Sulsel. The first day of the workshop covered the background theory to the IAT, including what assumptions are made, why they are made, and the implications for interpretation of the output. The second day was a detailed explanation of all the input requirements for the model, and what was required at each prompt. This day also covered detailed explanation of how to interpret the output from the IAT. The third day was a supervised practice session with all participants conducting their own hypothetical analyses, observing the changes in the predicted outcomes, and interpreting the implications. Whilst no formal assessment was made of participant competency, observation of their use of the IAT, the questions and discussions held, and their enthusiasm for its use, indicated that all were confident in its use. The following participants completed the full course and were awarded certificates: Lalu Wirajaswadi – BPTP Narmada, Lombok Lia Hadiawati – BPTP Narmada, Lombok Achmad Muzani – BPTP Narmada, Lombok Nurul Himliati – BPTP Narmada, Lombok Dahlanuddin – University of Mataram, Lombok Yusuf Sutaryono – University of Mataram, Lombok Rachmat Rachman – BPTP Makassar, Sulsel Syamsu Bahar – BPTP Makassar, Sulsel Nasruddin Razak – BPTP Makassar, Sulsel Marsetyo – Tadulako University, Palu, Central Sulawesi Asmuddin Natsir – Hassanuddin University, Makassar, Sulsel A number of other participants attended for short periods to gain exposure to the IAT and whole farm analysis. Separate two-day training workshops were held in Mataram and Makassar as part of the start-up meetings for the new scaleout projects. These workshops covered the theory and practice of the systems, participatory, modelling approaches developed and implemented over the course of the 005 project. This training was conducted by 005 project staff for the new on-ground team members of the scaleout projects. The Centre for Simulation and Modelling in Agricultural Systems was originally intended as a centre for ongoing training in farming systems science and modelling. The Centre was subsequently shut down during the course of the project. While disappointing this did not prevent the conduct of farming system and IAT training in the final year of the project. Various learnings and case studies from the project have subsequently been incorporated into the curriculum of the farming systems course under the direction of Dr Rusnadi Padjung. Furthermore, the IAT has developed into a generic tool that requires little ongoing 'maintenance'.

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7 Key results and discussion

Part 1: Benchmarking

The benchmarking activities conducted across the four study sites showed that the structure and nature of smallholder crop-livestock farming systems are generally similar across these sites, indeed for most of eastern Indonesia. With this in mind, the following text summarises some of the key characteristics that define smallholder farming crop-livestock farming systems in eastern Indonesia derived from both the benchmarking activities in this project and selected references. More detailed insights into the structure and nature of the systems investigated in this project are provided in a separate benchmarking report prepared for Desa Mertak (Appendix D).

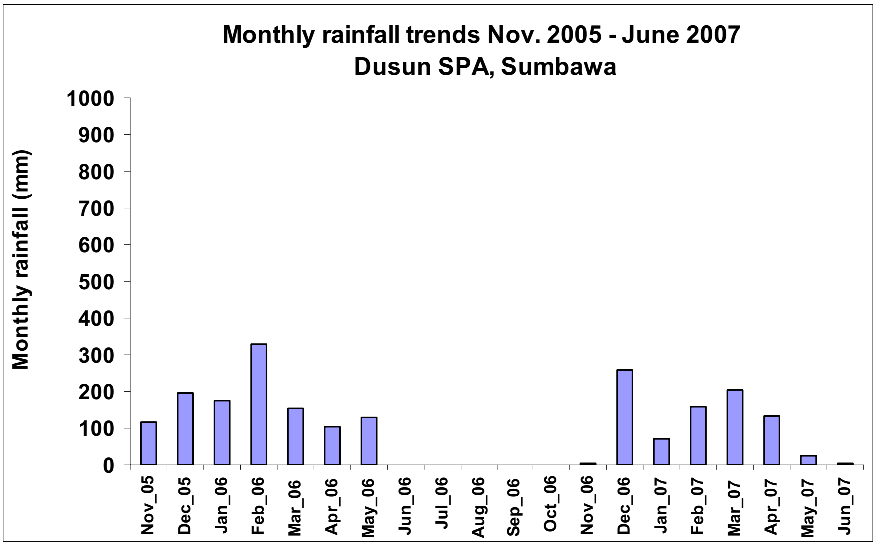
Key characteristics of the smallholder farming systems of eastern Indonesia

The smallholder crop-livestock farming systems that exist in eastern Indonesia are dominated by small farms (usually < 2ha) that comprise an integrated mix of crop, forage, livestock and human activities. Like those in much of Asia, Africa and the Pacific, these enterprises possess linkages between the 'farm' and 'household' that are argued to be much stronger and more mutually dependent than for western farming systems (Ruthenburg 1980, Norton et al. 2006). For example, labour is potentially used both on-farm and off-farm (e.g. ploughing, weeding, harvesting, herding for other farmers), and away from the farm in non-farming roles (e.g. operating a kiosk, construction).

Some crop and animal activities produce intermediate outputs that become inputs to other activities (e.g. Bali cattle provide crop nutrition inputs through manure and also provide draught power for cultivation). The products from these smallholder systems seldom have alternative markets and so opportunity valuations are given far less prominence in decision making than is the case in agricultural systems in more developed countries. Additional commitments to new activities can reduce opportunities elsewhere with consequences for family welfare.

Seasonal climate

The nature and timing of farm activity is strongly influenced by the seasonal climate pattern. While there is substantial spatial and inter-seasonal variability in the timing and extent of rainfall across eastern Indonesia, the 'wet season' typically commences about November-December and ends about April-June, followed by an essentially rain-free 'dry season' for the remainder of the year (Figure 5).



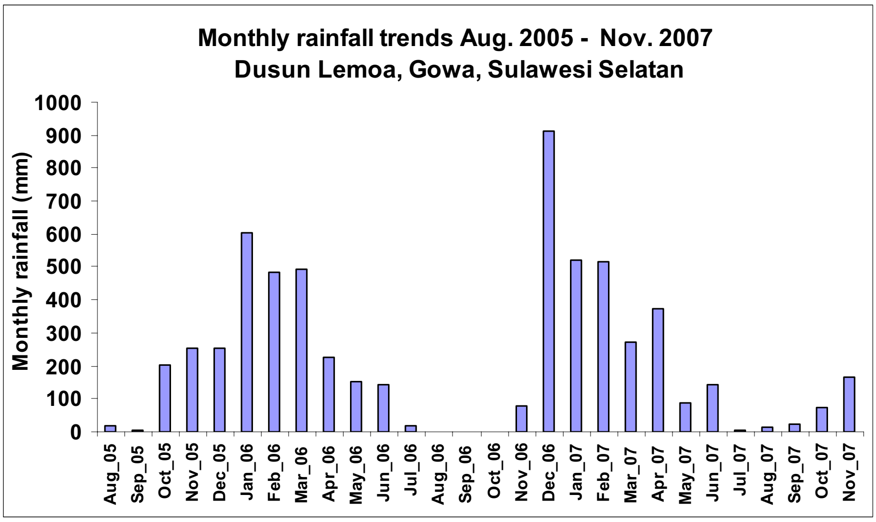


Figure 5. Monthly rainfall trends 2005-2007 for Desa SPA, Sumbawa and Desa Lemoa, Sulsel.

Land use

Smallholder farms are commonly comprised of two basic land types. ‘Cropland’ is characteristically close to the main residence, naturally flat or formed into terraces, with deeper and more fertile soils, often with access to simple irrigation and/or is bunded to retain overland flow. This land is used for cultivating a range of annual crops. Essential food crops such as rice and maize are grown during the wet season. The length of the wet season and/or access to irrigation determines the selection, extent and number of crop cycles in one year. Other important annual food crops that are grown principally in cropland areas include peanut, sweet potato, soybean, mungbean, cassava and tobacco.

‘Upland’ is typically further away from the house and less accessible, larger in area, often on sloping ground with shallow and less fertile soils and with no access to irrigation. These parcels of land are used to grow perennial fruit (e.g. mango, coconut, cashew), fibre (e.g. kapok) and timber crops (e.g. teak, bamboo). They are also important areas for the production of native and introduced perennial and annual forages and are important areas for cattle grazing. Many of the forage species grown in the upland are also grown around the perimeter of cropland as fences and/or on top of cropland bunds. Upland is often shared by more than one farmer and so usually the grazing in this land is communal, whereas cropland use is usually exclusive to the farm owner, although communal grazing of crop residues does occur in some locations.

Livestock production

Bali cattle play a central and multi-functional role in these farming systems as: (1) draught animals for field operations such as tillage, (2) a readily saleable store of capital to meet major household needs (e.g. school fees, house repairs and electronic equipment, Haj travel), (3) as a means of accumulating wealth and status over time, and (4) as a business enterprise to generate income (Padjung and Natsir, 2005). Traditionally the last of these roles, that of generation of an income stream from cattle production, has been rare. Depending on the time of year, cattle either free graze crop residue and/or ‘native’ pasture, are tether grazed, or are penned and hand fed various mixtures of ‘cut and carry’ and other supplements. In addition to Bali cattle, farmers keep a variety of other livestock types including buffaloes, goats, ducks, chickens and geese for the provision of meat and other animal products (e.g. milk, eggs) for home consumption.

Forage availability

Depending on the time of year, cattle either free graze crop stubble and/or ‘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, with maximum rates of biomass production occurring during the wet season, declining to near zero at the peak of the dry season. Hence, during the wet season when feed is plentiful, farmers allow their cattle to free graze in the upland and/or tether graze (often supplemented with some 'cut and carry' feed) closer to the house so as to avoid damage to the field crops. This situation continues for a period after the wet season with the grazing of 'pasture' supplemented by the grazing of crop residues and stubble following removal of the harvested crop.

As the dry season continues, the more accessible feed sources are gradually depleted and farmers are required to invest increasingly more labour to provide feed for their cattle, either manually gathering feed for stock (if penned or tethered) or moving their cattle more often and/or further away from the house (if grazed). The quality of available feed also declines during the dry season with greater dependence on less palatable, less digestible and protein impoverished feed.

The shortfall in both quantity and quality of feed can be addressed through the use of tree leaves, banana leaves and stem, occasionally perennial legumes such as Gliricidia, Leuceana and Sesbania or by the use of conserved leguminous crop residues in some regions, but usually the amount provided does not overcome feed deficiencies, leading to weight loss at this time of year.

Family structure and labour profile

The household family structure tends to be multi-generational (typically three generations) with all members contributing to a varying extent in the management and operation of farm activities. Key farm activities include: land preparation (i.e. 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. Additional labour is often hired to help out with harvesting and land preparation activities; while supplementary income may be sought from off-farm activities that are both agricultural or non-agricultural in nature.

Part 2: Farmer workshops

Constraints to livestock production

There was substantial uniformity across the 4 project sites in terms of the key constraints to livestock production. The majority of the constraints described below were identified directly by the farmers during the workshops conducted in the first 12-15 months of the project. Some, such as housing and late weaning, were recognised by members of the project team.

Feed availability was recognised as a major constraint by farmers in Barru, Lemoa / Manyampa and Mertak, especially in the latter part of the dry season when 'cut and carry' feed sources are limited. Farmers in SPA had been encouraged in the previous AS2/2000/125 project to increase the production of tree legumes (mainly Gliridicia) for use as cattle feed, especially during the dry season. The adoption of this advice by many of the SPA farmers has to some extent reversed the feed shortfall reported at the commencement of the 125 project. However, at the time of the farmer workshop at SPA (April 2005), many of the farmers were still trucking feed in from off-farm locations (e.g. irrigated cropping regions near Dompu) and/or spending many hours each day collecting feed closer to home. In addition, it was clear to the project team and from our discussions with the farmers, that knowledge of optimal feed management practices (i.e. when and how much of what to feed animals of different age and condition) was limited.

Limited access to a bull for mating was listed as a constraint in each village. Most of the males were sold prior to breeding age to provide cash for large expenses such as schooling, house renovations, travel and, during the recent drought, to purchase food. Farmers typically pay for the services of another farmer's bull, but delays in availability severely reduce the efficiency of mating and conception.

In Barru, farmers complained about the monopolistic nature of the trading mechanism and the difficulty in estimating cattle live-weight in the absence of cattle scales. The sale price is based on the traders' estimate of weight which (not surprisingly!) is typically less than reality and/or the farmers estimate.

Drinking water for stock is sourced from community wells, dams and/or individual on-farm wells. Some farmers also capture rooftop water, but this is primarily used for household consumption. Typically, a member of the household employs part of their 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 farmers. Farmer knowledge about the optimum daily water requirement of cattle was also limited.

In most of the villages, cattle housing and feed troughs are either non-existent or poorly designed and maintained. This results in significant feed spoilage and may act to promote the incidence of various cattle diseases and other parasitic conditions.

Cattle disease and parasites were raised as potential production constraints by some of the farmers attending the workshops. However, these conditions appear to be isolated in nature and adequately controlled by the existing drenching and immunisation programs of Dinas Peternakan.

Labour availability, especially during the dry season, was mentioned as a constraint by farmers in Mertak, Lemoa / Manyampa and Barru. During this period when there is no crop-related activity, farmers often work off-farm to generate additional income, leaving the tending of cattle to the rest of the family.

Another consistent constraint to increasing livestock production is access to capital. Farmers typically don't have the cash reserves or access to loans to enable them to buy a bull or more cows for breeding. Hence, they must build up their herd independently and must buy the services of another farmers' bull. However, this is often difficult as farmers need to sell cattle to release cash for other household expenses.

In most of the villages, farmers are not producing a calf every year due to the stress imposed on the cow by a sub-optimal breeding cycle and delayed weaning. Currently, mating occurs 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 follows where the cow's milk is supplemented with 'cut and carry' material. The lactation period coincides with the dry season when feed of high quality is in short supply. Once the wet season commences, the existing labour use is prioritised to field preparation and planting of rice. Consequently, the cutting and carrying of forages to supplement tethered or housed animals is a relatively low priority for farmers.

Furthermore, the mating cycle often leads to an overlap between milking/lactation and draught activities early in the wet season when the fields are being ploughed in preparation for rice planting. It is not unusual early in the wet season to see cows ploughing the field while being followed by milking calves. Additional stress can occur about this time of year when the diet changes from primarily dry forage to green forage as the wet season takes hold. This cycle leads to declines in the condition of lactating cows, calf growth rates and the reproductive ability of cows.

Strategies for addressing these constraints

A range of strategies was identified for addressing these constraints and discussed with the farmer groups in the village workshops. These strategies (summarised below) formed the basis of the farm-specific, best-bet activities/trials. Selected strategies relating to feed supply and quality and animal management, for which the solutions and the implications are typically more complex, were explored using the Integrated Analysis Tool (see following section).

Feed availability and management

Strategies for improving the quantity and quality of feed options on-farm fell into three main categories: 1) improved utilisation / management of existing fresh forages and crops; 2) introduction of new forage grasses and legumes to increase fresh forage supply options; 3) better use and improvement of crop residues.

Introduction of new, improved forage species

The selection of new forage species for on-farm trialling was based on the experience of forage scientists Jeff Corfield and Syamsu Bahar and with reference to the tropical forage database: Tropical Forages – An interactive selection tool (Peters et al, 2005). Selection took into account adaptation to the soil and climate conditions of eastern Indonesia and suitability for cultivation in a variety of locations and arrangements including: mixed forage banks in either lowland, upland or backyard areas; along bunds bordering lowland fields; after annual crops (i.e. as part of the crop rotation); and as an understorey to upland estate crops.

Figure 6. Forage bank comprising alternating strips of *Stylosanthes* and *Brachiaria* at Desa Harapan, Barru.

A total of 10 grass and 7 herbaceous legume species were introduced and trialled on-farm as part of the best-bet trials (Table 2). The majority of the seed was sourced from Southedge Seeds, Mareeba, North Queensland, while supplies of Mulato *Brachiaria* and *Stylosanthes guyanensis* CIAT 184 were obtained for the project by Dr Peter Horne from suppliers in Thailand and Mexico, respectively.

Table 2. Details of forage grass and legume introductions for forage best-bet activities.

Forage type	Use	Species	Cultivar
Grass	Pasture/ Cut and carry	*Bothriochloa insculpta*	Hatch
Grass	Pasture/ Cut and carry	*Brachiaria decumbens*	
Grass	Cut and carry	*Brachiaria X*	Mulato
Grass	Pasture/ Cut and carry	*Chloris gayana*	Katambora
Grass	Pasture	*Digitaria milanjiana*	Jarra
Grass	Pasture/ Cut and carry	*Panicum maximum*	Green panic
Grass	Cut and carry	*Panicum maximum*	Mombasa
Grass	Cut and carry	*Panicum maximum*	Simuang
Grass	Cut and carry	*Paspalum atratum*	
Grass	Pasture/ Cut and carry	*Setaria sphacelata*	Splenda
Herbaceous legume	Pasture / cut and carry	*Arachis pintoi*	Amarillo

Herbaceous legume	cut and carry	*Centrosema pascuorum*	Calavcade
Herbaceous legume	Pasture / cut and carry	*Centrosema pubescens*	Cardillo
Herbaceous legume	cut and carry	*Clitoria ternatea*	Milgara
Herbaceous legume	Pasture / cut and carry	*Stylosanthes hamata*	Verano
Herbaceous legume	Pasture / cut and carry	*Stylosanthes guyanensis*	CIAT 184
Herbaceous legume	Pasture / cut and carry	*Stylosanthes scabra*	Seca

Many of these, including *Panicum, Paspalum, Setaria, Chloris, Arachis* and *Stylosanthes* species had been previously introduced and distributed to farmers across eastern Indonesia by NGOs and previous ACIAR projects. However, subsequent adoption and distribution has been limited. Furthermore, the previous AS2/2000/124 and 125 projects introduced some of these genotypes into Lompo Tenggah (Mahmud land) and SPA (Amaq Sapri and Mamiq Anti) between 2001 and 2003.

When planning best-bet activities relating to new forage introductions there is a trade-off between having sufficient area to make an early impact on forage supply and livestock production, and having too much area for the farmer to manage. This is particularly so in the critical establishment phase which often coincides with crop planting in the early wet season in eastern Indonesia. Within the project team there were differences of opinion on which path to take in this regard, especially as the ability and resources of individual best-bet farmers varied across the study villages. As a consequence, there was considerable variation in trial plot size; ranging from small plots of <0.02ha to areas of around 0.2ha.

Improved use of existing forage and crop species

Many existing forage species are of high quality but are poorly utilised. For example, tree legumes such as *Gliricidia sepium* and *Leucaena leucocephala* are commonly used as a living fence but are not widely used as a feed source due to farmer perceptions of poor palatability. One of the reasons for this poor palatability is the infrequent nature of cutting which leads to a 'woody' feed with older, less palatable leaf material. Similarly, elephant grass (*Pennisetum purpureum*), while of poor quality, is popular in some regions due to its fast growth rate and persistence into the dry season. However, the management of elephant grass is often poor (i.e. cut too hard and too often, or let grow tall and rank).

Figure 7. Gliricidia 'living fence' at SPA, Sumbawa.

Participating best-bet farmers were provided with advice on optimum cultural practices and in the case of tree legumes, this information was collated into two fact sheets (Appendix E).

Better use and improvement of crop residues

There is potential in these systems for the conservation (after drying) and improvement of crop residues as well as current and introduced forage species. Legume crops such as cowpea and mungbean are grown for human consumption but their residues are not widely used as cattle feed. There is the potential to grow these crops in rotation with rice and other food crops on lowland fields with the resultant residue either fed directly or conserved. In most areas there is surplus native green feed during the wet season, some of which might be dried and conserved for use during the dry season (e.g. Glycine). Potential exists for improving the quality of rice straw, which is abundant in these systems, via ammoniation.

Figure 8. Conserved mungbean residue, SPA, Sumbawa.

Feed budgeting

Advice on the correct amount and composition of feed required by animals of different age, condition and activity was provided to participating farmers throughout the project and captured in a series of fact sheets (Appendix E).

3. Cattle breeding / weaning

Advice on optimum times for mating, calving and weaning was provided to each participating best-bet farmer. That is, the suggestion is to calve late in the wet season (March/April) and then mate after no longer than 3 months later to make it a 12 month cycle. With this schedule, the cow is being used for draught at a safe time of the pregnancy (avoid final 2 months of gestation) and is not raising a calf at the same time. Furthermore, the calf is born about the end of the wet season when there is still plenty of feed available and the cow is in good condition. Such modifications may result in improved growth rates for cattle and faster turnaround times from birth to sale.

Farmers were also encouraged to wean their calves at a younger age (~6 months) and to preferentially feed thereafter. This is known from the work of Panjaitan et al (2008) to maximise calf growth rates and to reduce the stress on the cow, especially during the dry season.

4. Stock drinking water

While some farmers already capture water from their roof into the house mandi (water reservoir for domestic water supply) using simple guttering (e.g. bamboo), this is limited in extent and restricted to the collection of household water. This strategy was promoted during the farmer workshops as an efficient means for collecting both household and stock drinking water.

Simple calculations were made to estimate the volume of rain water able to be potentially harvested from selected homes, based on the roof area and annual rainfall estimate. Typically, this volume was greater than the combined annual needs of both stock and household. The success of this strategy requires an investment in a tank or well to store the runoff. In the case of Mertak, the project purchased roof guttering and associated piping and sealant for an existing in-ground concrete storage tank.

Another strategy is to recycle household grey water (post washing) for use as stock water. This involves capturing the water in a simple above-ground, concrete-lined trough, from which stock drink either directly or from which water is decanted and carted to where the stock are located. Selected best-bet farmers were provided with bags of concrete and design plans to construct their own troughs.

Questions were raised by Dinas staff in NTB about the impact on livestock of household detergents in grey water and also the possibility of disease transfer (especially malaria). Observations in study villages indicate that in most cases household detergent use is very low and restricted to simple soaps, so this should present few problems for use of grey water by stock. The potential for grey water storages to act as possible breeding sites for malaria and other water borne diseases and parasites is less clear. At least one best-bet farmer reported that he only used his grey water resource during the dry season (when stock water is limited) and covered the storage structure in the wet season to prevent contamination or mosquito breeding.

The amount of water that should be provided to cattle of different age, size, sex and condition (e.g. lactating, pregnant) and options for improving water supply were incorporated into two farm notes provided to farmers and their advisors (Appendix E).

Figure 9. Grey water recycling as stock water, SPA, Sumbawa.

5. Access to bulls

Given that 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 for the use of the best-bet farmers (and through negotiation, by other farmers). These bulls were managed by one of the best-bet farmers.

6. Disease and parasites

The incidence of disease and parasites in cattle belonging to best-bet farmers was generally minor. All cattle health issues were brought to the attention of local Dinas Peternakan staff.

7. Cattle pricing

The 'tight' weight X girth X height relationships developed through the cattle monitoring activities of this and previous projects were used to develop estimation tables for farmers. By measuring girth and height with a simple (and cheap) measuring tape, farmers can use these relationships to estimate animal weight which can subsequently be used in negotiations with cattle buyers.

8. Cattle housing

Advice on the potential benefits and optimum design of cattle housing (kandang) and feed troughs were provided to each participating best-bet farmer.

Figure 10. Improved cattle housing, Lompo Tenggah, Sulsel.

Modelling the potential impacts of these strategies

Selected livestock improvement strategies relating to improving forage supply and quality and animal management (strategies 1 and 2 above) were put through the IAT in order to explore/quantify the potential impacts (for a 'typical' farm) on the whole-farm feed, labour and cash balances. The strategies were explored in a sequential fashion, commencing with consideration of the current farm design followed by a series of changes, such as increasing feed availability and quality, increasing the number of cows, increasing the amount of cut and carry fed to cattle each day, and the introduction of seasonal mating.

In response to a question raised at the Barru workshop, an additional scenario was set up to explore the potential financial impact of a 20% reduction in cattle price. At the Mertak workshop, there was a discussion about the merits of shifting away from rice production and placing more emphasis on cattle production (and purchasing food from cattle sales). This came about in response to the recent drought that had decimated much of the village rice crop. The resultant IAT scenario indicated that substantial financial gains were possible from the adoption of this strategy (notwithstanding the cultural/social reasons for growing rice). The results were presented to the farmers in a simple tabular form.

An example from the Barru workshop is shown in Table 4. Table 3 summarises the farm structural details upon which the simulations were based.

Table 3. An example baseline farm from the Barru workshop.

Farm structure	
Family	4 (2 adults, 2 children)
Land	0.6 ha lowland (L), 1 ha upland (U), 0.1 ha backyard (B)
Living costs	500,000 Rp/month
Rainy season crops	0.54 ha rice (L), 0.3 ha groundnut (U)
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 & carry	30 kg/day
Plantation crops	None
Tree legumes	None
Commodity prices	
Rice	1000 Rp/kg
Groundnut	3500 Rp/kg
Beef (weaners)	10000 Rp/kg
Beef (2 year-old)	14000 Rp/kg
Beef (old animals)	12000 Rp/kg

Table 4. Output for selected intervention strategies.

Case scenario	**No. cattle sold over 5 years**	**Annual fodder surplus/deficit (kg)**	**Dry season labour surplus/deficit (days)**	**Final cash balance after 5 years (Rp million)**
Case 1: baseline				
	6	-3000	-10	14
Case 2: baseline + retaining 80% of groundnut residue				
	7	-1000	+50	15
Case 3: case 2 plus 0.3 ha Elephant grass on upland, 40% of dry season rice straw fermented				
	8	+5000	+90	23
Case 4: as for case 3 plus increase number of breeding cows to 4, increase cut & carry to 40kg/day				
	14	-1500	+40	41
Case 5: as for case 4 but reduce beef prices by 20%				
	14	-1500	+40	36

Under current practice, over a 5 year period, the farmer sells only 6 animals, has a labour shortage for cut and carry in the dry season, a fodder supply deficit and accumulates only Rp14m. Strategies 2 and 3, indicate how the farmer might address the fodder by growing elephant grass on under-utilised 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.

In doing so, the farmer can increase their off-take to 8 animals, generate a surplus in both fodder supply and dry season labour and increase the accumulated funds to Rp23m over a 5 year period, all without interfering with their primary activity of growing rice. The surplus fodder then allows more animals to be kept with the potential for offtake to be increased to 14 animals and accumulated funds to Rp41m. Naturally, the above outcomes would vary depending on the sequence of seasons experienced. Also, farmers may not be able to implement all interventions simultaneously and are more likely to implement them in a step-wise fashion with subsequent incremental gains in offtake.

This example illustrates the value of the IAT as a communication tool to inform the dialogue between the operator (R, D and E agency staff) and farmer. It enables rapid analysis of the financial, resource and production impacts of livestock improvement strategies (identified by the farmer) and their sensitivity to key climate, soil, management and farm design variables. Less desirable strategies can be readily identified and discarded, leaving a shortlist of best-bet options that can then be assessed in the field by participating farmers. This provides a degree of confidence to both project staff and farmers that the actions they are about to undertake are unlikely to have an adverse effect. Furthermore, this screening enables a more efficient and targeted use of limited project resources. By being able to view the potential results of change prior to implementation, farmers commented that the modelling provided substantial motivation to participate further in the project.

The complexity of the smallholder farming systems in eastern Indonesia means that it is not possible to model all the component processes and associated interactions within it. A balance needs to be reached between the level of detail, the precision required, the model's flexibility and the input data requirements (Thornton and Herrero 2001). For example, the range of crop and forage genotypes able to be simulated mechanistically by APSIM (and included in the IAT database) does not cover the full range of genotypes currently occurring on-farm.

Furthermore, only some of the best-bet forage genotypes recommended for introduction are covered by APSIM. Consequently, simple, empirical models have been incorporated into the IAT to cover a number of the more important genotypes (e.g. tree legume). For other genotypes, the operator must choose a surrogate or 'like' genotype from those that are available and interpret the results accordingly. Furthermore, the crop and forage component models assume that production is not constrained by biological factors (e.g. insects, diseases, weed competition), micro-nutrient deficiencies, weed competition or other atypical/extreme events (e.g. waterlogging, storm damage). Similarly, the livestock models assume that growth is not constrained by parasites or other ailments. Some of these assumptions will break down under the low-input management practices and extreme climatic conditions that prevail in these regions.

Each of the component biophysical models that sit behind the IAT have been individually validated across a range of independent datasets. It is much harder to validate the performance of the integrated model against household data for all the reasons outlined above. The real power of the IAT lies in being able to compare the production, economic and social consequences of different scenarios and the tradeoffs between crop and forage/cattle production, where the difference between scenarios is typically more informative than the output for each individual scenario.

Part 3: On-farm testing of best-bet strategies

Uptake of best-bet strategies by best-bet farmers

A total of 142 best-bet options relating to forage and cattle management were identified for the 40 best-bet farmers. Of these, 85 were implemented by farmers during the period from November 2005 to February 2008. Only one of the 40 starting farmers dropped out of the project (Pak Nunding, Lompo Tenggah). One new farmer joined the project in mid 2006 (Ramli, SPA).

In the first season, best-bet activities focussed on forage related interventions for the following reasons:

- Forage supply and quality issues were often the major or most immediate constraint to improved cattle production

- In order to introduce farmers to animal management related best-bets such as early weaning, farmers needed to have a reliable source of high quality forage
- There is benefit in an incremental approach whereby farmers gain confidence and trust through tangible success with forage strategies (modest in size) before trying animal management strategies which require long-term planning and investment.

Figure 11 summarises the type, occurrence and status of best-bet activities across all sites based on exit interviews conducted in February 2008 (and other project records).

Note: The exit interview results shown in this section are based on the results from all sites. This is done to simplify the presentation but also reflects the high degree of response uniformity across all of the villages.

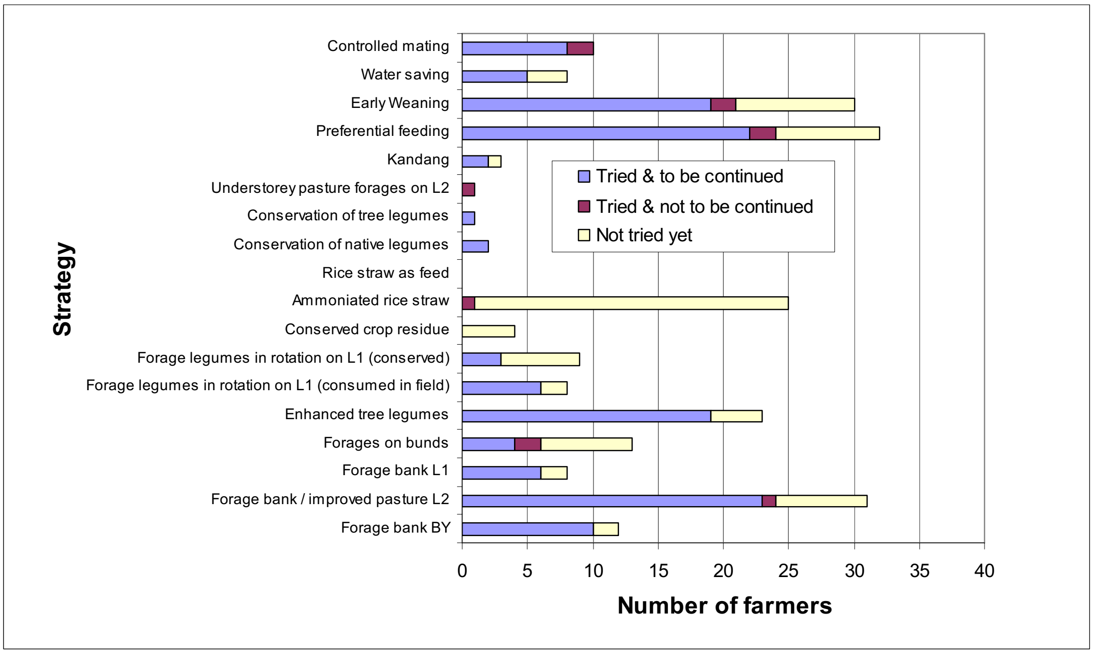


Figure 11. Application outcome for 'best-best' activities - all sites.

On the whole, the main forage improvement practices of establishing forage banks and tree legumes (or enhancing existing plantings in the case of tree legumes) were either successfully pursued by the majority of the households, were already being trialled to some extent, or would be in the coming season. Relatively few of the households reported having tried these particular practices and made a definite decision to abandon them in the future. Interest in Gliricidia was generally much greater in the NTB villages of Mertak and SPA compared to the Sulsel villages of Barru and Lemoa / Manyampa, due to the pre-existing familiarity with tree legumes (especially Gliricidia) in the former region.

Only a small number of 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. Rice straw ammoniation was trialled by just two farmers but is not to be continued due to the logistical difficulty in carting and storing bulky rice straw at peak labour times in the cropping cycle, and the perception that returns are better from other forage improvement options such as standing forage banks of elephant grass, tree legumes and / or new forages. A relative reluctance by local project colleagues to promote crop residue conservation in preference to new forage introduction also contributed to lack of adoption. A similar situation applied to promotion of Gliricidia use within Sulsel study villages, which again resulted in lower than anticipated uptake of a highly successful and valuable NTB forage technology there. Continued education and demonstration of impact to farmers and agency staff is required to address this in the follow-up scale-out projects.

Of the three main cattle management practices of controlled mating, early weaning and preferential feeding, only the latter two practices had been applied by more than half the households (Figure 11). Nevertheless, most of the remaining households recognised the claimed benefit of both practices and intended to employ them in the coming season or when they at least had a calf to warrant it.

The timing and extent of farmer uptake of early weaning / preferential feeding is dependent on the availability of calves and (simultaneously) high quality forage. While these options were identified in the original farmer interviews and canvassed with all best-bet farmers throughout the course of the best-bet program, they were mostly tackled once forage constraints had been addressed in line with the step-wise approach described earlier. This mainly occurred in the second wet season when calves of around 6-7 months age and high quality forage were both available.

Less than one quarter of the households had practiced controlled mating of their cattle, the majority of whom had achieved this independent of the project - failure to do so was largely due 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 commenced some form of controlled mating by February 2008.

All best-bet households at SPA constructed a trough for recycling grey water in the dry season and had used it successfully during the course of the project. While attribution of this uptake to the current project is somewhat confounded by the fact that at least one of the best-bet farmers was recycling grey water prior to the project commencing, the approach was actively encouraged during the workshop and through the provision of cement to some of the best-bet farmers. Cement was also provided to each of the best-bet households in Desa Mertak, but no structures had been erected at the time of the exit interviews. This was due to problems obtaining suitable local sand for concrete.

For many of the best-bet farmers, the list of activities identified as having been undertaken at the end of the project differed to some extent from the initial farm specific recommendations. Farmers were influenced and motivated not only by the actions of the project team but by interactions with other farmers (via field days and less formal interactions) and the legacy of previous ACIAR projects. Hence, while most farmers adopted the initial best-bet strategies, there were some deviations over the course of the project. All best-bet farmers that attended field days at one of the other established sites commented that these visits were important in terms of providing both knowledge, ideas and motivation (and in many cases planting material!).

Forage production

Since the commencement of the best-bet program, many farmers have significantly expanded their original forage introduction best-bet areas. For example, Amaq Warni (SPA) plans to plant up to 1 ha of new grasses and legumes in his upland and re-locate all of his cattle operations to that site; Bella (Lemoa) has more than doubled his forage area under cashews from 0.2 to 0.5ha; Saiful (Lemoa) and Jufri (Lompo Tenggah) are developing significant new areas of forages in their upland; and Amaq Adul (Mertak) plans to double his stylo/grass/Gliricidia hedge grazing and cut and carry system in 2008. Of all the new forages trialled in the best-bet program, by far the most successful have been: new cultivars of *Brachiaria* X cv Mulato and *Panicum maximum* cv Simuang, both introduced via Peter Horne in 2007; *Paspalum atratum* which was originally introduced to Mahmud's land at Lompo Tenggah and *Clitoria ternatea* cv Milgarra. Verano stylo has been successful, particularly in NTB while *Stylosanthes guyanensis* CIAT 184 has worked well in the Sulsel locations.

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

Farmer education on proper management of forage legumes to encourage tillering and ensure sufficient seed for regeneration remains a major challenge for such forage oriented best-bet programs. The same applies to education regarding forage grass cutting and fertiliser management. The challenge is to get farmers to see forage banks as a crop and to manage for optimum forage leaf production. When this happens, as in the case of Jufri (Lompo Tenggah), real breakthroughs can be made in the sustainability of quality forage production and improved animal nutrition.

Cattle production

Responses from exit interviews showed a strong level of agreement among roughly one quarter to two thirds of the households that the strategies employed during the project were already leading to improved cattle productivity (Figure 12).

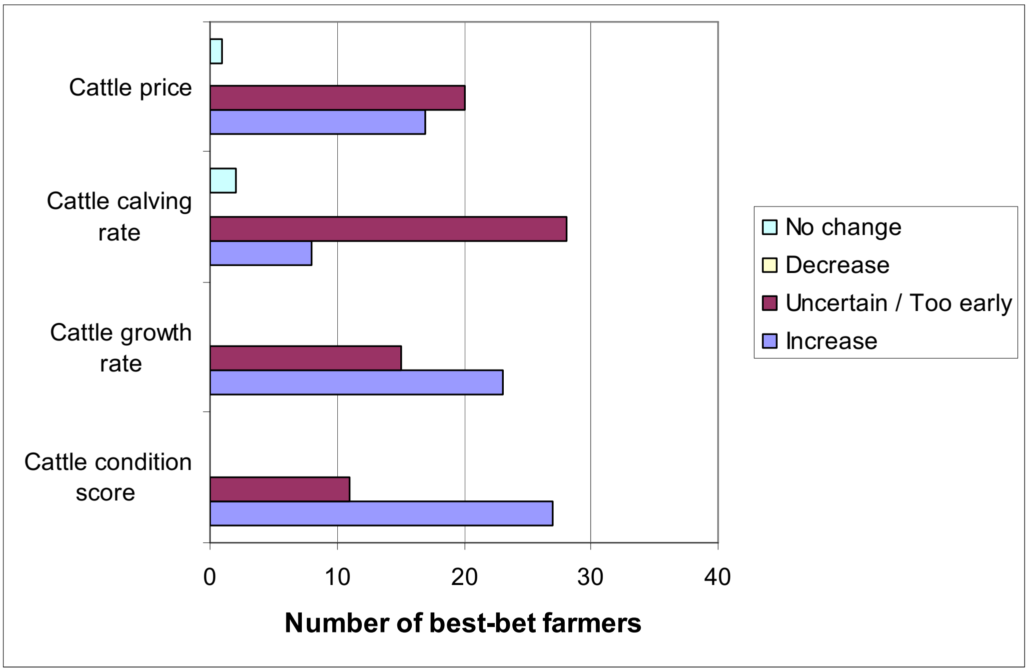


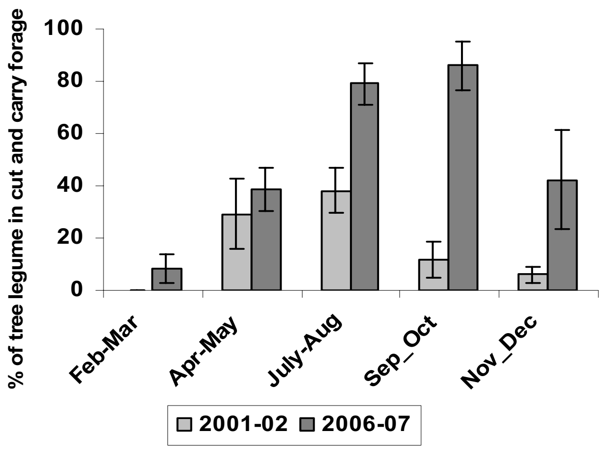
Figure 12. Impact on cattle from best-best practices - all sites.

The view that availability of forages was already having an effect on animal performance was particularly strong when considering the body condition of all classes of animals and the growth rate of young cattle. While less than one quarter of the households thought there had been an improvement in reproductive performance of their cows, almost half were sure that their cattle were now much more valuable than those of similar age and sex owned by other households in their communities, margins in the order of 33-50% being commonly suggested. Nevertheless, a significant number of households were uncertain as to whether there was 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 specific impact of individual best-bet activities through the on-farm monitoring activities is difficult, especially in the early stages of the new forage introductions where the contribution to total forage supply is often relatively small, and farmers often chose to save their forage banks for late dry season cut and carry use or as planting material. The difficulty is compounded by the relatively infrequent monitoring intervals. As these were mere 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 farmer best-bet activities is often compromised by the small numbers of stock involved and relatively short turnover times for some classes of animals, especially young males, which are sold off to meet planned or unplanned household cash needs or share farmed out to other farmers. Nevertheless there were many examples where the individual or combined impacts of a farmer's best-bet activities led to measurable improvements in both forage supply and cattle condition.

In SPA, the widespread adoption of tree legumes which was instigated by the precursor AS2/2000/2005 project (Figure 13a) provided the platform for rapid adoption of improved livestock reproduction and feed management strategies and has resulted in significant gains in late dry season cattle liveweight in that village (Figure 13b).



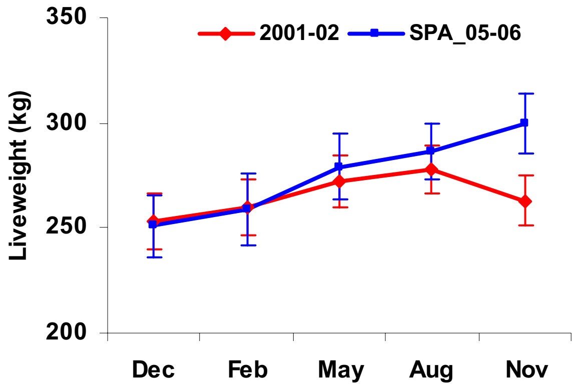


Figure 13 a) Comparison of tree legume fraction of cut and carry diet of Bali cattle at SPA village, Sumbawa between 2001-02 and 2005-06. b) Comparison of Bali cow liveweight trends at SPA village for 2001-02 and 2006-07. Data are mean liveweight and standard errors.

In Lompo Tenggah, Jufri established a 0.05ha forage bank of Clitoria ternatea, Setaria sphacelata, Gliricidia sepium and later Paspalum atratum which provided up to 40 % of fresh forage requirements for three yearling male cattle for most of 2006 and resulted in improved growth rates relative to other Lompo Tenggah farmers (Figure 14). Jufri's cattle grew at twice the rate (0.30kg/hd/day) of the Lompo Tenggah average of 0.14kg/hd/day.

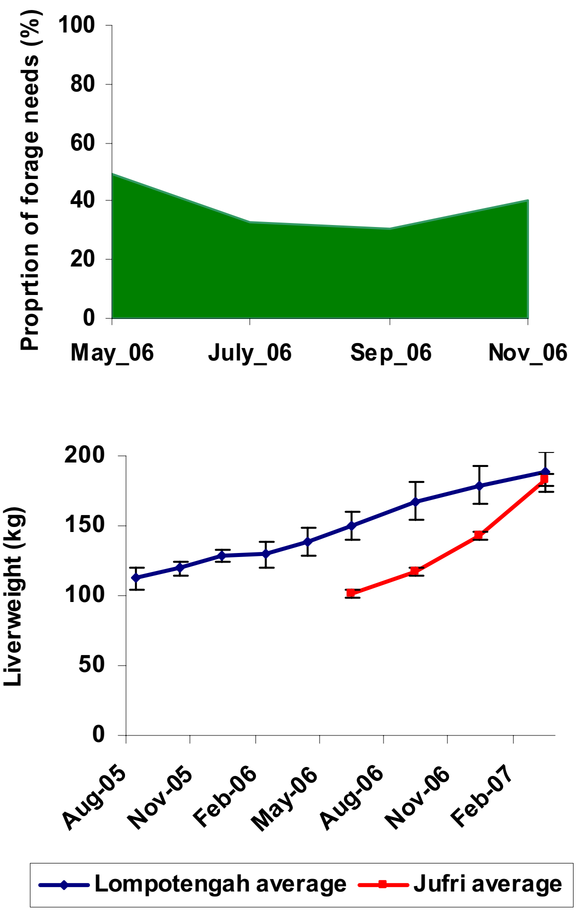


Figure 14 a) Proportion of cut and carry forage dry matter requirements supplied from Jufri's 0.05ha forage bank for 3 yearling male cattle during 2006 (assuming a daily dry matter requirement of 3% of body weight for maintenance and growth). Forage was a mixture of Clitoria ternatea, Centrosema pascuorum and Paspalum atratum and Setaria sphacelata which contributed around 17000kg/ha dry matter during 2006-07 or around 850kg dry matter from the 0.05ha forage bank. b) Comparison between growth rates of Jufri's yearling male cattle fed from his forage bank and average growth rates for similar young male Bali cattle at Lompo Tenggah during 2006-07.

At Harapan, the liveweight gain of La Matta's cows and young males exceeded the average gains across the other best-bet farmers within the village. This is attributed to the combined effect of new forage banks, better management of existing elephant grass to maximise leaf production and improved feeding management (Figure 15)

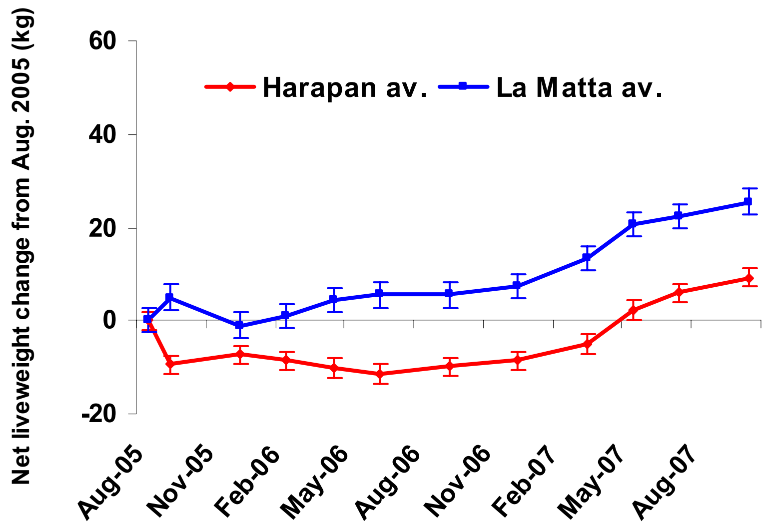


Figure 15. Net liveweight change comparison August 2005 to August 2007 between La Matta's cows and the average across the other best-bet farmers at Harapan, Sulsel.

At SPA, the relative performance of young male cattle belonging to Amaq Ahyar was better than the average across all other SPA best-bet farmers, due to the combined impacts of 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 (Figure 16).

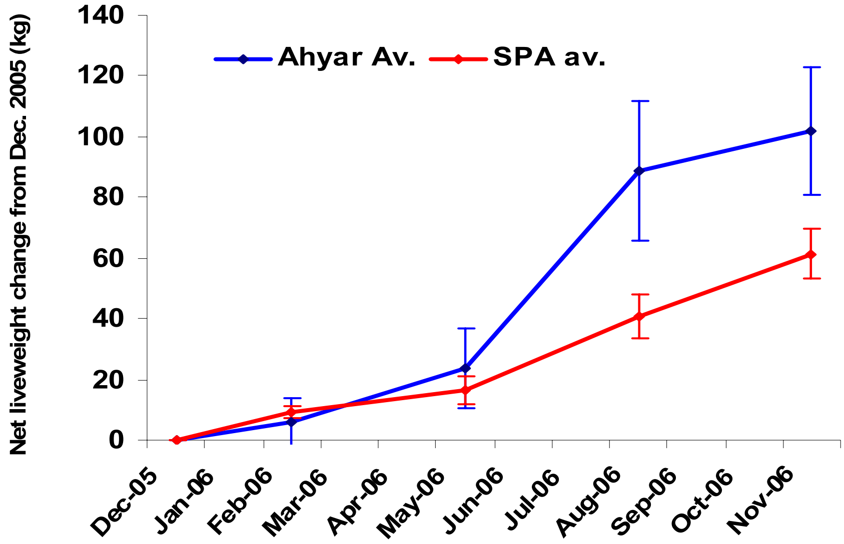


Figure 16. Net liveweight change comparison from Dec. 2005 to Nov. 2006 between Amaq Ahyar's young male cattle and the average across the other best-bet farmers at SPA, Sumbawa

Many of the best-bet farmers at Mertak had a best-bet strategy relating to the greater cultivation, utilisation and management of tree legumes as a source of high quality feed that persists through the dry season. Forage monitoring results show a sharp increase in the use of Gliricidia (previously under-utilised) from September 2006 (Figure 17), and the corresponding partial replacement of off-farm feed sources (i.e. trucked crop residues from outside the village (Figure 18). This uptake is attributable to the farmer workshop and SPA visit in July and October 2006, respectively. The Mertak farmers recognised the much better condition and size of cattle at SPA attributable to the improved utilisation of

Gliricidia (Figure 19). The decline in use in the second half of 2007 is attributable to reduced availability due to severe drought conditions and extensive harvesting during the preceding early to middle dry seasons.

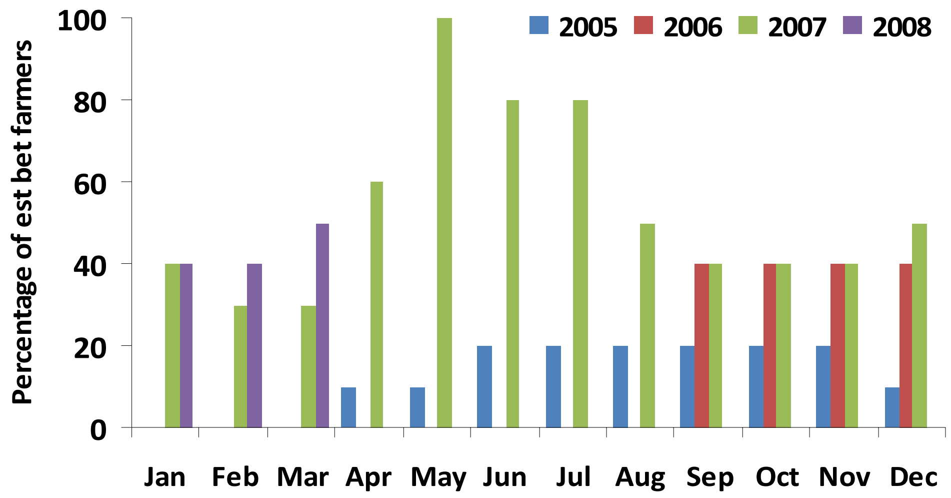


Figure 17. Percentage of best-bet farmers using Gliricidia sepium for cut and carry forage from 2005-2008 at Mertak, Lombok.

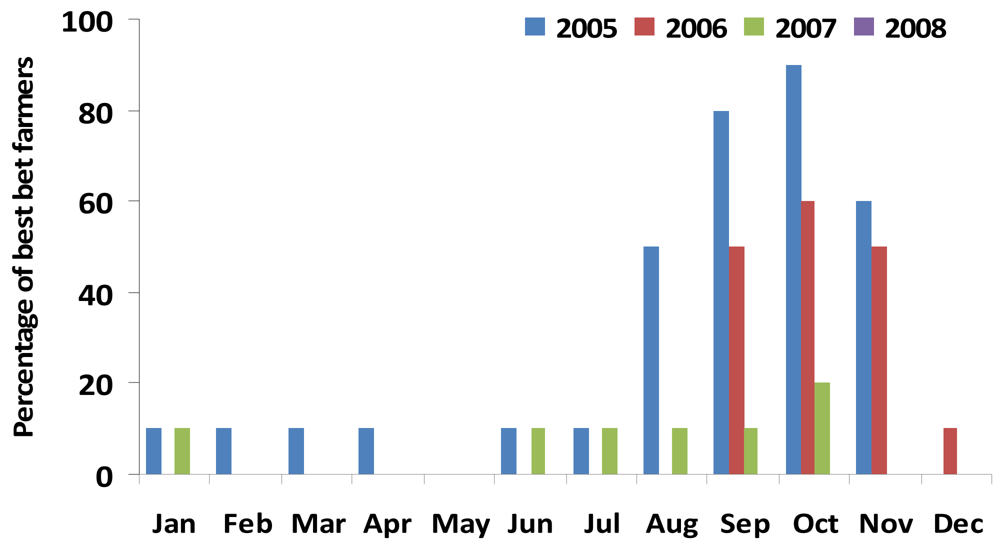


Figure 18. Percentage of best-bet farmers using cut and carry forage sourced off-farm Mertak, Lombok 2005-2008.

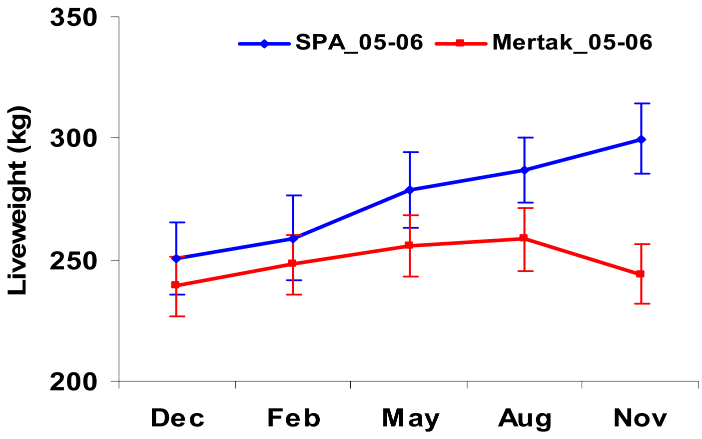


Figure 19. Comparison between SPA and Mertak seasonal liveweight trends for cows during 2005-06. Note that Mertak cow liveweights trend down in mid-late dry season, as they did at SPA prior to adoption of tree legume forage technology.

While the impact of changes in feed supply and usage is yet to show through in liveweight trends at Mertak (Figure 20), farmers did report a general improvement in cattle coat condition and wellbeing, which often precedes liveweight change. However, Figure 20 shows that the greater severity of drought in 2007 did not lead to the expected decline in performance compared to 2006.

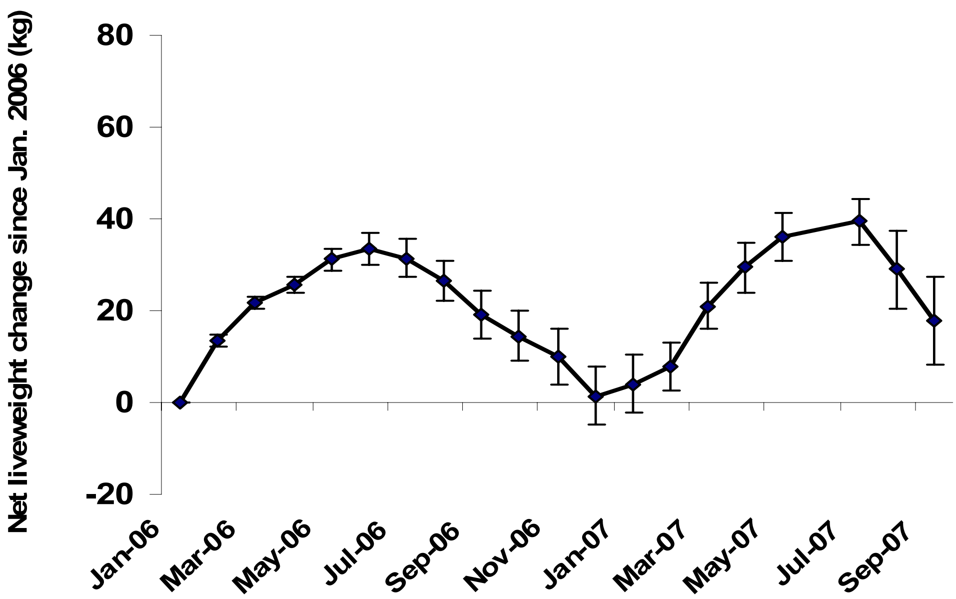


Figure 20. Seasonal trends in mean net liveweight change (with standard errors) since January 2006 for best-bet farmer cows.

While these examples indicate improvement in the performance of both cow and young male Bali cattle over the course of this project, the measured growth rates are still fairly poor at between 0.15 and 0.25 kg/head/day for young males. Exceptions to this are Jufri and Amaq Ahyar's kandang-fed young cattle at Lompo Tenggah and SPA respectively, which grew at around 0.4kg/head/day for several months during 2006-2007 until sold. Much of this constraint to optimal liveweight performance is tied up with the quantity and quality of forage fed to livestock, even when the availability of forage is adequate. Figure 21 shows the substantial variation in average cut and carry forage dry matter supplied per adult animal equivalent (AAE) by best-bet farmers in the more 'mature' villages of SPA, Harapan, Lompo Tenggah and Pattappa (August 2005-February 2008). The broken line indicates the amount of dry matter required by a 250 kg Bali cattle for maintenance and growth based on 3% of body weight.

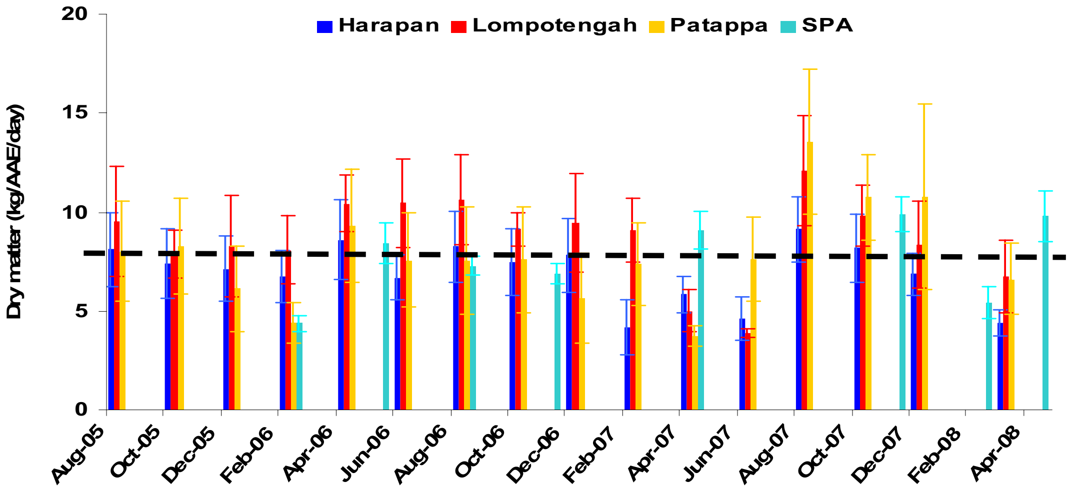


Figure 21. Seasonal trends in the amount of cut and carry dry matter offered per adult animal equivalent (AAE) per day in the older study villages of Harapan, Lompo Tenggah and Patappa (Barru, Sulawesi) and SPA (Sumbawa) between August 2005 and February 2008. Data are the mean of all best-bet farmers in each village. The dashed line represents the daily dry matter requirement for a 250kg Bali cow for maintenance and growth based on 3% of body weight (i.e. 7.5kg/head/day).

While the figure indicates considerable variability across the villages, the average amount of dry matter offered falls below recommended maintenance levels in many instances. While grazing is the source of significant forage requirements for some farmers, cut and carry forage supplies the bulk of quality forage for many farmers, especially in the dry season. This indicates that there is still considerable room for improvement in cattle performance and forage supply and a need for further farmer education in the relationship between Bali cattle nutritional requirement and forage supply and quality.

Crop production

Results from the exit interviews show that only 6 of the 39 best-bet households had actually decreased the area planted to food and cash crops, while another 2 households had made some direct change to the mix of cropping activities in their farming systems (Figure 22). Most of this small group had actually made a significant commitment to planting forages on their available land. None of the 39 households suggested that their present 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 been facilitated by labour savings in cut and carry tasks resulting from more ready access to forage sources closer to their house yards (see labour section).

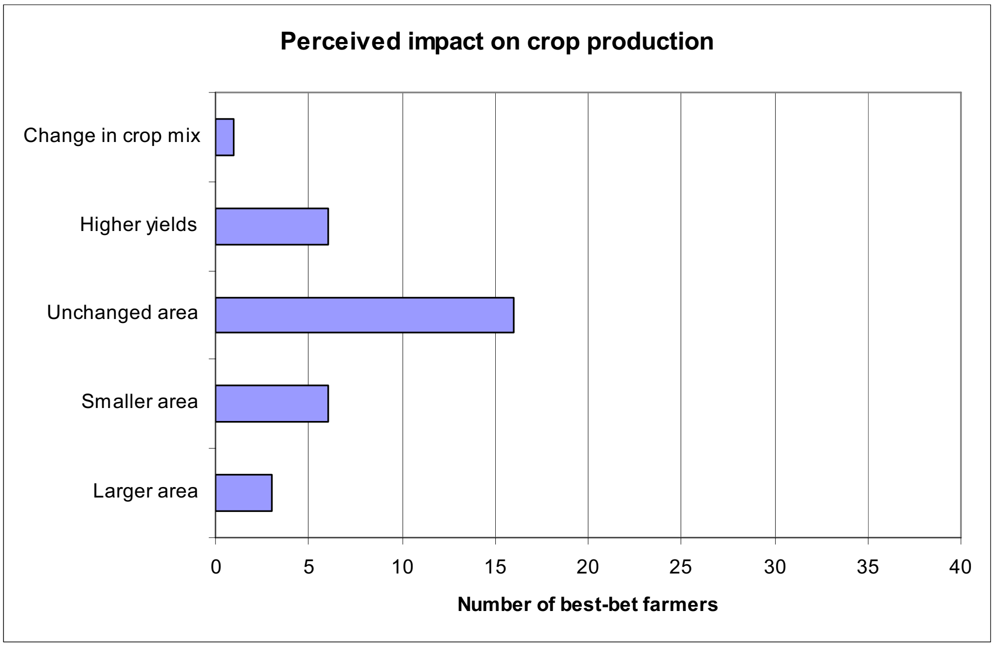


Figure 22. Impact on crop activities from best-bet practices - all sites.

Labour

Sourcing forages and water for livestock is typically a time-consuming activity for smallholder households, particularly in the dry season when forage availability becomes particularly limited. Therefore, the impact of trialling the forages and animal husbandry practices on household labour demands was of particular interest to the project - presented in Figure 23.

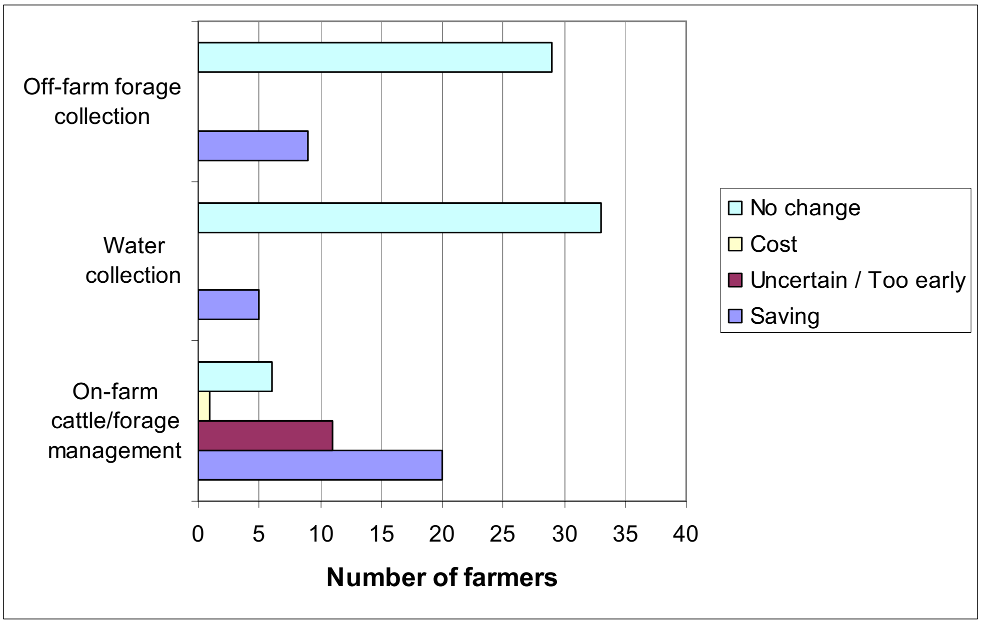


Figure 23. Impact on labour activities from best-bet practices - all sites.

With respect to sourcing forages from beyond the boundaries of the immediate community, the majority of households reported no change in the labour in this task. The 9 households that did experience a saving in labour used to source forages from outside their local community were all from SPA and Mertak (representing most of the best-bet households). These are particularly dry locations, for which hiring trucks to collect residues and straws from other regions several times during the dry season, was previously a common and expensive practice. In most cases, this activity and its associated financial cost had been entirely eliminated (later section).

While the project recommended using household grey water, the majority of households also reported no change in labour committed to procuring water for their livestock. The 5 households that did report a saving in labour allocated to this task were all from SPA kampung which had previously been a recipient community for GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) sponsored rainwater tanks and in which several of the best-bet households had successfully trialled grey water recycling. The households in Mertak were keen to trial grey water recycling, but had encountered delays in procuring cement to construct troughs prior to the last dry season and, at the time of interview, also reported difficulties in locally obtaining suitable sand for making concrete.

By far the largest impact on labour relates to on-farm labour use for both forage and cattle management where almost half the households reported definite labour savings, and one quarter were uncertain about the impact to date. For the former group, the actual savings in household labour were quite significant with most households (not shown) reporting that previous practices had involved 1-2 family members spending 6-8 hours per day for most of the dry season (either supervising cattle grazing away from their house yards or undertaking cut and carry or cut and drop activities). Only 1-2 hours per day was now spent on feeding and managing cattle. The majority of households who felt that it was too early to determine if there was any labour saving had also only planted relatively small areas of forages. Most of this group intended to expand their forage areas (later sub-section) in the coming seasons and anticipated similar savings.

A specific example of labour saving in relation to on-farm cattle and forage activities from Lemoa / Manyampa is shown in Figure 24. Prior to the best-bet program and the visit to the Barru field day, most Lemoa and Manyampa farmers relied almost exclusively on free or tethered grazing for forage supply and did little cut and carry, due to a perception that it was more labour demanding. Subsequent forage and socio-economic monitoring showed a sharp increase in the uptake of cut and carry and a reduction in grazing activity. In many cases this resulted in a reduction in labour required for livestock management in those villages.

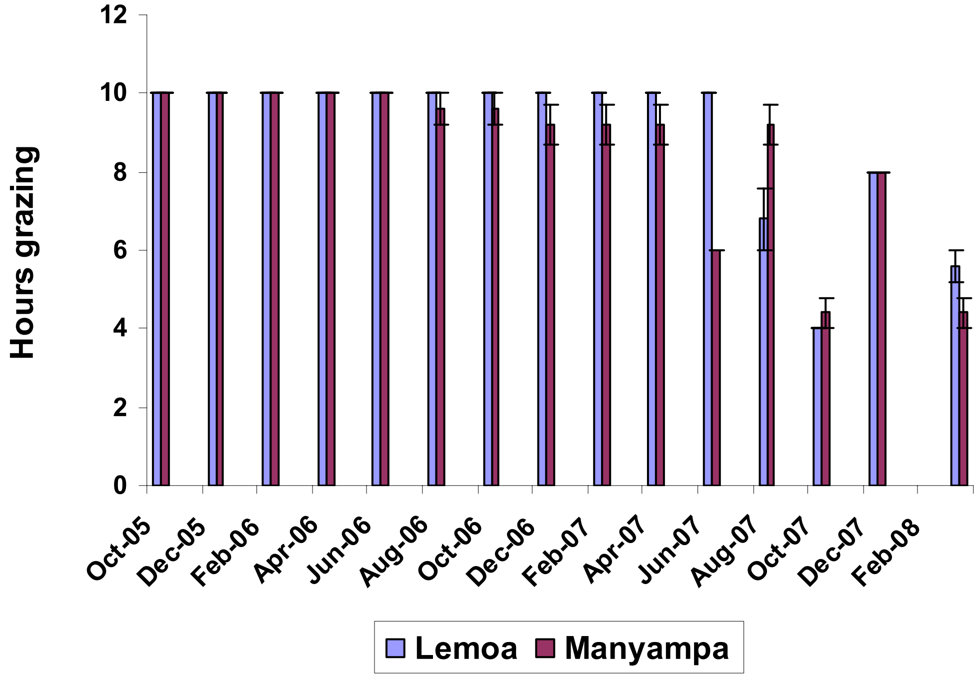


Figure 24. Trends in the average number of hours spent grazing each day by animals on best-bet farms at Lemoa and Manyampa sub villages, Gowa, Sulawesi. Note that forage best-bet activities commenced in wet season 2006-07 but only started to contribute significant cut and carry forage from April 2007, which coincides with a drop in the number of hours animals spent grazing. Data are means and standard errors. Note: the maximum hours recorded in these surveys was 10 per day. Actual hours may have exceeded 10 at times.

The use of freed up labour, for those households that reported labour savings, to support other farm and non-farm activities is presented in Figure 25 (from exit interviews).

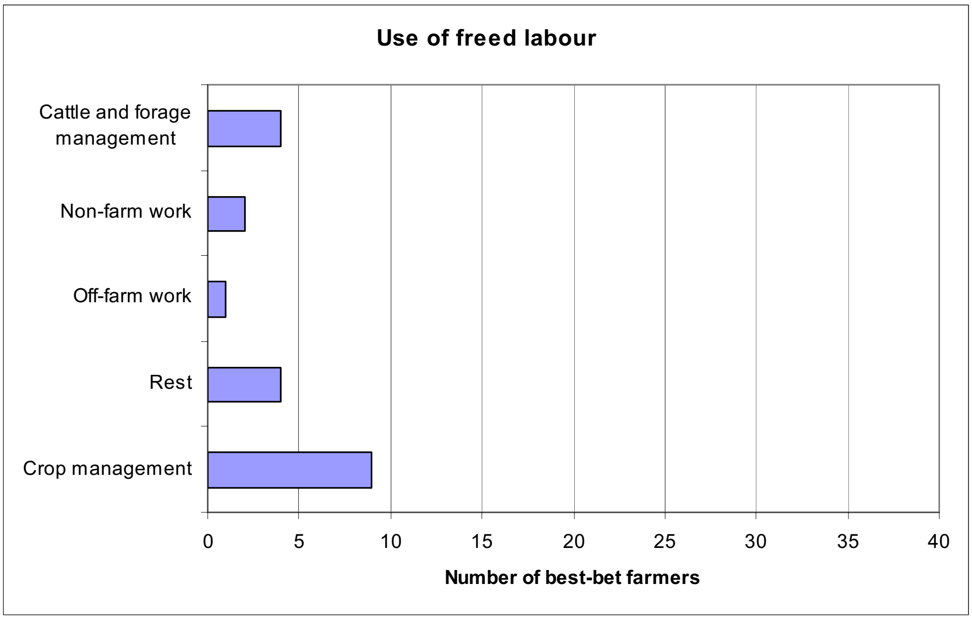


Figure 25. Activities to which labour freed up from previous forage and cattle management tasks was directed - households reporting labour savings.

Consistent with the previous observation that crop areas and, to a lesser extent crop yields, had increased or were unaffected by the best-bet practice changes for many of the households, most of the households reporting freed up labour allocated extra labour to crop management tasks. About half that number used the freed up labour to further intensify their forage and cattle management practices and the remainder used it to support either non-farm or off-farm employment activities or simply to rest.

Household finances

Beyond the gains revealed in labour, crop and animal productivity for many households, an important consideration is whether or not the forage and livestock practices being trialled by the best-bet households are actually making them financially better off. Some indicators of this project impact are presented in Figure 26.

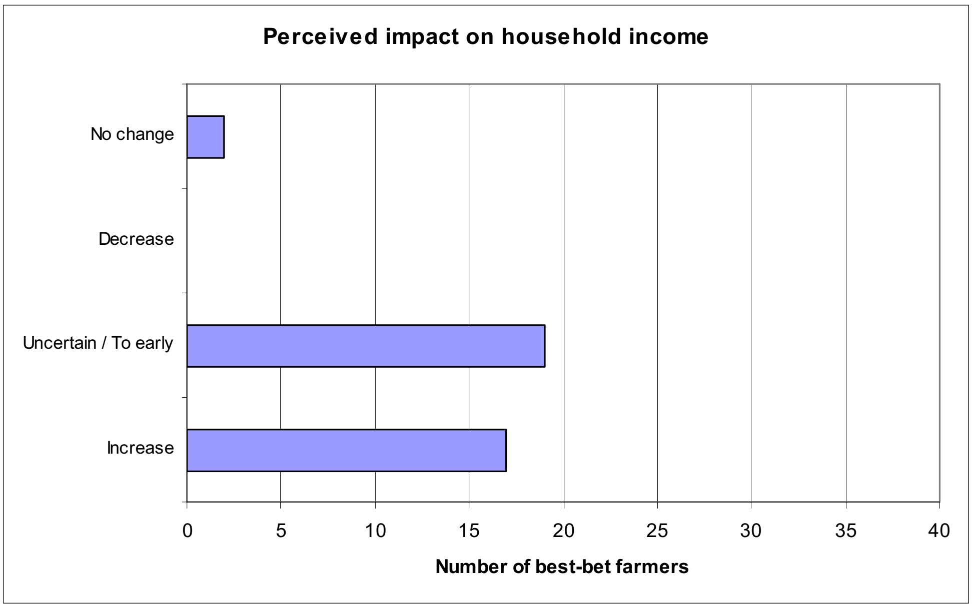


Figure 26. Impact on family income from best-bet practices - all sites.

None of the best-bet households reported having their income decrease as a direct result of trialling the forages and livestock management practices, and only 2 households were definite about there having been no change so far. The majority of households either had already experienced an increase in their income or were not yet in a position to respond positively.

Basically, the bulk of the income gain, where this was recorded was the result of producing additional cattle which to the time of interview had already been sold. Most of the 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 actually sold any more cattle yet. As many households had reported that their cattle were growing faster or were in much better condition than previously (Figure 12), there was a clear expectation that they would enjoy higher incomes in the future with the cattle being sold.

Many of the households who 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 Rp 2-3million and typically involved selling 1-2 extra animals per year.

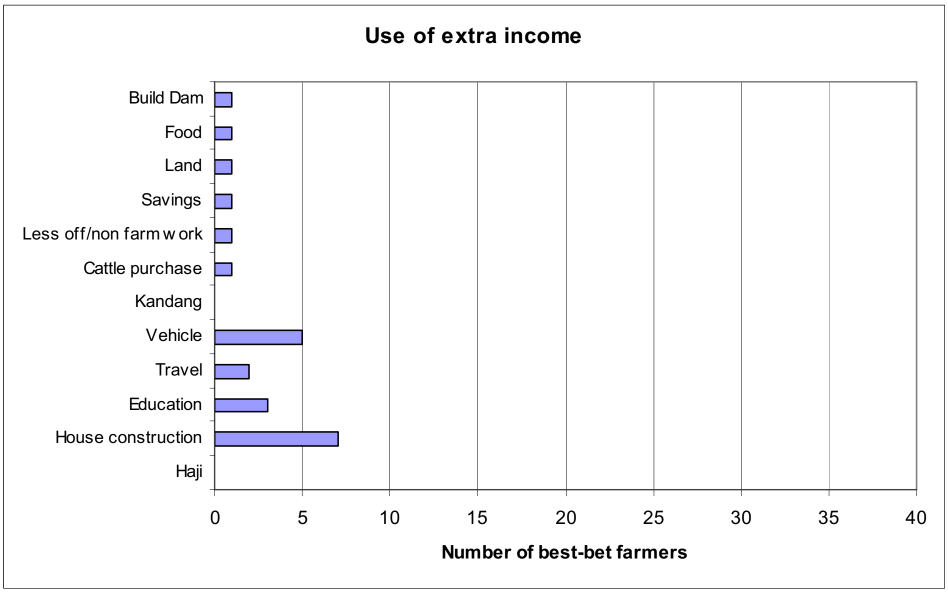


Figure 27. Uses to which any additional income had been put - all sites.

Having determined that the practices had already brought some financial benefit, or promised such. how this additional income might have been used was also of interest (Figure 27). Smallholder households in eastern Indonesia are generally not active participants in any formal market economy and cash outlays are frequently restricted to a narrow range of major and infrequent expenses and, to a lesser extent, small necessities to supplement their more dominant subsistence production and consumption activities (e.g. condiments, paraffin, fuel, herbicides etc).

Much of the additional income from cattle sales was used to acquire or improve major capital assets, particularly house construction and motor vehicles, and to a lesser extent purchase of land and more cattle. Education and travel were also financed by several of the households, mostly to support older children (school fees) and young adults (travel to distant work sites). While 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 sale of cattle are a long-recognised path to finance travel associated with religious aspirations (Haj) and several of the best-bet households were headed by community-respected Haji, none of the households had as yet used their additional incomes for this particular purpose.

Future intentions

As the exit interviews were conducted at a relatively early stage in the adoption cycle of new practices, the best-bet households were asked several questions relating to the future plans and aspirations for their farming enterprise (Figure 28), as well as the level of interest in what they had been doing by other households (Figures 29 and 30).

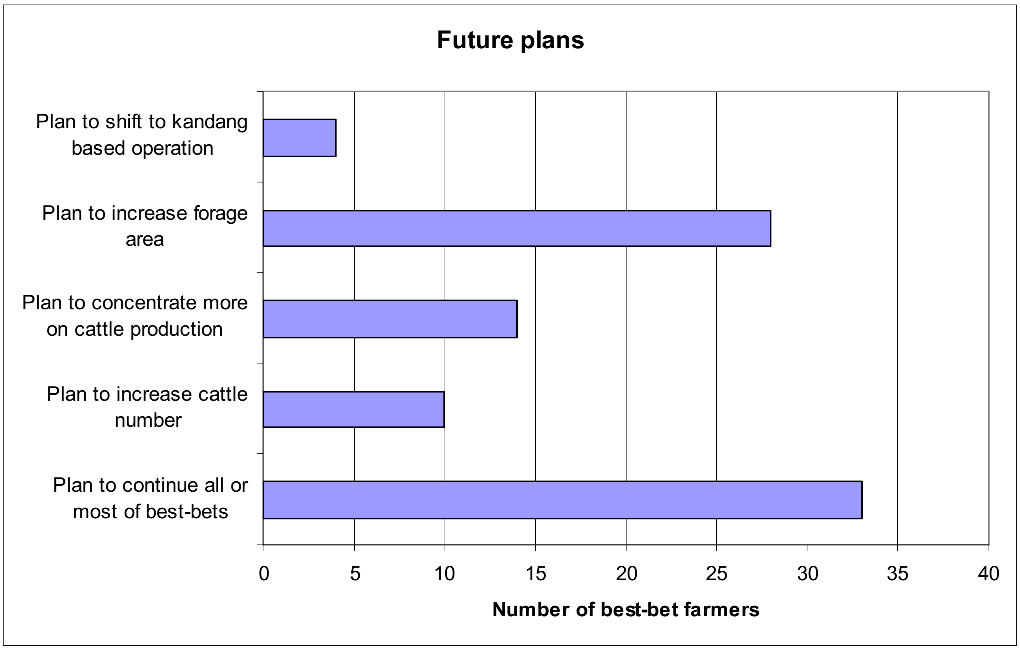


Figure 28. Future intentions with respect to employment of forage and livestock management practices - all sites.

The majority of households were planning to continue to employ most, if not all, of the best-bet practices that had been introduced to them by the project team. While a couple of households asserted that they would not employ any or most of the practices in the future, most of those who were not definitely proposing to continue 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 have still only relatively small areas of forages established to date. It also reflects the fact that many of the households already have more cattle than they can realistically feed and ‘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 elsewhere on the owners’ land and cut and carried to those animals.

Interest from other farmers / scaleout

Beyond a major role in trialling and refining their best-bet practices, the participating households were also seen to represent important platforms for extending the practices to other households as part of the natural technology diffusion process. The households were asked about the interest shown in what they were doing by other households in the community (Figure 29).

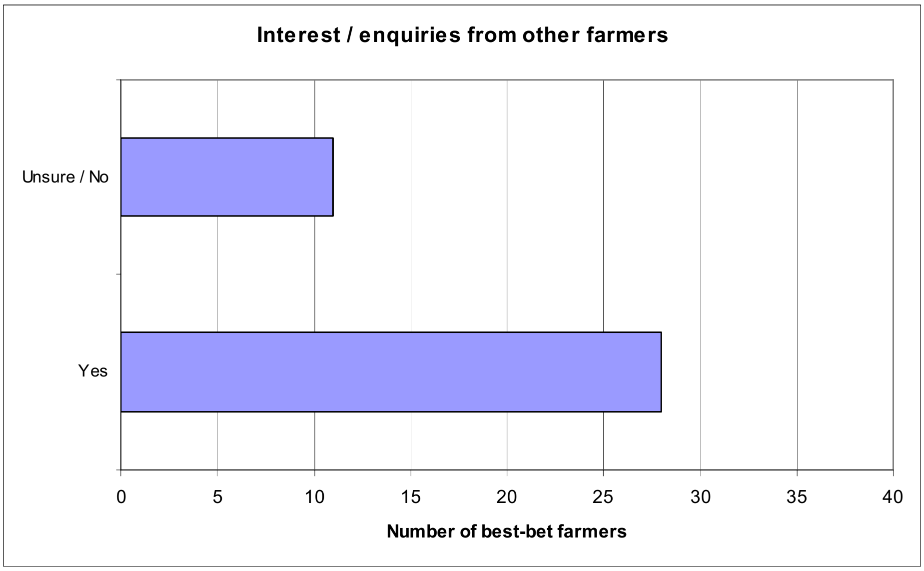


Figure 29. Interest shown in best-bet involvement by other households - all sites.

The majority of best-bet households interviewed had fielded some inquiries from other households about their involvement in the project or about some particular aspect of the practices that they had been trialling. Results from the exit interviews (and from records kept by individual farmers) indicate significant interest from other farmers in best-bet activities. The number of inquiries was generally higher at the more mature sites of SPA (~130) and Barru (~120) compared to Lemoa / Manyampa (~17) and Mertak (~10).

A comprehensive assessment of the geographic extent and nature of scaleout of best-bet technologies is beyond the scope of this project but a separate comprehensive study is planned for the second half of 2008 (with follow-up surveys to be performed later). A preliminary survey of 15 known scaleout farmers in the immediate vicinity of Lompo Tenggah conducted in April 2008, showed that ~80% of these farmers had implemented forage improvement technologies such as new forage introductions (sourced from the original best-bet farmers) and forage conservation; with more than 50% having trialled preferential feeding and kandang based feeding. All farmers interviewed commented that there had been a positive effect on cattle condition. Most plan to continue some or all of the activities into the future.

The nature of the interest shown by the inquiring households was heavily skewed towards establishing forages (Figure 30). Most of the household to household inquiries related directly to requests for access to cuttings and seeds of various forage species - often after the inquiring household had participated in a field day or been told about forages by other households who either were growing forages or had also participated in a field day or workshop.

Advice on establishing and feeding forages, especially tree legumes, was also a major reason for some households to specifically seek out best-bet households. Topics relating to cattle management, other than feeding, were not common enquiries. While some interest was shown in early weaning practices (usually ‘why’ and ‘how’), this did not extend to controlled mating and preferential feeding practices which complement early weaning as a package.

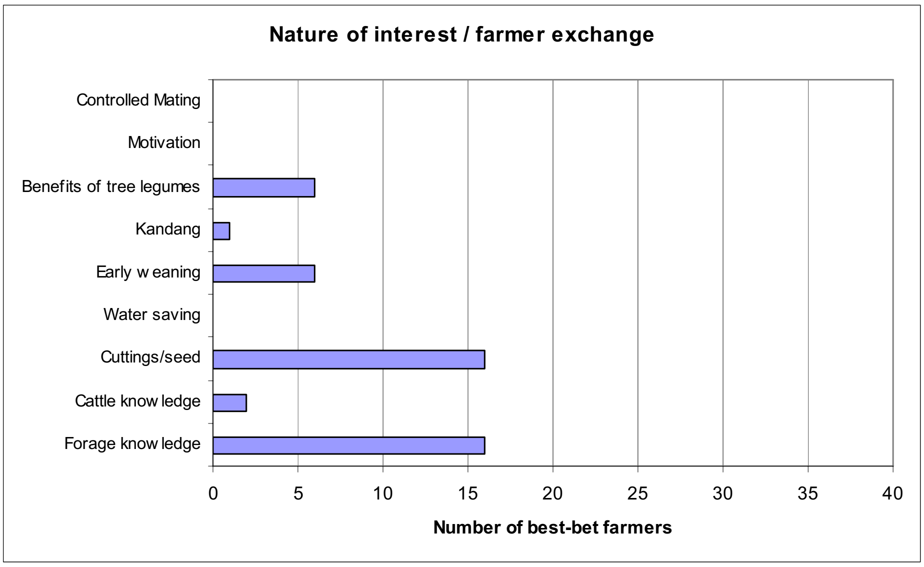


Figure 30. Nature of inquiries by other households - all sites.

Value of farmer workshop

The first major project-related activity that many of the best-bet households would have actively participated in were the series of workshops conducted in 2005 at which the project was discussed, local issues relating to livestock production canvassed and general options explored using the Integrated Analytical Tool (IAT). Not all of the households participated in those workshops, with only 45% of the present best-bet households having a member attend. The majority of best-bet farmers joined the project after they were held. While a good many of the households who had attended the workshops could not recall a great deal of what was specifically discussed, about a quarter of those who did attend recalled that it provided motivation and knowledge.

Value of field days

While there were many forms of interaction between the individual best-bet households and the project team on either an individual or a group basis through the life of the project, one other significant activity that was thought to have some scope for impact was the field days at Lompo Tenggah (Barru) and SPA (Sumbawa) in 2006. A key feature of these two exercises was that the field days did not just involve the immediate local communities, but also involved transporting household members from Lemoa / Manyampa (Gowa) to Lompo Tenggah and from Mertak to SPA.

Just over half of the best-bet households participated in one of the two field days. There was a more even spread of interest across both forage and cattle management topics. Of note is the interest in using tree legumes for forage which was particularly noted by the Mertak households who visited SPA where this practice largely underpinned the success of cattle raising activities by overcoming dry season feed shortages; and the use of kandangs for feeding cattle which featured at both sites.

A major impact of both field days on the participating farmers was the opportunity it provided to take forage materials (both cuttings and seed) to plant and trial on their own land - over and above the materials that the project was formally providing to each household.

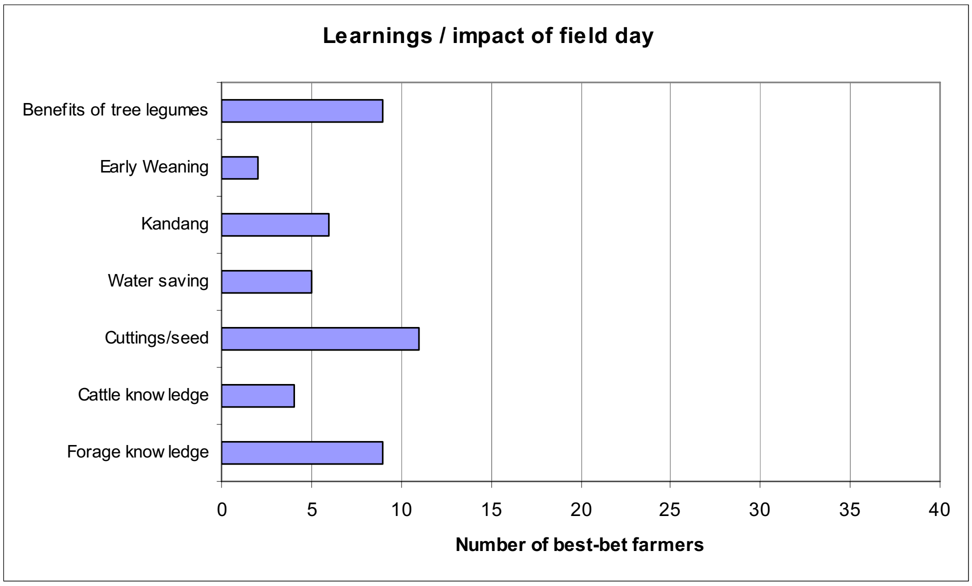


Figure 31. Useful learnings / impacts from field days - all sites.

Overall perspectives of project participation

On the question of lasting value from project exposure, with almost no exceptions, each of the participating households claimed during the exit interviews to have received something of value from the project and their experiences in trialling various aspects of the technologies and practices associated with the project. For example, bar 2 households whose heads claimed to be too old for future activity, all of the households were prepared to work with another project in the future. However, this participation was also conditional on a prior understanding of what the project would actually be about.

While rooted in apparent common sense, this proposition warrants reflection because many of the households had previously been exposed to aid projects that from their perspective promised something of immediate value but most often delivered little of lasting or tangible benefit. This was eloquently summed up by one householder who described most previous projects as being like ’pasar malam’ (traditional night markets) - set up this afternoon and gone by tomorrow morning.

This ACIAR project was typically described as having delivered much of lasting benefit because it addressed problems of major significance, adapted solutions to individual capabilities and circumstances and, importantly, provided repetitive reinforcement and technical support. In terms of lasting value another householder said that the project technologies were now habit and like Suharto’s original edict for Indonesia to become self-sufficient in rice production were now ‘encultured’ in his practice.

This positive attitude toward the project was also expressed in mid-project farmer interviews conducted in November 2006. The participating households who had already trialled the forage options for at least one growing season (Barru and SPA) reported high levels of satisfaction with the materials that they had been working with, even in cases where the progress and performance of the plantings had been disappointing to the project team. In these cases, there was a commonly expressed belief that the project (unlike many previous projects) was bringing genuine prosperity to their communities.

Several households in Barru actually reported a firm intention to abandon cropping activities within their farming systems altogether in order to specialise in growing forages for cattle raising and finishing activities. This was backed up with informal estimates of the net profitability of cattle being ~400% higher than subsistence and cash cropping if all of the produce to be sold and food for family consumption purchased from local sources. (Note: At the time of writing none of the households had entirely abandoned their food crops, highlighting the entrenched cultural value that may be placed on households directly meeting their own food needs as a mark of farming proficiency and a right to hold community respect). Similarly, households (Mertak and Lemoa / Manyampa) just setting out to trial the various forage and cattle management options had a high level of belief that the outcomes would be good, even when faced with set-backs to their principal food crops (i.e. drought).

The basis of this optimism was largely underpinned by members of these households previously travelling to the villages which had already incorporated the forages into their farming systems as part of the previous APS/2004/124/125 projects in Barru and SPA, and personally seeing the results and/or engaging with the farmers there. In all cases, the interviewees expressed a strong belief that the forages would perform better in their own context either because they believed that their local resource endowment was much better than in the visited sites or because there was a large amount of forage materials (notably Gliricidia, and to a lesser extent Leucaena) already present in and around their villages from previous re-afforestation or development projects. The appropriate management of this resource material for livestock production had never previously been demonstrated to them.

Another insight from the mid–project farmer interviews was the belief expressed by several of the households at Lemoa / Manyampa (and the Kepala Dusun) that the wider establishment of improved forages would ultimately enhance social harmony 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 it was enclosed by a secure fence. Once a secure perimeter was established (e.g. by planting a tree legume fence around the parcel), the 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.

In the exit interviews, several households quite honestly stated that they had originally participated in the hope of getting something free - especially cattle - and had initially become a bit 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 very enthusiastic about their participation - reinforced particularly by a visit to another community (SPA) where the results were not only impressive, but were something that they quickly recognised could be accomplished for themselves.

This sense of project value was often described in terms of confidence and security (Figure 32). In fact, when asked what they thought the most important impact of the best-bet practices might have been on overall household welfare many households identified that they felt less vulnerable to the sorts of crises that had beset them in previous years. For example, when food and cash crops failures, or sudden illness of family members, had forced them to quickly liquidate their limited reserves of wealth under quite unfavourable circumstances.

Beyond seeing forages and cattle as being more capable of withstanding climatic shocks than crops, having access to increased numbers of cattle and the ability to feed them year around meant that they held security against such setbacks. Moreover, owning such collateral also meant they were sufficiently creditworthy to be able to access credit if it were needed on much more favourable terms than otherwise. Many households suggested that they were more confident to face the future because, not only were they more financially secure, they also felt that having overcome the hurdle of safeguarding their financial future through a major shift in their farming systems, they could apply similar problem-solving capabilities to tackle new challenges as such emerged.

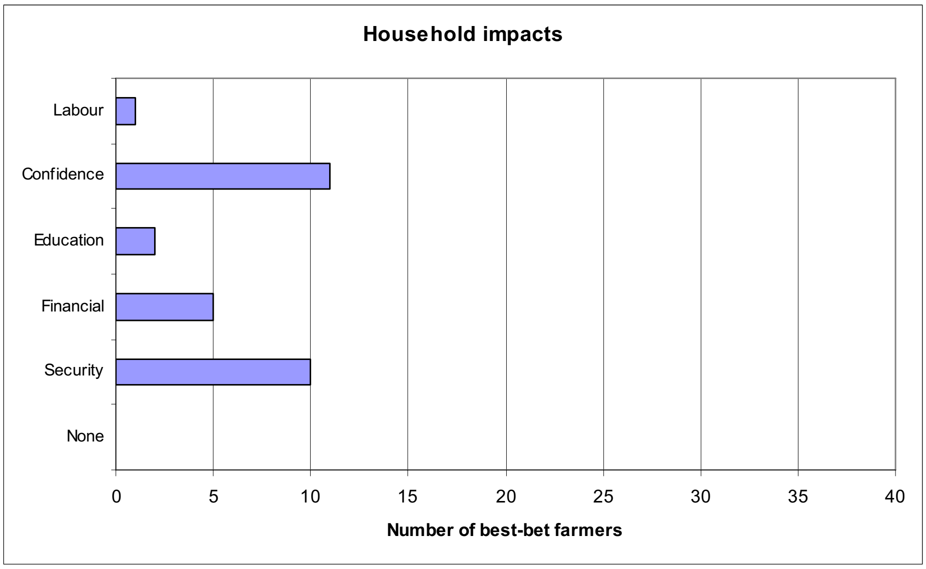


Figure 32. Overall impact of project participation on family welfare - all sites.

8 Impacts

8.1 Scientific impacts – now and in 5 years

This project (and its predecessors AS2/2000/124 & 125) has successfully developed and tested an approach combining the principles of participatory, on-farm engagement with farming system analysis and modelling, to encourage the uptake of technologies that improve the productivity and welfare of smallholder farmers.

While the specific focus in this project has been on livestock improvement for smallholder farmers 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.

Indeed, the success of this current project has led directly to the establishment of two new projects based in Sulsel (Building capacity in the knowledge and adoption of Bali cattle improvement technology in South Sulawesi, SMAR/2006/061) and Lombok (Scaling up herd management strategies in crop-livestock systems in Lombok, Indonesia, SMAR/2006/096). The objective of these projects is to expand in-country capacity in the approaches and tools developed in the 005/124/125 and related projects, and to then use that capacity to improve livestock production and household welfare in a large number of households across eastern Indonesia. These projects commenced in late 2007 and will run for at least 3 years. Consideration is currently being given to using these same approaches to improve livestock production in south-central Vietnam.

8.2 Capacity impacts – now and in 5 years

The capacity of project staff from BPTP, the Universities and Dinas to undertake the approaches and analysis outlined in this proposal commenced in the earlier AS/2000/124 & 125 projects and has been further enhanced over the course of this current project. Most of the learning/training has been of an informal nature via regular contact with the Australian project team. To enable this, one or more of the Australian team visited Indonesia every two to three months for up to two weeks at a time. Most of those visits were spent in the field, talking with farmers and discussing/ reviewing/adjusting techniques. At every possible opportunity, in-country project staff were encouraged to try themselves (i.e. learning by doing).

These informal approaches were complemented by more formal, targeted training in modelling, scientific writing, forage and cattle monitoring. Separate model training workshops were conducted at the University of Hasanuddin and Mataram University for project staff and other invited students and university staff. A more comprehensive training workshop was held toward the end of the project covering the broader principles of farming systems and participatory approaches. The latter workshop involved new staff from the new SMAR projects. The overall success of these capacity building activities is illustrated in a number of ways:

- The co-ordination and delivery of material and subsequent farmer engagement at the farmer workshops and field days was primarily performed by in-country project staff
- In-country staff successfully undertook many of the project activities in the absence of or with limited input from the Australian staff
- In-country staff played a lead role in delivering summaries of project activity at each of the sites at the project annual review meetings

- The same staff are now entrusted with providing the training for new on-ground staff in the two new SMAR projects (SMAR/2006/061 and SMAR/2006/096). It is hoped that at the end of the SMAR projects, these people will return to or be recruited by Dinas, BPTP and the Universities and continue to apply the techniques and skills developed during these projects
- Most of the in-country staff have presented project summaries at internal agency conferences and collaborated with Australian team members on the various journal and conference papers listed below.

Importantly, when directly canvassed about the impact of the project on themselves in two evaluation sessions (May 2005, 2007) the majority of the project team members identified growth in personal capacity as a major impact of their exposure to the project approach and constituent activities. This contrasts with a similar exercise conducted previously for project 124 & 125 in which a relatively high proportion of the teams reported some ambiguity in role understanding or personal contribution to project outcomes.

The results from the exit interviews clearly show substantial gains in forage and livestock management knowledge by participating farmers. Indeed, virtually all farmers nominated knowledge gain as the most important gain from the project. Many made the comment that the knowledge was now 'part of them' and that they had greater confidence to go forward, try other options and/or expand current activity. This increase in capacity was achieved through a combination of informal (e.g. conducting their own on-farm trials, discussions with other farmers and project staff) and more formal activities (e.g. village workshops and field trips).

8.3 Community impacts – now and in 5 years

The feedback from farmers and the results from the monitoring of field trials 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 into the future as most farmers intend to continue (and in some cases expand) successful strategies beyond the life of the project. There is also evidence of significant adoption/adaption of the livestock improvement technologies by other (non-project) farmers. This is expected to extend further to other farmers.

There was some indication (notably Lemoa / Manyampa) that the use of forages in specialised plots was likely to increase community cohesion through less disputation over forage resources on communally used lands. There was also a high level of agreement in the exit interviews with the best-bet farmers that their successful participation in this project had given them confidence to seek solutions to other problems that were confronting their communities - not necessarily relating to forages or cattle management.

8.3.1 Economic impacts

For full details see Results and Discussion.

During the exit interviews, many of the best-bet farmers reported substantial savings regarding on-farm labour use for both forage and cattle management. Increased feed availability closer to home has particularly resulted in both labour and cost savings for SPA and Mertak farmers who regularly trucked feed materials in from some distance during the dry season. Freed labour was primarily used to intensify cattle production and/or to increase crop production.

The majority of households have either experienced an increase in their income or are not yet in a position to respond with confidence - but expect this to be the outcome. The increase in income was typically attributed to the sale of additional cattle and the higher price obtained for those cattle. The magnitude of these income gains varied, but was in the order of 50%-300% higher than their existing incomes.

8.3.2 Social impacts

Each of the participating households (40 in total) claimed during the exit interviews to have received something of value from the project and their experiences in trialling various aspects of the technologies and practices associated with the project.

Many of the farmers commented that the main benefit from this project was knowledge and that they saw this as having more lasting impact than a ‘handout’ (e.g. bull). The project was typically described as having delivered much of lasting benefit because it addressed problems of major significance, adapted solutions to individual capabilities and circumstances and, importantly, provided repetitive reinforcement and technical support.

At Lemoa / Manyampa, (noted before) it was commented that the wider establishment of improved forages would ultimately enhance social harmony by lessening the potential for inter-household conflicts over the limited forage supplies on communally held land (especially in the late dry season).

Project value was often described in terms of confidence and security. Many farmers identified that they felt less vulnerable to the sorts of crises that had beset them in previous years. They also felt more confident to face the future because, not only were they more financially secure, they also felt that having overcome the hurdle of safeguarding their financial future through a major shift in their farming systems, they could apply similar problem-solving capabilities to tackle new challenges as they emerged.

8.3.3 Environmental impacts

While not the primary focus of the project, many of the strategies identified for improving livestock production may also have significant positive benefits for the environment. The addition of new forages and/or the improved use of existing forages will impacts on whole-of-farm nutrient cycling and hence production. For example the use of forage legumes and/or grasses (e.g. Arachis pintoi) under estate crops will provide additional nitrogen and/or improved weed control. On those farms where forages can be grown as relay crops, the forages have the potential to provide both additional soil nitrogen and organic matter to subsequent cropping phases. Under systems where higher quality forages are being produced and fed, higher quality manure has the potential to enhance crop production.

Upland areas used for rice, maize etc are quite steep and are highly susceptible to soil erosion. Better integration of forages and fodder trees in the cropping system, which has a primary aim of improving animal production, will help to conserve soil resources. Increasing problems with massive soil erosion and accession of contaminants from cropping lands into the local watershed in the Parangloe subdistrict of the Gowa Regency in Sulsel highlight the importance of adoption of farming practices which retain soil surface cover on smallholder hill farms.

8.4 Communication and dissemination activities

Publications and presentations

Journal papers

Sutaryono YA and Corfield J. Forage resources in livestock-cropping small holder systems of Sumbawa, Indonesia. Tropical Grasslands Journal. (under review).

Shaun Lisson, Neil MacLeod, Cam McDonald, Jeff Corfield, Rachmat Rahman, Lalu Wirajaswadi, Tanda Panjaitan, Yusuf Sutaryono, Rusnadi Padjung, Sania Saenong, Syamsu Bahar, Andrew Ash, Bruce Pengelly and Lisa Brennan. A participatory farming systems research approach to improving Bali cattle production in the smallholder crop-

livestock systems of eastern Indonesia I. Description of process and simulation models. Agricultural Systems (draft stage).

Neil MacLeod, Cam McDonald, Jeff Corfield, Shaun Lisson, Rachmat Rahman, Lalu Wirajaswadi, Tanda Panjaitan, Yusuf Sutaryono, Rusnadi Padjung, Sania Saenong, Syamsu Bahar, Andrew Ash, Bruce Pengelly and Lisa Brennan. A participatory, farming systems research approach to improving Bali cattle production in the smallholder crop-livestock systems of eastern Indonesia II. Application to two contrasting villages. Agricultural Systems (draft stage).

Bai X. Wieczorek AJ, Kaneko S, Lisson S, Contreras A (2008). Enabling sustainability transitions in Asia: the importance of vertical and horizontal linkages. Technological Forecasting and Social Change Journal (in press).

Conference papers

McDonald,C. K., N. MacLeod, S. Lisson, A. Ash, B. Pengelly, L. Brennan, J.Corfield, L. Wirajaswadi, T. Panjaitan, S. Saenong, Y. Sutaryono, R. Padjung , R.Rahman and S. Bahar (2004) Improving Bali cattle production in mixed crop-livestock systems in eastern Indonesia using an integrated modelling approach. In: New Dimensions and Challenges for Sustainable Livestock Farming, H.K.Wong et al. (eds.). Proceedings of the 11th Animal Science Congress, Kuala Lumpur, 2004. Vol. II, pp.116-119.

Cam McDonald, Shaun Lisson, Neil MacLeod, Rachmat Rahman, Lalu Wirajaswadi, Tanda Panjaitan, Yusuf Sutaryono, Rusnadi Padjung, Sania Saenong, Syamsu Bahar, Jeff Corfield, Andrew Ash, Bruce Pengelly and Lisa Brennan (2004) A whole-farm system approach to enhancing Bali cattle production in the mixed crop/livestock systems of eastern Indonesia. Proceedings Seminar Nasional Pemberdayaan Petani Miskin di Lahan Marginal Melalui Inovasi Teknologi Tepat Guna, Mataram 2004. pp1-8.

MacLeod, N.D., McDonald, C.K., Lisson, S.N. and Rahman, R. (2007). Modelling for scenario analysis for improved smallholder farming systems in Indonesia. In. (Oxley, L. and Kulasiri, D. Eds) MODSIM 2007 International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2007, pp. 109-114. ISBN: 978-0-9758400-4-7.
http:/www.mssanz.au/modsim07/Papers/DegreeofSite_s44_Basenet_.pdf

MacLeod N., Lisson S, McDonald C, Corfield J, Rahman R, Puspadi K (2008). Integration of smallholder crop-forage-livestock systems in South East Asia - an eastern Indonesian case study. Keynote paper to IRC-IGC Conference, Hohhot, China, 28th June to 5th July 2008.

Corfield J. et al (2008). The impacts of enhanced tree legume utilisation in the smallholder crop-livestock farming systems of eastern Indonesia, AAAP Conference, Hanoi, Vietnam 2008 (draft stage).

Wirajaswadi L, Sutaryono YA, Dahlanuddin, Puspadi K., Lisson S, Corfield J., MacDonald C. and Hadiawati L. (2006). 'Perbaikan Sistem Tanaman-Ternak Skala Kecil di Lahan Kering Indonesia Timur (Kasus Nusa Tenggara Barat)', Prosiding Seminar Nasional Balai Besar Pengkajian dan Pengembangan Teknologi Pertanin (BP2TP), Mataram, Lombok.

Book chapters (draft only)

MacLeod N., Lisson S. & Pengelly B. (2008). Farming systems, potential impacts, adoption and outputs. ACIAR book chapter.

Lisson S. and MacLeod N (2008). Farming systems, potential impacts, adoption and outputs – Indonesia case study. ACIAR book chapter.

Other presentations (project overview)

Lisson and McDonald, University of Copenhagen, May 2007.

Lisson, ACIAR Program review, Brisbane, August 2007.

Lisson, CSIRO Sustainable Ecosystems Program Review Meeting, May 2008.

Lisson, UTAS seminar series, April 2006.

Other communication and extension activities

Field days were conducted at each of the project sites: Barru in July 2006, SPA in July 2007, and Mertak and Lemoa / Manyampa in April 2008.

Fact sheets were prepared for many of the best-bet activities as handouts to participating and other farmers and for broader distribution by Dinas and staff from other agencies.

Permanent (weather-proof) signs were installed at selected best-bet trial sites to promote the project and associated activities to passing farmers.

In addition to the more formal field days, best-bet farmers were regularly visited (at least once per month) by in-country project team members and less regularly (3-4 months) by Australian team members. The visits from in-country staff were typically for monitoring activities and staff would take the opportunity to discuss the progress of best-bet activities, provide additional advice and discuss cattle and forage monitoring results.

9 Conclusions and recommendations

9.1 Conclusions

This project has identified a range of factors that are constraining livestock production in the smallholder farming systems of eastern Indonesia including: availability and quality of forages, especially during the dry season; poor knowledge and/or capacity to implement optimum feed management practices; limited supplies of readily accessible stock water; bull availability; inadequate cattle housing; labour availability; extended and sub-optimal breeding cycles; diseases; marketing constraints and limited access of smallholders to the formal credit sector for acquiring cattle and livestock handling materials. Some of these constraints are largely beyond the power of the individual farmer to overcome (e.g. access to capital, market shortcomings). Others are comparatively easy to rectify with generally predictable, positive results (e.g. stock water availability and cattle housing). A third group of constraints is characterised by solutions that require more skill and knowledge to implement, and for which the implications are often more complex and less predictable (e.g. feed availability, breeding cycle) due to inter-dependencies between the various components of these farming systems. Uniquely, this project has utilised a whole-farm simulation tool collaboratively with farmers to analyse the inter-dependencies and associated system impacts of strategies in this latter grouping, prior to on-farm trialling.

The pathways to adoption varied with the region and the technology concerned. While the participatory nature of this project and the regular contact with, and knowledge provided by the project team were highly regarded by the best-bet farmers, adoption was strongly influenced by the involvement and support of village 'champions'. For example in Lompo Tenggah, Mahmud is a highly respected leader of the local farming group and fostered strong engagement of the best-bet farmers within the group and other non-project farmers. Amaq Sapri played a similar role in SPA. The substantial expansion of Gliricidia plantings at SPA occurred prior to the commencement of the current project and the implementation of the process described above. Prior to the commencement of the pre-cursor project, Gliricidia served as a 'living fence' but was not valued as a source of feed. Once convinced of the feed value via involvement in the pre-cursor project (AS2/2001/125), farmers readily embraced the technology so that by the time the current project commenced it had become a vital source of persistent dry season feed and could be used as a 'platform' for the delivery of other livestock improvement technologies. The rapid uptake of Gliricidia, achieved with minimal input from the project team, is perhaps attributable to the fact that the farmers were already familiar with the species and its cultivation (i.e. simple, vegetative propagation) and that being suited to field perimeters and fencelines it did not involve significant displacement of other more productive areas. Conversely, the uptake of new forage species requires greater input from the R, D and E agencies, especially if that uptake involves the partial displacement of other activities. Typically, an incremental approach was taken to the rollout of best-bet strategies. The initial focus was to address forage supply and quality constraints through modest plantings of selected forages. The confidence and trust arising from successful adoption of these comparatively simple technologies was then used as an entry point for more complex animal management strategies which require long-term planning and investment.

Participatory approaches in which farmers, researchers and extension experts come together to co-learn through the identification, exploration and on-ground testing of new agricultural management options have been shown to be successful for forage technology uptake by smallholder farmers (Horne and Stür 2003). Dimes et al (2003) note that there can be synergies between simulation models and participatory approaches. The approach developed and used in this project employs whole farm simulation modelling as an analysis and learning tool within a broader participatory process aimed at improving Bali cattle production and household welfare for smallholder farmers in eastern Indonesia.

The feedback from the best-bet farmers and indeed their on-farm actions indicate that the participatory, farming systems approach has been successful. There is a range of evidence to support this:

- Willingness of farmers to participate in project activities and to allocate farm and personal resources to trial best-bet strategies.
- Quantifiable gains in forage and livestock production, labour savings and gains in household income over the life of the project.
- The intention of most of these farmers to continue (and in some cases expand) successful strategies beyond the life of the project.
- Virtually unanimous farmer appreciation of the knowledge provided by this project and the close and regular contact with project staff. There was matching criticism/cynicism toward the 'single-visit / ‘handout' philosophy of previous projects.
- Evidence of significant adoption/adaptation of the livestock improvement technologies by other (non-project) farmers. Unanimous sentiment amongst these farmers that cattle condition has improved. Most plan to continue some or all of the activities into the future.

The Integrated Analysis Tool (IAT) was found to be a useful component of the overall approach in the following ways:

- A communication tool to inform/underpin the dialogue between the project team and the farmers.
- Enabling rapid analysis of the financial, resource and production impacts of livestock improvement strategies and their sensitivity to key climate, soil, management and farm design variables.
- The screening out of less desirable strategies and shortlisting of feasible and viable best-bet options for subsequent on-farm testing, thus ensuring a more efficient and targeted use of limited project and farm resources.
- Providing a degree of confidence to both project staff and farmers that the strategies to be tested on-farm are unlikely to have an adverse effect.
- Providing motivation to some farmers about the potential impacts of proposed livestock improvement strategies.

The modelling and the results from the on-farm trials highlight the strong inter-dependencies / interactions between the various elements of these smallholder farming systems and the value of the holistic R, D and E approach. Clearly, changes in one part of the system can and do have profound effects elsewhere. For example, expansion of more accessible and persistent cut and carry resources on-farm were found to not only increase cattle growth, cattle price and household income but in some cases acted to free up labour previously used to shift cattle to feed sources or to collect fodder off-farm. This freed labour was then used to improve crop production (either area or yield).

9.2 Recommendations

The apparent success of the approaches developed and tested in this project provides support for wider adoption in other regions of Indonesia. Servicing the scaleout of this approach will require a substantial investment in capacity building within the key R, D and E agencies within Indonesia. Local universities can play a role in the training of future technicians in farming systems approaches and tools. Indonesian development agencies such as Balai Pengkajian Teknologi Pertanian (BPTP) have a role in the ongoing maintenance, adaptation and application of these tools to new regions. Extension agencies provide a conduit to farming communities and facilitate the on-farm activities and outscaling of the best-bet technologies.

The efficient and widespread scaleout of the approach trialled in this project will necessarily require some rationalisation, especially in relation to the scope (and hence duration and resourcing) of the benchmarking and monitoring activities.

There is a need for a comprehensive assessment of the geographic extent and nature of the scaleout of best-bet technologies from the best-bet farms in this project. Results from this study should provide valuable insights into the scaleout mechanism that would be of benefit to the conduct of the aforementioned scaleout project. This activity should also revisit the best-bet farmers to assess the extent and nature of uptake beyond the life of the project, especially considering the lag in many instances between uptake of the technology and demonstrable impact.

Consideration should also be given by ACIAR to supporting ‘maintenance’ visits for the Mertak site. Uptake of livestock improvement technologies has been slower at this site due to effect of drought and hence, some ongoing (low input) involvement would be beneficial.

10 References

Adiku SK, Carberry PS, Rose CW, McCown RL, Braddock R. (1993). Assessing the performance of maize-cowpea intercrop under variable soil and climate conditions in the tropics. Proceedings of the 7th Australian Society of Agronomy Conference, September, Adelaide, South Australia p382.

Bouman BAM, Kropff MJ, Tuong TP, Wopereis MCS, ten Berge HFM, van Laar HH (2001) ORYZA2000: modelling lowland rice. Los Banos (Philippines): International Rice Research Institute, and Wageningen: Wageningen University and Research Centre, 235p.

Carberry PS, Abrecht DG. (1991) Tailoring crop models to the semi-arid tropics. In: Muchow RC, Bellamy JA (Eds), Climatic Risk in Crop Production: Models and management for the semiarid tropics and subtropics. CAB International, Wallingford, UK, pp157-182.

Carberry PS, Gladwin C, Twomlow S (2004). Linking Simulation Modelling to Participatory Research in Smallholder Farming Systems. In: Delve, R.J. and Probert, M.E. (Eds.) Modelling nutrient management in tropical cropping systems. ACIAR Proceedings No. 114. pp32-46.

Castelan-Ortega OA, Fawcett RH, Arriaga-Jordan C, Herrero M (2003a). A decision support system for smallholder campesino maize-cattle production systems of the Toluca Valley in Central Mexico. Part I – Integrating biological and socio-economic models into a holistic system. Agricultural Systems, 75 1-21.

Castelan-Ortega OA, Fawcett RH, Arriaga-Jordan C, Herrero M (2003b). A decision support system for smallholder campesino maize-cattle production systems of the Toluca Valley in Central Mexico. Part II – Emulating the farming system. Agricultural Systems, 75 23-46.

Devendra, C., Lee Kok, T. and Pathmasingham, M. (1973) The productivity of Bali cattle in Malaysia. Malaysian Agricultural Journal, 49: 183-191.

Hennessy, D.W., Williamson, P.J. and Darnell, R.E. (2000) Feed intake and liveweight responses to nitrogen and/or protein supplements by steers of Bos taurus, Bos indicus and Bos taurus x Bos indicus breed types offered a low quality grass hay. Journal of Agricultural Science, Cambridge, 135, 35-45.

Herrero, M., Thornton, P.K., Googenboom, G., Ruiz, R., Fawcett, R.H., Jones, J.W., 2002. An integrated modeling platform for animal-crop systems. In: Proceedings of the 17th Symposium of the International Farming Systems Association. November 17–20, 2002, Lake Buena Vista, FL, US. p.107.

Horne, P. and Stür, W.W. (1999). Developing forage technologies with smallholder farmers – how to select the best varieties to offer farmers in Southeast Asia. ACIAR Monograph No. 62. 80pp.

Horne PM and Stür WW (2003). Developing agricultural solutions with smallholder farmers – how to get started with participatory approaches. ACIAR Monograph No. 99. 120pp.

Ivory, D.A. (1986). Performance of germplasm in new environments. In: G.J. Blair, D.A. Ivory and T.R Evans, eds., Forages in Southeast Asian and South Pacific agriculture: proceedings of an international workshop held at Cisarua, Indonesia, 19-23 August 1985. ACIAR Proceedings No. 12 pp 61-68.

Keating BA, Carberry PC, Hammer GL, Probert ME, Robertson MJ, Holzworth D, Huth NI, Hargreaves JNG, Meinke H, Hochman Z, McLean G, Verburg K, Snow V, Dimes JP, Silburn M, Wang E, Brown S, Bristow KL, Asseng S, Chapman S, McCown RL, Freebairn

DM, Smith CJ (2003). An overview of APSIM, A model designed for farming systems simulation. European Journal of Agronomy 18, 267-288.

Little, D.A., Kompiang S. and Petheram, R.J. (1989) Mineral composition of Indonesain ruminant forages. Tropical Agriculture, 66, 33-37.

Makeham, J.P., and Malcolm, L.R. (1981). The Farming Game, Gill Publications, Armidale, N.S.W.

Mastika, M. 2003. Feeding strategies to improve the production performance and meat quality of Bali cattle (Bos sundaicus). In: Entwistle, K., Lindsay, D.R. (Eds.) Strategies to Improve Bali Cattle in eastern Indonesia. Proceedings of a Workshop 4-7 February 2002, Bali, Indonesia. ACIAR Proceedings No. 110, Canberra.

McCool, C. (1992) Buffalo and Bali cattle – exploiting their reproductive behaviour and physiology. Tropical Animal Health and Production, 24, 165-172.

Norman D. and Collinson M. (1985) Farming systems research in theory and practice. In: Agricultural Systems Research for Developing Countries. ACIAR Proceedings No. 11 pp 16-30.

Panjaitan TS, Fordyce G, Quigley SP, Winter WH, Poppi DP (2008). An integrated village management system for Bali cattle in the eastern islands of Indonesia: The 'Kelebuh' model. AAAP Conference, Hanoi, Vietnam 2008 (under review).

Paris, T.R. 2002. Crop-animal systems in Asia: socio-economic benefits and impacts on rural livelihoods. Agricultural Systems 71, 147-168.

Peters M. (2005). Tropical Forages: An interactive selection tool. DPIF (Queensland), CIAT and ILRI. CD-ROM.

Poppi, D.P., McLennan, S.R., Bediye, S., de Vega, A. and Zorilla-Rios, J. (1999) Forage quality: strategies for increasing nutritive value of forages. Proceedings XVIII International Grassland Congress, Winnipeg, 1997, pp.307-322.

Probert ME, Dimes JP, Keating BA, Dalal RC, Strong WM (1997). APSIM's water and nitrogen modules and simulation of the dynamics of water and nitrogen in fallow systems. Agricultural Systems 56, 1-28.

Robertson MJ, Carberry PS, Chauhan YS, Ranganathan R, O'Leary GJ (2001a) Predicting growth and development of pigeon pea: A simulation model. Field Crops Research 71, 195-210.

Robertson MJ, Carberry PS (1998) Simulating growth and development of soybean in APSIM. Proceedings 10th Australian soybean conference, Brisbane, 15-17 September, 130-136.

Robertson MJ, Carberry PS, Huth NI, Turpin JE, Probert ME, Poulton PL, Bell M, Wright GC, Yeates SJ, Brinsmead RB (2001b). Simulation of growth and development of diverse legume species in APSIM. Australian Journal of Agricultural Research 53, 429-446.

SCA (1990) Feeding Standards of Australian Livestock: Ruminants. Standing Committee on Agriculture, Ruminants Sub-committee, Corbett, J.L. (Ed.). (CSIRO Publications, Melbourne).

Schultze-Kraft, R. (1986). Exotic and native legumes for forage production in Southeast Asia. In: G.J. Blair, D.A. Ivory and T.R Evans, eds., Forages in Southeast Asian and South Pacific agriculture: proceedings of an international workshopheld at Cisarua, Indonesia, 19-23 August 1985. ACIAR Proceedings No. 12 pp 36-42.

Sukarini, I.A.M., Sastradipradja, D., Sutardi, T., Mahardika, I.G. and Budiarta, I.G.A. (2000) Nutrient utilization, body composition and lactation performance of first lactation Bali cows (Bos sondaicus) on grass-legume based diets. Asian-Australian Journal of Animal Science, 13, 1681-1690.

Talib C., Entwistle K., Siregar A., Budiarti-Turner S, Lindsay D. (2003). Strategies to improve Bali cattle in eastern Indonesia. ACIAR Monograph Series No.110, 94pp. (ACIAR Canberra).

Teleni, E, Campbell, R.S.F. and Hoffman, D. (1993) Draught animal systems and management: an Indonesian study. ACIAR Monograph Series No.19, 167pp. (ACIAR Canberra).

Wirdahayati, R.B.(1994) Reproductive characteristics and productivity of Bali and Ongole cattle in Nusa Tenggara, Indonesia. Ph.D. thesis (University of Queensland, Brisbane).

11 Appendices

11.1 Appendix A. Description of Integrated Analysis Tool (IAT)

The IAT integrates three separate models: the farming system model (APSIM), a model for Bali cattle growth and a smallholder enterprise economic model.

APSIM (Agricultural Production Systems Simulator)

APSIM simulates the growth of a wide range of crop types in response to site-specific soil, climate and management data (Keating et al. 2003). Simulation modules representing different parts of the farming system are integrated to represent the system of interest. In this case, crop modules for rice (Bouman et al 2001), peanut (Robertson et al. 2001a), mucuna (Robertson et al. 2001b), cowpea (Adiku et al. 1993), maize (Carberry and Abrecht 1991), stylosanthes, soybean (Robertson and Carberry 1998) and mungbean (Robertson et al. 2001a) were combined with the soil water module SOILWAT2 (Probert et al. 1997), the soil nitrogen and carbon module SOILN2 (Probert et al. 1997) and the residue module RESIDUE2 (Probert et al. 1997). These modules were parameterised using management, soil and climate data collected from the farmer surveys and biophysical benchmarking/monitoring activities.

APSIM simulations were configured for a range of species X soil type X climatic zone combinations, with the resultant model output relating to forage and crop yield and quality incorporated into a database within the IAT. The IAT user selects the APSIM configuration that best matches the conditions of the farm under consideration. Additional regional databases can be added as the approach is adopted in new areas.

It should be noted that while APSIM captures the key processes influencing crop and forage production, it does not capture all the yield limiting constraints such as weed competition, insect damage, waterlogging and severe weather effects. Hence, simulated yields and related resource demands often exceed reality, especially in these low input systems. In the absence of comprehensive field trials, model ‘validation’ was based on comparison of model output (e.g. yield) with village records and/or individual farmer records. This is considered adequate for the purposes of this application.

Bali cattle growth model

The component cattle model needed to be precise enough to predict realistic livestock production outcomes and yet simple enough to be integrated into the larger IAT model. There are many published models of liveweight gain for beef cattle, but many of these require detailed information on passage rates of forage through the rumen, information which is not readily available for many feedstuffs used by Indonesian smallholders, or were developed for European breeds. The latter could not be confidently applied to Bali cattle as these animals are small in comparison with European breeds with estimates of mature weight of females ranging from 250-350 kg and males up to 450 kg (Devendra et al. 1973; McCool 1992; Sukarini et al. 2000). They are well adapted to heat, can work up to 5 hours per day without apparent physical disturbance and survive well on poor pasture (Teleni et al. 1993; Sukarini et al. 2000). They have higher fertility rates than other cattle breeds and buffalo under similar conditions (McCool 1992), but milk production is poor (Sukarini et al. 2000) and calf mortality rate is high (Wirdahayati 1994). Nevertheless, the key determinant of animal growth, reproduction and mortality rate is animal nutrition. Forage quality, as measured by digestibility and protein availability, commonly limit production, but smallholders have an array of different feed sources of varying quality (Little et al. 1989) available at intermittent intervals e.g. native and introduced grasses and legumes, field crop residues, plantation residues (leaf, stem, fruit), tree leaves etc.

A spreadsheet-based model was developed from published data and data collected during the life of the project relating to animal liveweight, liveweight gain, milk production, age at first calf, and calving interval as well as the quality, composition and quantity of the various sources of feed. The model is based largely upon the energy functions outlined by SCA (1990) with coefficients recalibrated for Bali cattle, but also includes intake restrictions based on the estimated crude protein requirements of the animal (Poppi and McLennan 1995). Currently, the model is specific to Bali cattle and to the feeds and husbandry practices of Eastern Indonesia. It is robust enough to capture responses to both grazing and cut and carry systems, and to cope with distinct wet and dry season conditions and the feeding of crop residues.

Data input is restricted to pasture protein concentration (g/kg) and dry matter digestibility (%) of the forage, with annual pasture and forage residue biomass, nitrogen content and date of harvest, input from the database of APSIM output. Seasonal changes in crude protein concentration (CP) and dry matter digestibility of native pasture are empirically derived based on values quoted in the literature for northern Australia and field measurements over 3 years in Indonesia.

Animal growth is determined from the quantity and quality of animal intake. Potential intake is determined from the age and current or previous highest weight of the animal. This is then adjusted for the effects of available forage (for grazing), forage quality, or whether the animal is currently lactating. Based on the adjusted intake, necessary protein requirements are calculated (Hennessy et al. 2000), and if insufficient, intake is reduced linearly in relation to CP required and CP supply. The digestibility and calculated intake determines the digestible and metabolisable energy intake which is then partitioned into energy for maintenance and, if sufficient, energy for growth. The animal growth rates predicted by the model are in reasonable agreement with observed values however, a high degree of correlation could not be expected due to extreme variability in observed values.

Calving interval, age at first calf and calf mortality rate are related to cow condition, based on the survey data of Wirdahayati (1994) and field observations during the project. The derived functions indicate a 200kg animal will have its first calf at around 2.5-3 years of age, and a cow needs to be approximately 260kg to have a calf at 12-monthly intervals. These values are in good agreement with observed calving intervals.

Labour requirements for cut and carry of necessary forage are varied according to forage availability, or lack-there-of if none is available on farm. The greater the shortage of forage, the greater the labour requirement as farmers need to go further afield to collect forage or spend time herding animals on common land. The model runs on a daily basis with information on calving, animal liveweight, sales, and labour requirements passed to the socio-economic model on an annual basis.

Smallholder economic model

The complexity of a typical farm-household system in Eastern Indonesia is presented schematically in Fig. 1. While the overall system performance might be judged in terms of a monetary unit (e.g. annual net profit in Rupiah as depicted) it is immediately evident that production and consumption pathways are typically indirect and not always well defined. A key task of the biophysical and socio-economic modelling components of the project was to better understand how these pathways might operate in order to generate improved system performance and welfare outcomes.

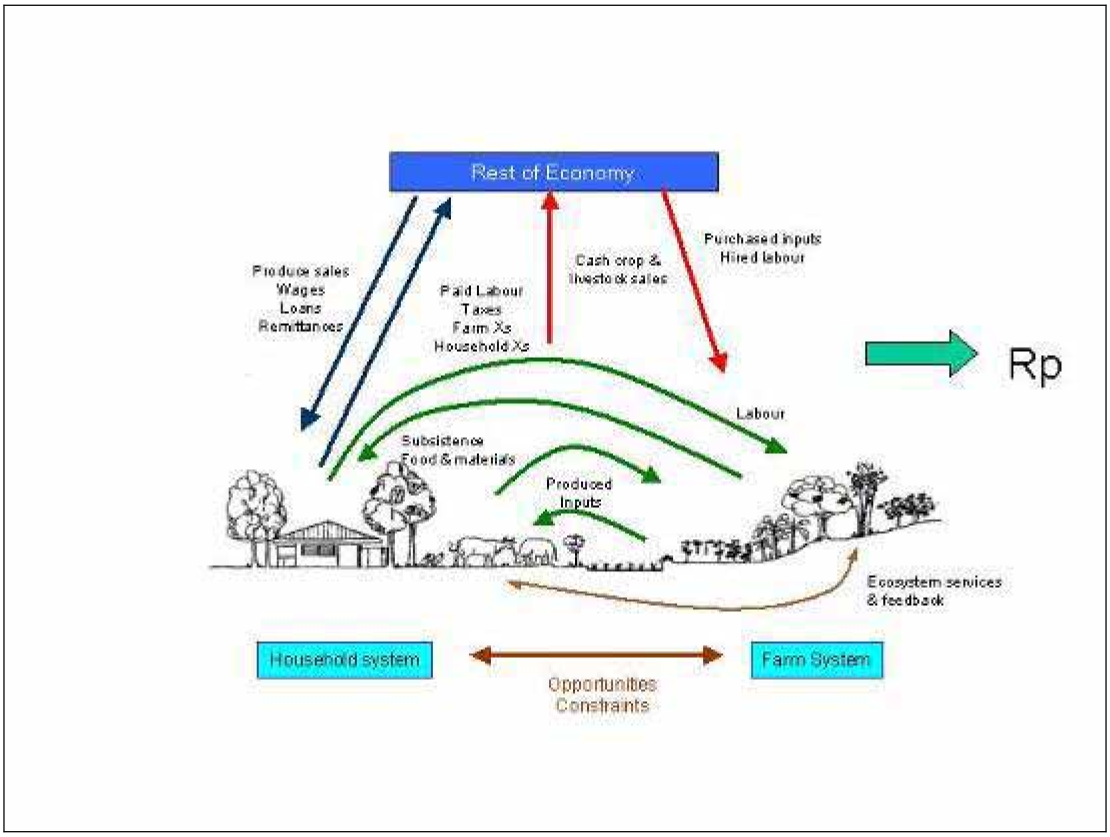


Fig. 1. Schematic representation of farm-household and resource flows between production and consumption activities.

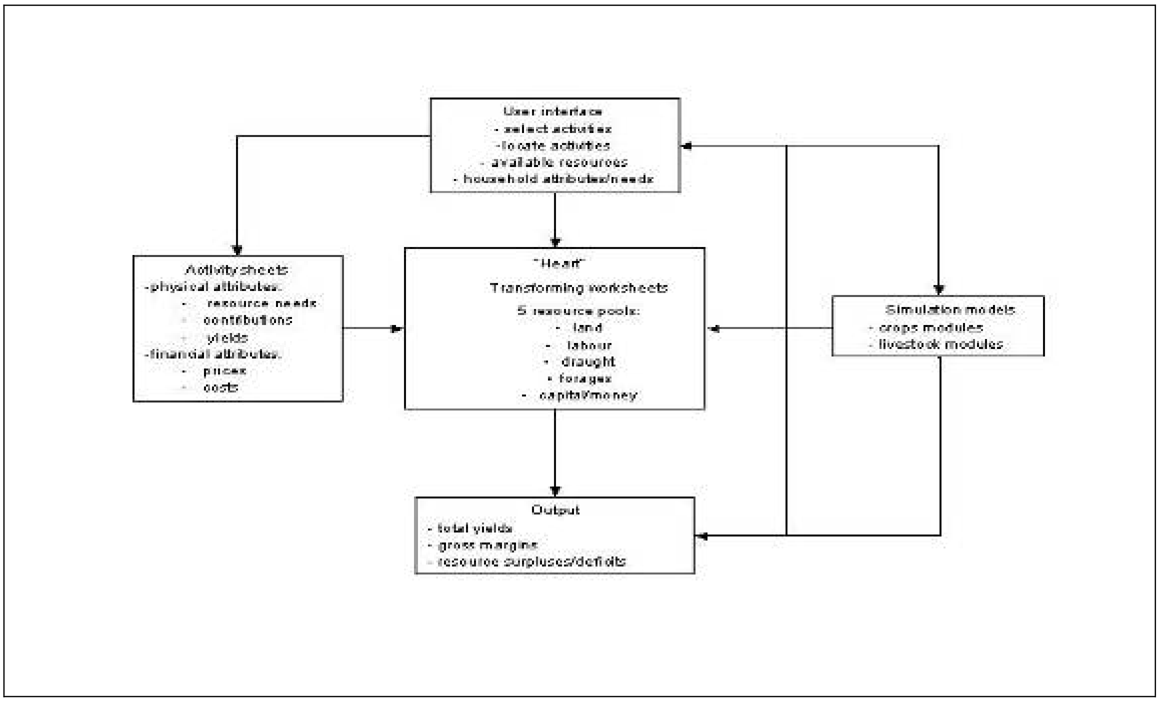


Fig. 2. Schematic representation of farm-household economic model structure.

The economic model is built on a Microsoft Excel spreadsheet platform and its central features are presented schematically in Fig. 2. Consistent with the interlinked "farm" and "household" dependencies illustrated in Fig. 1, the economic model is constructed around a wide array of activities that may be undertaken by the household. These include crop, forage, livestock, off-farm and non-farm activities that are linked systemically through five resource "pools" on which they either draw or contribute. The crop, forage and livestock activities include both final and intermediate farm activities, which represent the farm activity mix, or “farm enterprise” as it is commonly known in western farming systems. Off-farm activities (e.g. contract ploughing, planting, weeding and harvesting etc) are those which are still farm-based in orientation and may draw on the same resources as on-farm activities. Non-farm activities (e.g. operating a kiosk, construction labour) also potentially contribute to, or draw on, the resources available to the family for production, consumption (e.g. education, consumer goods) or wealth accumulation (including increased herd sizes). By including all of the activities that are available to, or necessary for, the household to meet its needs and objectives, the model is able to more accurately provide an indication of whether different crop and forage options will actually make them better or worse off.

The heart of the model is the constraining and enabling potentials of five resource pools. These include (a) labour including casual labour - by functional category and season, (b) land by type and quality, (c) draught available for ploughing, (d) forage by type and seasonal availability, including crop residues, and (e) cash (working capital to support production and consumption activities) and credit. The starting size of the different pools is set according to assumptions on the resource endowment associated with the case farm-households under review. Crop and livestock activities also provide input for home consumption, which are treated as a sixth pool. As different activities, and their respective levels, are entered into the model their net demands and contributions to the various pools are evaluated and a series of “flags” is created on the user interface screen that will confirm whether or not the activity mix and levels is feasible given the resources available to the farm-household. The model specifically identifies which pools are acting as constraints on the particular activity mix being explored, and the extent to which other resources are free to provide opportunities for other activities on or off the farm. In this way, it contains functions that are similar to a linear programming format – the difference being that it does not automatically identify the “optimum” solution. The rationale for not selecting an optimising algorithm format is examined further below.

Inputs to the economic model are from several sources. Yield data for crop, forage and livestock activities are from the APSIM database and the livestock model. Price and cost data, production input levels (e.g. fertiliser, seed, materials), and home consumption needs of different products and family expenses are derived from the baseline survey.

The main measures that are produced by the economic model include: (a) total gross margin – including value of home consumed produce, (b) disposable income after household consumption, (c) net cash position, and (d) the level of household capital and/or outstanding debt. These measures are calculated by placing prices on produce outputs and production inputs along with “opportunity values” for home consumption and other non-market uses or disposals of activity outputs (e.g. food crops, residues, manures etc). The major advantage of the gross margin budgeting approach lies in its simplicity and transparency for potential users of the model. It has the further capacity to run simple sensitivity and risk analyses by varying the main parameter values in the gross margin budgets.

Mathematical programming that would have enabled optimization of all the constraining resources as a single package was not employed. Such an analysis typically requires the problem setting to be heavily simplified and the process of finding solutions is rarely transparent. These constraints were considered to be major drawbacks when using the model to assist smallholders (and parties who provide them with information) with their decision-making processes and to better understand the consequence of different crop-livestock choices.

Rather than employing an optimization strategy, it was judged that an alternative method that enabled a more appropriate counter balance of the complexity of the farm-household linkage with simplicity and transparency was required. A creep budgeting approach was subsequently selected. This strategy combines the simplicity and transparency advantages of gross margin budgeting and the ability of mathematical programming techniques to consider the constraining impact of all resources and to provide an optimal solution. This approach involves re-specifying large numbers of input and output variables in a systematic manner to explore the response to these changes (Makeham and Malcolm 1981). That is, the decision-maker “creeps” around the economic response surface in a systematic fashion to examine whether there is a shift towards or away from a more optimal solution. In this way, the use of “what-if” questions is able to provide farmers, researchers and extension specialists with a good many insights into how the economic position of the farm-household system will respond to different activities, input and output levels and their respective prices. Moreover, we believe that the progressive search for a more optimal position is more closely aligned to the intuitive way that many farmers actually approach their own decision-making tasks. The model has been structured to be amenable to creep budgeting processes and to provide a high level of transparency concerning the impacts on the household resources and welfare of adopting various production and consumption activities both on and off the farm.

Integrated Analysis Tool

The IAT integrates the three models to enable a whole-of-farm analysis of alternative forage and livestock options (Fig. 3). An easy-to-use interface (Fig. 4) forms the ‘hub’ of the IAT with links to other input forms. Different regions/climatic zones can be selected to align with the appropriate village. User forms allow entry of farm-specific details (i.e. model inputs) relating to farm area and design, family structure, labour allocations for family members, cattle herd structure and management, crop sequence and management. Sub-forms allow more detailed information on crop input costs, non-farm income, labour etc. This information parameterises the cattle and economic models and directs the selection of input from the database of APSIM output. The ‘real-time’ cattle and economic models are then run over a 10-year period with the exchange of relevant output. Final model output is then presented in graph or tabular form describing: (a) biophysical characteristics of the system (i.e. crop and forage yield/biomass and animal liveweight gain); (b) labour details and; (c) economic performance (cash balance and gross margins).

Output can be saved for later comparison. The parameter settings used to generate the particular output are saved with the output and these can be reloaded at a later date. The operator can choose between English and Indonesian language versions.

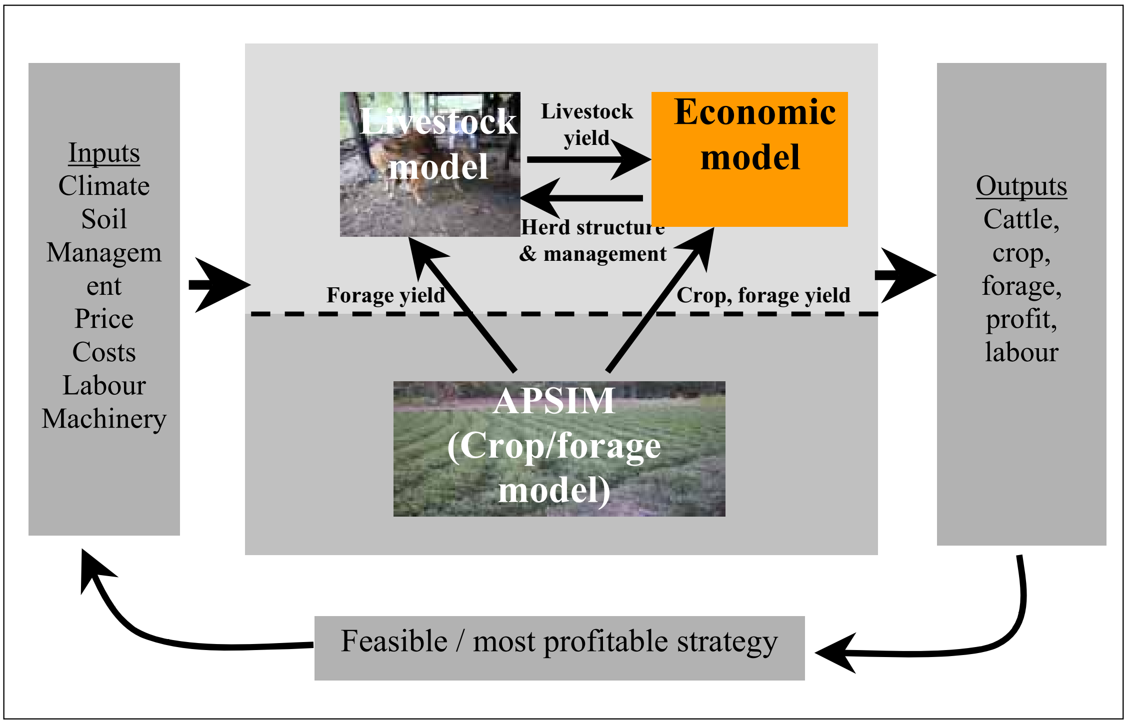


Fig. 3. Structure of Integrated Analysis Tool (IAT).

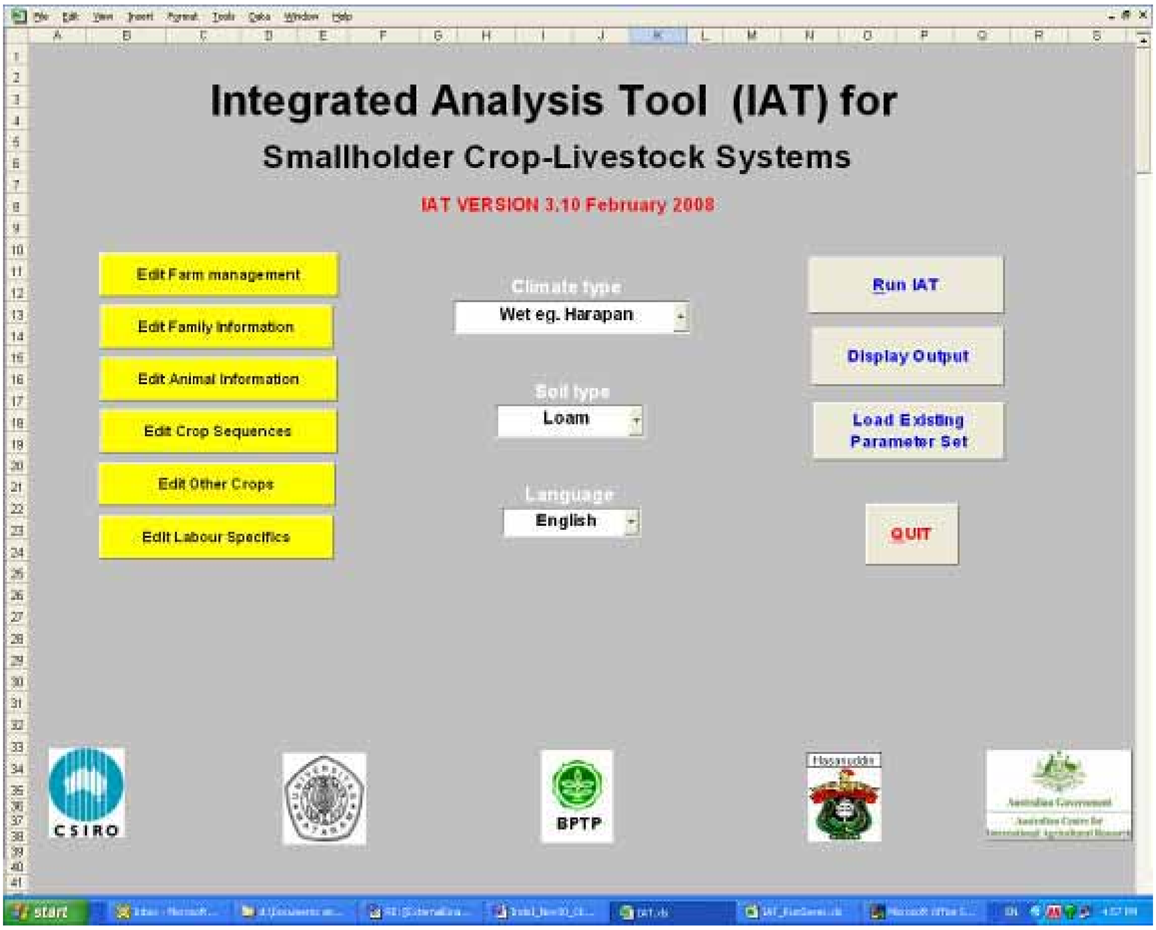


Fig. 4. Initial screen of the IAT user interface.

11.2 Appendix B. Soil characterisation report

Introduction

Between 23rd September and 2nd October 2005 research sites were visited in southern Lombok and South Sulawesi, Indonesia to participate in soil identification and characterisation for Plant Available Water Capacity (PAWC). This work forms a component of the ACIAR Project: AS2/2004/005-Improving smallholder crop-livestock systems in eastern Indonesia, and is a pre-requisite for simulation of local farming systems using the APSIM model.

Mertak village, 80 km south-east of Mataram, Lombok and Manyampa/Lemoa villages 35km south-east of Makassar, Sulawesi were surveyed in terms of land use and soil type. Based on the survey results the major soils, in terms of agricultural potential, were identified for characterisation. A collaborative process including research staff, local sub-village chiefs, and agricultural extension staff was used to identify potential sites for further work. It is anticipated that the majority of the physical activity associated with soil characterisation, including the field work and chemical and physical analyses, will be undertaken by the Indonesian team in consultation with CSIRO staff.

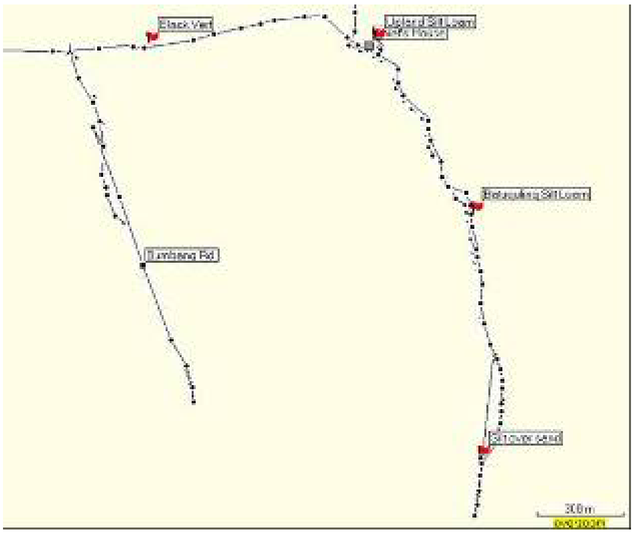
Lombok-Mertak Village

A familiarisation visit was made to the village on the 24th September by Ahmad Suradi and Lia Hadiawati from BPTP, Mataram and Neal Dalgliesh, CSE. In consultation with the local chief, four likely variations in soil type were identified and sampled to a depth of 90 cm. to inspect profile characteristics. Sites were located from the top of the catchment at an elevation of approx. 40-60m, to near sea level (and a short distance from the shore).

Site Description

Two major soils were identified in the village area, the dominant one being a brown silt loam located at both the higher and mid elevations of the village. Rocks were evident in the highly eroded version of this soil on the tops of the hills and also present at one of the sampling locations (Batuguling). The other major soil type was a black cracking clay which was limited to a relatively small area (in terms of the whole village area) adjacent to a watercourse. Field texture assessments will be confirmed through particle size analysis.

Co-ordinates of preliminary sample sites		
Site	**Site Name**	**Co-ordinates**
a)	Upland Silt Loam	S8 53 03.2 E116 22 35.9
b)	Black Vertisol	S8 53 03.5 E116 22 10.1
c)	Batuguling Silt Loam	S8 53 22.6 E116 22 47.0
d)	Silt over sand	S8 53 50.0 E116 22 47.8
Datum: Indonesia 74		



- Upland Silt Loam

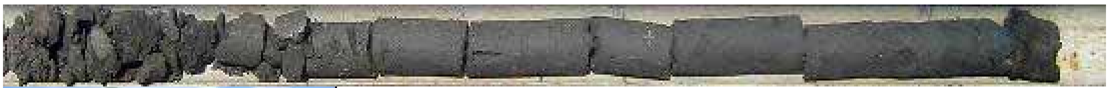
This site, adjacent to the Chief's house (at approx. 40m elevation) is a brown silt loam grading into clay at approx. 30 cm. It is recommended that consideration be made to sampling this profile on horizons instead of standard sampling depths.

100 cm

Silt grading into clay

- Black Cracking Clay

The profile sample indicated a typical black Vertisol with severe surface cracking and slicken-slides present at depth. There was substantial soil moisture present (close to DUL) from a depth of approx. 60 cm. Whilst this may just indicate limited soil water requirements by the last crop, it is recommended that EC, Chloride and Exchangeable Sodium levels be determined to rule out sub-soil constraints.



90 cm

- Batuguling Silt

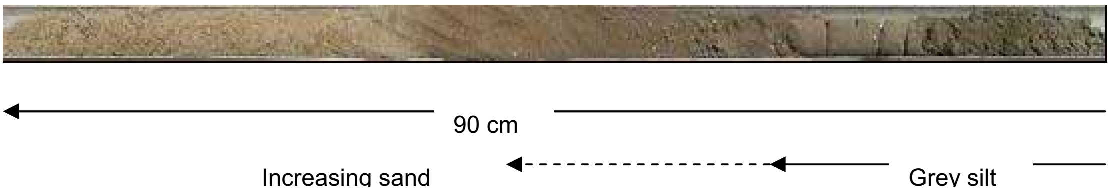
Located at approx. 25m above sea level this profile was similar to the upland Silt Loam, grading to clay at approx. 30-40 cm depth. Surface soil was light grey compared to the brown found at the higher site. Whilst the local farmers indicated that this soil was rocky (and some were observed in the locality) no problems were encountered during sampling.

100 cm

Grading to clay

- Silt over sand

This profile was taken at approx. 5m above sea level and consisted of grey silt, with little organic matter, overlying coarse sand. The sand commenced at a depth of approx. 30-40 cm. Due to its location in the landscape it is possible that this soil is prone to transient water logging and salt incursion.

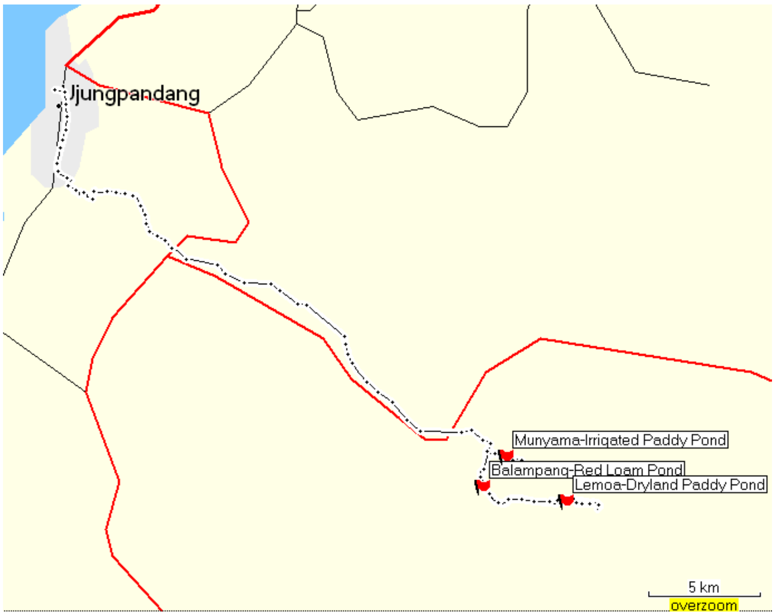


Recommendations for Lombok

It is recommended that characterisation be undertaken on sites representative of the upland Silt Loam and the Black Vertisol. It is considered that the Batuguling Silt Loam is similar to the upland Silt Loam, and the Silt over sand is likely to be limited to the very lower end of the catchment and not representative of the major soils of the village. Actual characterisation sites are to be identified by Ahmad Suriadi and should be located in close proximity to the preliminary evaluation sites, taking into consideration proximity to trees, bunds and the operational requirements of land owners.

9. Southern Sulawesi, Lemoa/Manyampa villages

A visit was made to the village on the 27th September by Rakhmat Rachman and Syamsu Bahar of BPTP, Makassar, Ahmad Suradi, BPTP, Mataram and Neal Dalgliesh, CSE, with the intention of gaining an understanding of the topography and soils of the area. After a preliminary tour of the village with local officials, three sites were selected for soil characterisation based on soil type and land use. Over the following two days initial assessments were done at these sites including soil coring to a depth of 180 cm for measurement of soil depth and physical and chemical evaluation.



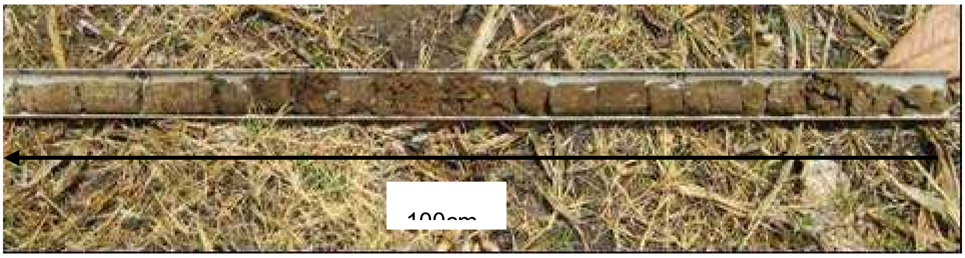
Site Descriptions

The predominant soils of the village range between a red loam and a medium clay. The landscape is dominated by steep hills (>40% slope) and undulating valley floors with elevation ranging between 50 m and >250 m. The soils at the higher elevations are highly eroded, shallow and interspersed with large exposed rocks. Most of the agricultural production is done at the lower elevations although annual crops (such as maize) and tree crops are grown higher up the slopes during the rainy season. The soils for characterisation were selected at the lower elevations. If required, characteristics for the soils of the upper slopes will be able to be developed using information obtained for the lower elevation soils. These soils have been formed through movement of alluvium from the upper slopes and are very similar physically, (particularly the case with the Lemoa dryland paddi soil). Field texture assessments will be confirmed through particle size analysis.

Co-ordinates of characterisation sites		
Site	Site Name	Co-ordinates
a)	Lemoa Dryland Paddi (Loam)	S5 18 44.3 E119 36 56.8
b)	Balampang Red Loam	S5 18 22.6 E119 34 55.6
c)	Manyampa Irrigated Paddi (Clay)	S5 17 39.5 E119 35 29.5
Datum: Indonesia 74		

- Lemoa Dryland Paddi

This soil is predominantly used for dryland rice production with one crop grown annually during the rainy season. The soil is a grey/brown loam grading into gravel at approx. 80 cm. Depth of sampling varied between 135cm and 170 cm The profile was dry to full depth although roots were only found to a depth of 120 cm.



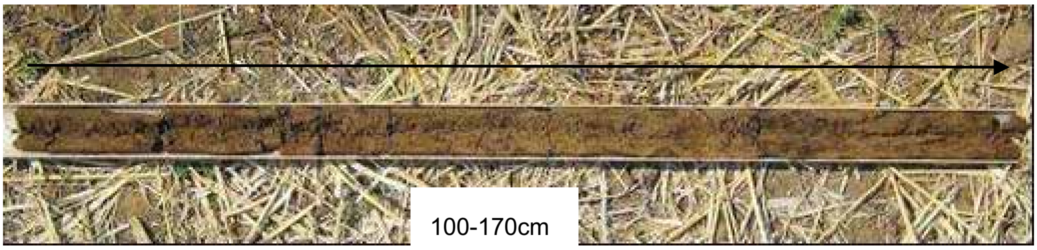
- Balampang Red Loam

This soil is used for dryland crop production (maize and sugar cane) during the rainy season. The soil is a sandy loam/clay loam with gravel at approx. 80 cm. Depth of sampling was 170 cm. with roots to a depth of 80 cm, some moisture was evident below this depth.

100cm

- Manyampa Irrigated Paddi

This brown clay soil is used for intensive rice production with a crop grown during the rainy season and a second under irrigation during the dry. The continuing irrigated rice mono-culture has resulted in some compaction in the top 30 cm. There is limited water use below this depth, likely as a result of compaction and a reduced requirement for crops grown under irrigation to seek water deeper in the profile. No roots were found below 30-40 cm. with the soil at near field capacity at depths >60 cm. Some soil mottling and soft, black nodules (5-10 mm diam) were evident below 90 cm.



Recommendations for South Sulawesi

Soil characterisation has commenced with sampling for chemical and physical analysis during this visit. PAWC will be determined from field measurement over the coming season. It may be necessary, due to the operational requirements of the farmers, to undertake the characterisation of the Manyampa irrigated paddi soil during the second seasonal rice crop, although this will be decided as the season progresses. The other two sites will be characterised during the wet season with soil sampling for DUL and BD planned for the end of the rainy season (~April).

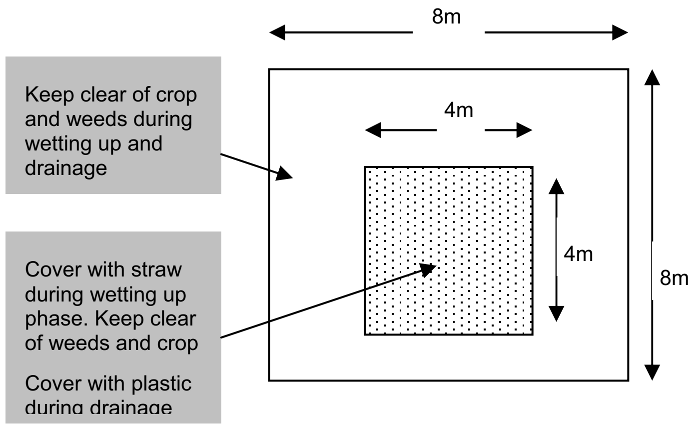
General characterisation recommendations

- Characterisation to be undertaken to a maximum depth of 150-180 cm. or to depth of parent material.
- The Black Vertisol soil at Mertak and the irrigated clay at Manyampa should be sampled using standard depth increments of 0-15 cm, 15-30 cm and 30 cm layers thereafter. Other soils may need to be sampled on horizons but this decision will have to be made at the time of sampling.
- Field based determination of Drained Upper Limit (DUL) and Bulk density (BD) to be undertaken after appropriate wetting up of each soil site. Access to the soil profile will be via a pit. DUL and BD will be determined from the same sample using a ring of known volume (nominally 70-75mm diameter by 50mm high). 2-3 replications per depth layer should be taken. Samples to be dried at 1050 Celsius. Samples to be either weighed in the field (immediately after sampling) or stored in sealed plastic bags until return to the laboratory. Accurate recording of sampling ring dimensions and sample weights is important.

- Drained Upper Limit is also to be determined by laboratory analysis. Dr S. Gusli of Hasanudin University has recommended using the sintered funnel technique with 5 KPA as the measure of DUL. Dr Brian Bridge (CSIRO, Toowoomba) has endorsed this technique with the suggestion that a No. 4 funnel and 10 kpa would be appropriate (this needs to be discussed). Analyses will be undertaken by the university and will require 3-4 replicates per soil layer. As samples will need to be shipped from Lombok to Sulawesi appropriate packaging is critical.
- Due to issues with technique it has been recommended that lower limit of water extraction not be determined by laboratory analysis. Crop Lower Limit (CLL) for at least one crop per soil needs to undertaken during the coming season (likely to be rice or maize). This will require the erection of a plastic rain-out shelter to protect the maturing crop from rainfall. The protected area should be at least 3m x 3m and erected on well grown crop adjacent to the wetting-up area.
- The BPTP laboratories at Mataram and Makassar will undertake physical (particle size) and chemical analysis of soils. Syamsu is to investigate obtaining a copy of a recent laboratory analytical accuracy comparison report which is done routinely for all BPTP labs in Indonesia. Data to be forwarded to Neal Dalgliesh (data to include individual lab results for range of chemical analyses in which we are interested, mean over all labs and CV%).
- It is suggested that a small set of samples (~6-10) from South Sulawesi and Lombok be analysed at both BPTP labs as a check on analytical accuracy and consistency. Consideration should be given to sending a small set of control samples from a lab in Australia for analysis at both of the Indonesian labs (NPD to talk to Shaun Lisson).
- Chemical analysis to determine any underlying sub-soil constraints, as well as inputs required for APSIM, should be undertaken for each depth layer. Sampling has already been completed at Pattalikang. At Mertak it is recommended that samples be collected either from the pit during soil characterisation, or adjacent to the pit site (when identified) using samples from 2-3 bulked cores. Samples should be dried at 400 Celsius or air dried. Analysis is required for pH, EC, Chloride, CEC, and Organic Carbon. Duplicate samples should be archived in case re-analysis is required.
- Particle size analysis (texture) to be done to confirm field assessments of texture.
- Suriadi to finally select the sites at Mertak village and undertake soil sampling for chemical analysis and soil characterisation.

Location of Characterisation Sites

It seems logical that the wet season be used to our advantage allowing rainfall to fill the profile before determination of DUL and BD. The difficulty will be ensuring that the profile is not allowed to dry out at the end of the rainy season and/or the profile is inadequately drained when sampling takes place. It is important to locate the sites away from bunds, trees and crops to ensure that soil water is not 'stolen' by the nearby vegetation, particularly during the drainage phase. I would suggest that an area of at least 8m square be identified as far from perennial vegetation as possible. This area will need to be kept clear of crop and weeds during the season. Covering the actual measurement area with organic material (rice straw for example) would be advantageous in terms of reduced evaporation, improved infiltration and reduction in weeds. It will be necessary to cover the measurement area with plastic sheeting whilst drainage is occurring. Plastic should be sealed around the edges to minimise evaporation. Sampling should be undertaken in the centre of the site. Animals should be excluded from the characterisation area.



If it is considered that the rainy season has been sufficient to wet the profile to full depth (assuming 180 cm) it is recommended that the ponds be left for 6-8 weeks after the final rain (or after water has been drained from field) before sampling. This will allow time for drainage and will be particularly important on the Black Vertisol at Mertak and the irrigated clay at Manyampa, both of which will be very slow draining. It is during the drainage phase that the covering of the sites with plastic sheeting will be critical in minimising evaporation.

If an opportunity arises (after rainy season crops have matured and/or after subsequent crops such as soy beans) to sample for Crop Lower Limit it is recommended that 3-6 cores be taken for soil water determination within close proximity to the soil characterisation site (within 10 metres of the site or on other fields with similar soil type). It is important that the same sampling increments be used for all sampling activities undertaken on the one soil type, both during characterisation and in subsequent monitoring of soil water and nutrients.

Soil equipment requirements

Both BPTP Mataram and Makassar have reasonable levels of soil sampling equipment available. The majority of gear imported during Phase 1 of the project is still in operating order although needing some maintenance.

- Lombok: fabrication of 180 cm x 31mm diameter tubes is required to replace those damaged during phase 1.
- Sulawesi: tubes are in good order although the tip of the 180 cm x 37mm diameter tube needs to be removed and re-formed. A new handle for the Dormer auger is also required.

All tubes should be fabricated using 1.6-2.0 mm thickness steel pipe. It is suggested that a number be fabricated at each site to ensure that sampling is not interrupted through lack of equipment. It is critical that tubes be cleaned internally and oiled regularly (both internally and externally) during use and long term storage. Cleaning and oiling with vegetable oil reduces tube blockages and rusting.

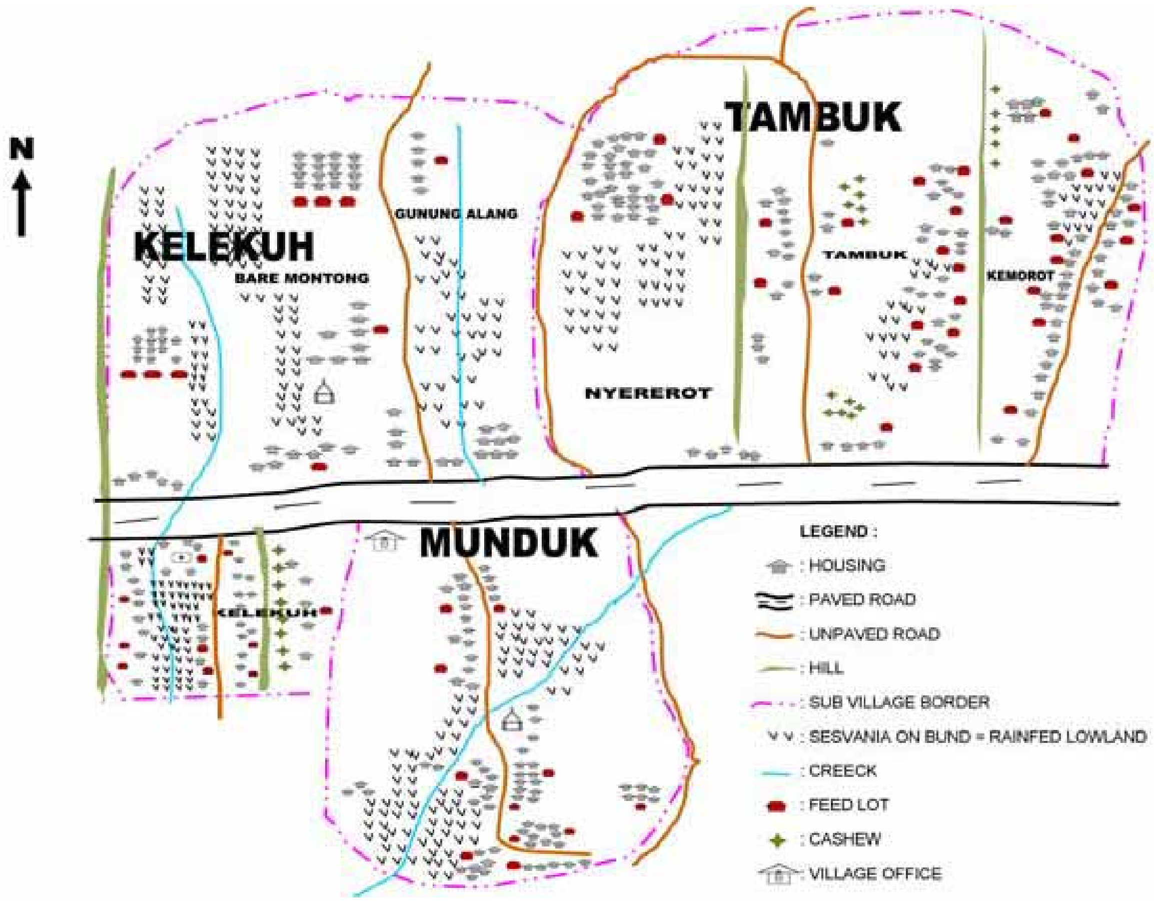
11.3 Appendix C. Details of variables assessed during best-bet forage and cattle monitoring

Forage monitoring		**Cattle monitoring**	
Variable	**Method/measure**	**Variable**	**Method/measure**
a. Cut and carry		**Performance**	
Biomass offered	kg fresh & dry	Cattle ID	farmer/age code
Composition	% estimate	Liveweight	weighing (kg)
Leaf proportion	% estimate	Condition score	estimate
Greenness	% estimate	Girth & height	tape (cm.)
Residue	% estimate	Age	mouthing
Source	location of forage source	Sex	
Number cattle fed	no. and class	Reproductive status	lactating, calving pregnancy stage
Water offered	l/head/day	Fate of animal	died, sold etc.
b. Grazing resource			
Biomass	estimate kg/ha		
Composition	% estimate		
Defoliation score	rating		
Time spent grazing	hours/day		
Size of area grazed	estimate (ha)		
Number of cattle grazing	no. and class		
c. Pasture exclosures			
Biomass	kg/ha		
Composition	% dry weight		
d. Best-bet forage banks			
Biomass	kg/ha		
Composition	% dry weight		

11.4 Appendix D. Key characteristics of the smallholder farming systems of Desa Mertak, Lombok

Desa Mertak in Central Lombok was selected as the target region after some reconnaissance trips to West, East and Central Lombok and a series of discussions between the BPTP collaborating staff, Dinas and Regency officials. The choice of Desa Mertak was largely based on community need, overall agro-ecological context, local cattle populations, and enthusiasm of the community leaders to participate. Mertak is comprised of 21 sub-villages and further segregated into approximately 63 sub-sub-villages (~ kampungs, although sub-sub-sub-villages do exist in some smallholder communities which would also have this descriptor). From this grouping, local data from the Kepala Desa's office and consensus meetings with sub-village leaders (Kepala Dusun) identified 3 sub-villages and 4 sub-sub-villages that were visited to assess their potential suitability for participation. The criteria included cattle ownership, enterprise types, local agro-ecological contexts, access and usefulness as exemplars to other sub-sub-villages. The 3 sub-villages that were investigated were Kelukuh, Tambuk and Semunduk, from which 4 sub-sub-villages were investigated, viz. Kelukuh, Bare Montong, Kemorot and Semunduk. The location of these sub-sub-village communities is presented in Figure 1.

Figure 1. Location of 4 sub-sub-villages in Desa Mertak, Lombok



Data on households, cattle ownership, and cattle numbers for these sub-sub-villages is included in Table 1.

Table 1. Households and cattle in 4 sub-sub-villages of Desa Mertak, Lombok (2005)					
Sub-village	Sub-sub-village	No. Households	Household with cattle	No. Cattle	Cattle per household*
Kelukuh	Kelukuh	43	32	105	3.3
	Bare Montong	36	32	88	2.9

Tambuk	Kemorot	17	17	34	2.0
Semunduk	Semunduk	110	74	220	3.0
Total		206	155	447	3.0
** Households with cattle.*					

From this example, it can be seen that kampung communities range in size, although Semunduk is on the larger end of the scale with more than 100 individual households, and the majority of those households have cattle, although the number of cattle owned or managed per household with cattle is generally small - often a single cow and last season and this season's calves.

B. Household data

The household structure and employment status in these sub-sub-villages are presented in Table 2.

Table 2. Household characteristics in 4 sub-sub-villages of Desa Mertak, Lombok (2005)				
	Kelukuh	Bare Montong	Kemorot	Semunduk
Age household head (yrs)	34	39	41	41
	(25-40)	(30-50)	(29-50)	(30-50)
Family members (no.)	5	5	4	4
	(4-7)	(4-8)	(3-4)	(3-6)
Full time farm workers (no.)	3	3	2	3
	(2-4)	(2-6)	(2-4)	(1-5)
Part-time farm workers (no.)	1	1	1	2
	(0-3)	(0.25-1)	(0-1)	(0-2)

For the selected communities, households of around 4-5 people are typically headed by a working age adult (usually male), and include 2-3 working adults and 1-2 dependant children. The adult family members commonly include an older grandparent who will look after dependent children and livestock. Many households may include a younger adult who has yet to establish their own independent household and may be supporting their attempts to establish a capital base through part-time work.

Land ownership and general land type for the 4 sub-sub-villages are presented in Table 3.

Table 3. Land area/type for households in 4 sub-sub-villages of Desa Mertak, Lombok (2005)				
	Kelukuh	Bare Montong	Kemorot	Semunduk
Lowland rainfed (ha)	0.5	0.3	0.3	0.9
	(0-1.0)	(0-0.9)	(0-1.0)	(0-3.8)
Upland (ha)	0.4	1.0	0.8	1.3
	(0-1.1)	(0.6-1.3)	(0.5-1.4)	(0-2.8)
Private grazing land (ha)	0	0	0.3	0
	0	0	(0-1.0)	0
Backyard (ha)	0.2	0.1	0.1	0.1
	(0-0.3)	(0-0.3)	(0-0.1)	(0-0.5)

The land ownership pattern for the selected sub-sub-villages is reasonably typical of smallholder communities across the region - households have a small backyard (occasionally 2 when multiple households are involved) on which their dwelling, garden plots and livestock housing are usually located. These home yards typically adjoin to form the kampung village structure. Food crops are usually produced on lowland paddy fields that are either irrigated or rainfed (Mertak is located in a dry region with no formal irrigation scheme). Most households also have additional upland areas on which cash cropping and estate cropping activities are often located, and to a lesser extent additional food cropping for household consumption. Livestock may also be grazed in these areas, especially during the rainy season when the lowland sites are under crops. The upland areas are often larger than the lowland areas (Kelekuh is an exception being located in a lowland area with limited upland in the near vicinity), and some sub-sub-villages may have further access to private grazing land (Semunduk in this case is also predominantly a lowland site, but is also located near some hill country that was formerly used for forestry).

The farming systems in the communities are often relatively complex and there is usually some variation between households, and also between years. An example of a general cropping calendar for one farming system in Desa Mertak is presented in Figure 2.

Land type	N	D	J	F	M	A	M	J	J	A	S	O
Rainfed lowland	Rice Maize				Soybean/ Mungbean/cowpea							
	Cassava Cotton											
								Tethered or free grazing Mating				
Upland	Rice/maize/mungbean /peanuts/soybean											
	Cassava											
	Tethered or free grazing Calving											

Figure 2. Generalised cropping and livestock calendar for smallholder farming system in Desa Mertak

Cropping choices depend considerably on seasonal conditions, relative price ratios between crops (including whether a market actually exists by harvest time) etc. Typically several crops are co-located (e.g. maize and cassava grown on bunds around rice crops), or inter-row cropping. Nevertheless, both lowland and upland crop areas can lie in fallow for much of the dry season and the actual area of cropping can vary between land types and seasons (e.g. 1ha of available upland fields might only have 0.2 ha of crops planted on them during the dry season). Mating of cattle can depend on availability of bulls or occur indiscriminately, and many young cattle are self-weaned at some time around 12-14 months. Cattle are generally tethered or free grazed for between 7-12 months each year, although access to grazing can become limited between July and September when crops are still standing in both lowland and upland fields - tether grazing becomes more common at this time. For cropping activities the peak demand for labour is usually between October/November through to February/March, while livestock labour demand peaks between July and November when dry season feed availability is limiting. Cropping activities on the majority of smallholdings are concentrated on producing food crops for direct family consumption.

The general mix of cropping activities on smallholder farms and how it may change between households and seasons is further illustrated in Figure 3(a to e) - taken from the monitoring of 10 `best-bet' households in Mertak from 2005 to 2008.

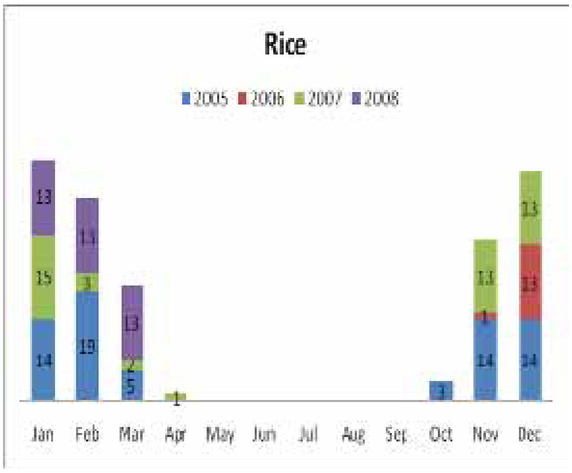


Figure 3a. Number of parcel planted to rice

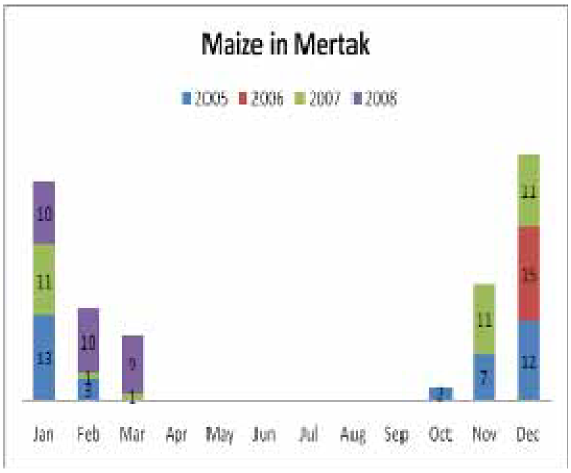


Figure 3b. Number of parcel palnted to maize

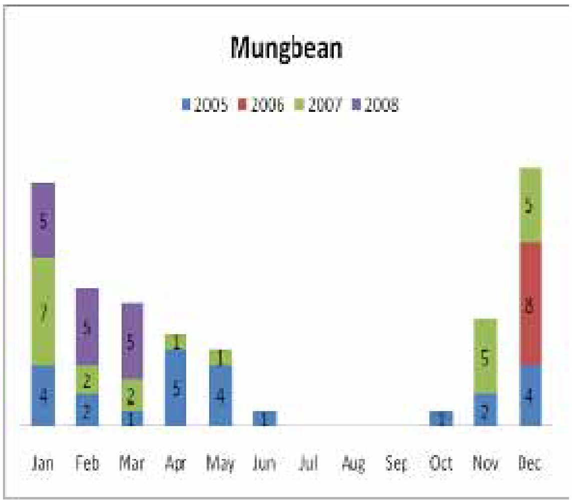


Figure 3c. Number of parcel planted to mungbean

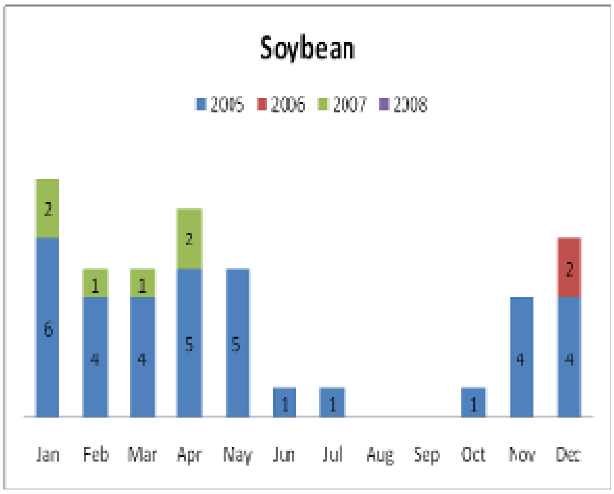


Figure 3d. Number of parcel planted to soybean

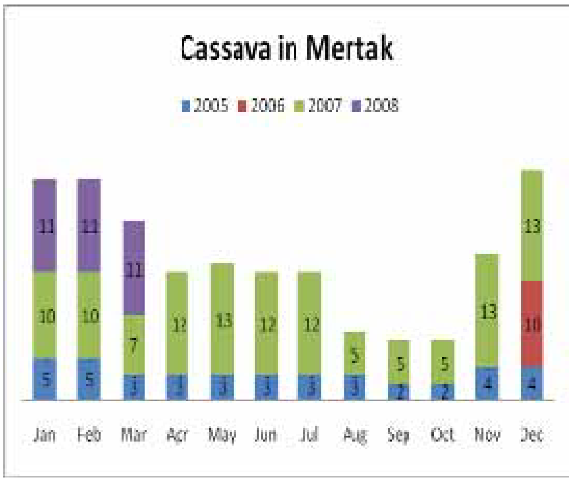


Figure 6e. Number of parcel planted to cassava

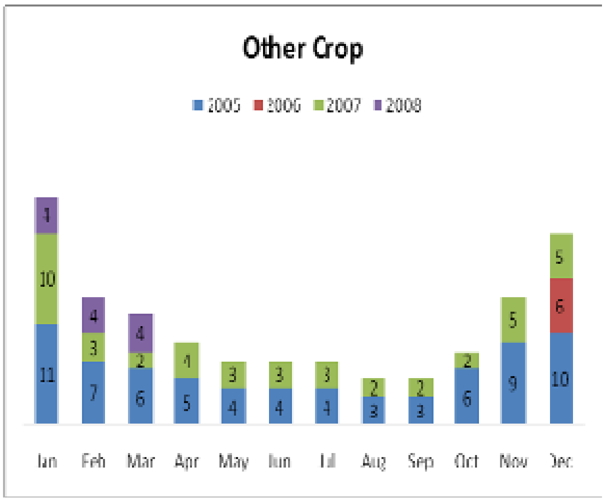


Figure 6f. Number of parcel planted to other crops

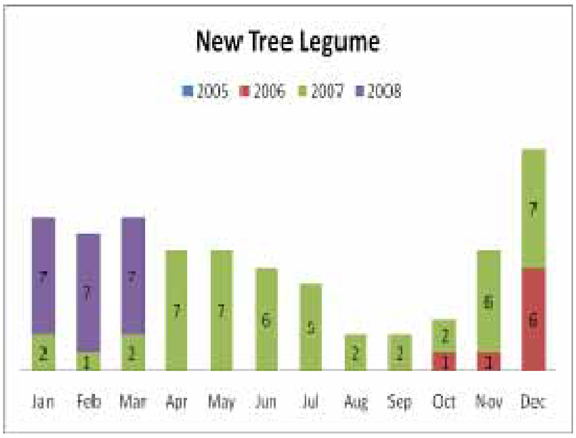
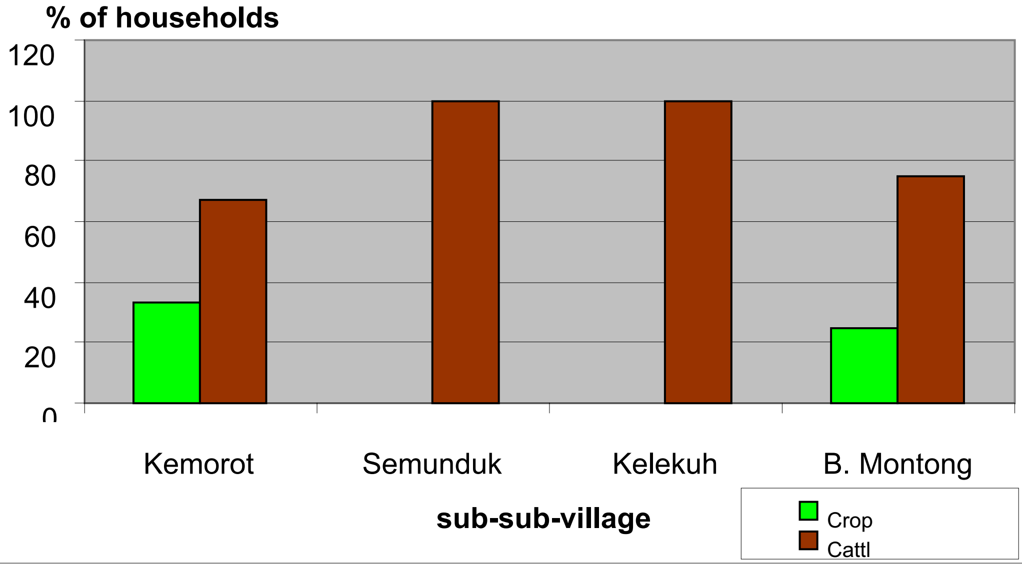


Figure 6g. Number of parcel planted to new tree legumes

Again the dominant crops that were grown by the 10 households are rice, maize, soybean, mungbean, cassava and a wide range of other crops grown on relatively small areas of land. Most of the households have several parcels of cropping land and the sub-figures record how many parcels of land were sown to a particular crop, and in which months the crop is present on that land. Rice is grown in each year on as many land parcels as will support this subsistence crop. However, from 2005 to 2007 the crop failed and many of the farmers sold cattle to purchase rice for household consumption (se again below). Maize is also mixed cropped with cassava, rice, mungbean and soybean by all of the households - with the grain fed to chickens and young leaf and stalks fed to cattle. The mungbean and soybean are grown for cash sales although this is a limited source of cash for most families (see below), while the residues are also fed to cattle. Cassava was planted in 2005 for household consumption, home industry and to a lesser extent cattle feed. However, due to the dry conditions experienced in 2006, most of the cassava was fed to cattle and some of the households also purchased cassava from other households to feed their cattle. While the area and number of parcels of land planted to cassava grew from 2006, plantings of mungbean and soybean began to decrease. Finally, since the project commenced in 2006, the area of new plantings of tree legumes has progressively increased.

Most of the cash income earned by smallholder households is derived from a relatively narrow range of farming activities, including cash cropping, with a significant role played by livestock (notably cattle) in generating cash resources. The principal sources of family income for the 4 sub-sub-villages examined in Desa Mertak are presented in Figure 4.

Figure 4. Principal source of family income (%), Desa Mertak 2005



Cattle are the principal source of cash income for the majority of households in all of the 4 sub-sub-villages, although cash crops are also the main source of cash income for 25% and 30% of households in Bare Montong and Kemorot, respectively. Part-time paid employment - either within local communities (e.g. performing farm activities for other households), or elsewhere (e.g. labouring, running kiosks, trading, ojek etc) - can also supplement family cash income for smallholder households, although this was not a primary source of cash income for any of the households canvassed in the 4 sub-sub-villages under review.

Table 4. Average number of cattle sold by households in 4 sub-sub-villages of Desa Mertak, Lombok (2005) and the principal reason (% households) underlying these sales.

	Kelukuh	Bare Montong	Kemorot	Semunduk
Cattle sold (no.)	0.5	1.3	1.3	1.3
	(0-1.0)	(0-4.0)	(1.0-2.0)	(0-4.0)
Principal reason for sales.				
Main source of income (%)	0	0	33	22
Special occasion (%)	25	50	33	44
Capital item (house, motorcycle) (%)	0	0	0	11
Other (Haj, emergency, school fees) (%)	75	50	33	33

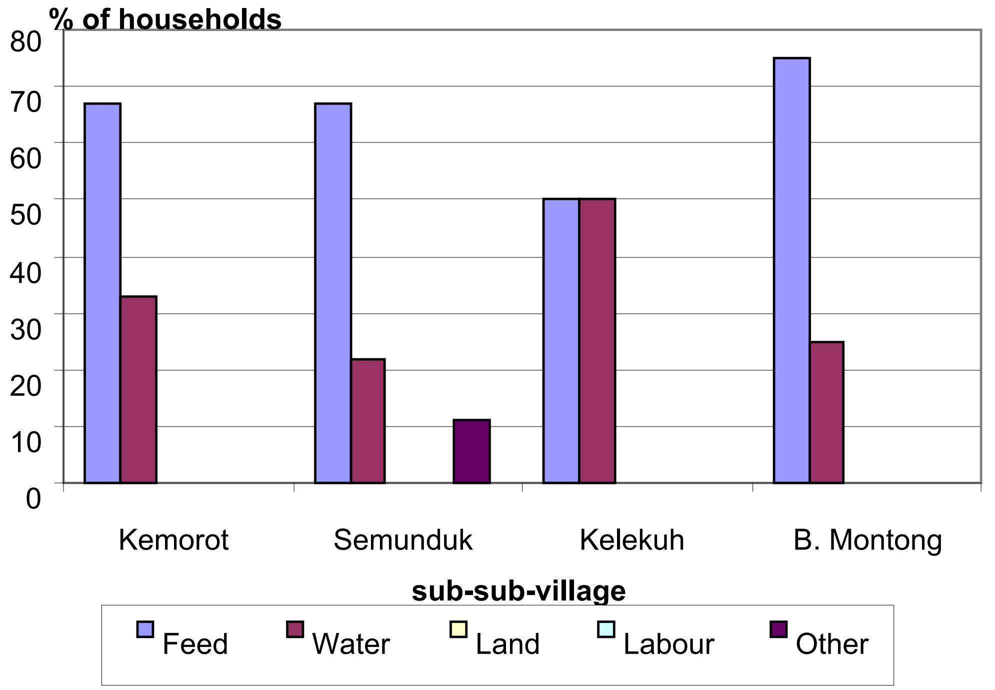
While cattle (and other livestock - e.g. goats, chickens) sales are the principal source of cash income for many smallholder households (Figure 4), the principal motivation for selling cattle in any particular season is not necessarily to support an ongoing stream of income for household consumption and wealth creation. The average number of cattle sold by the smallholder households in the 4 sub-sub-villages in 2005 is presented in Table 4 along with the principal reason given for selling these animals.

Consistent with relatively small number of cattle held by individual households (Table 1), the average number of cattle sold is also quite small, rarely involving more than 1 or 2 animals in a given year. While some households in 2 of the 4 sub-sub-villages (Kemorot and Semunduk) were reliant on cattle sales as a source of regular income, this still involved one third or less of those communities. Rather, the decision to sell cattle is more typically triggered by the need to meet some larger expense such as a medical emergencies, family celebrations (e.g. weddings, coming of age), school fees, house renovation or erection, purchase of transport (motorbike, truck or chidomo), or undertaking travel for Haj etc. For this reason, cattle sales for any given household can be quite irregularly undertaken between and within years.

A farming systems approach to improving the performance of existing smallholder livestock production activities will necessarily be interested to identify the smallholders' own perceptions of what factors might be significantly constraining their existing activities. The response to this question by the smallholders in the 4 sub-sub-villages is presented in Figure 5.

Given the relatively dry environment of the southern section of Central Lombok, it is probably not surprising that the principal constraint identified by the smallholders themselves in all 4 sub-sub-villages is the availability of feed for their cattle; followed by the availability of water for stock. Land and labour resource availability was not seen to be constraining expansion of cattle production at all, although labour required to feed cattle in the dry season is not an insignificant task - as noted in the following paragraph.

Figure 5. Principal constraints to cattle production, Desa Mertak



Something of the nature and scope of the problem confronting smallholders planning to intensify cattle raising activities, as well as the opportunities created by integrating specialised forages into their farming systems, is identified in Table 5 which presents data on cut and carry and water provision activities for the 4 sub-sub-villages.

Table 5. Cut and carry activities by households in 4 sub-sub-villages of Desa Mertak, Lombok (2005).

	Kelukuh	Bare Montong	Kemorot	Semunduk
Maximum distance for cut & carry (km)	84	55	32	40
	(64-100)	(45-70)	(0.5-50)	(2-60)
Hours/day/household for dry season CC	11	11	6	6
	(8-14)	(5-14)	(3-12)	(2-12)
No. months CC	3	3	5	6
	(2-3)	(2-4)	(1-12)	(1-12)
Hours/day/household providing water	0.8	0.7	0.5	0.7
	(0.5-1.0)	(0.1-1.0)	(0-1.0)	(0.5-2.0)

Forage availability for cattle becomes extremely scarce in all of the sub-sub-villages, particularly in the dry season (August-October), and households spend a considerable amount of time each day procuring feedstuffs and, to a lesser extent, water for their cattle. Cut and carry forages typically include local grasses between November-March, grasses and shrubs (sesbania, gamal, lantoro) between March to June, and shrubs and straws (peanut, soybean) from July-October. Although not shown, the cost of hiring transport for feeds from outside the village area (usually other villages in northern Central Lombok or East Lombok) is typically one of the largest cash outlays made by the households, second only to purchases of cattle. Despite the high cost of transporting in feedstuffs, this material is typically crop residues and straws (e.g. rice straw) of relatively low nutritional value. At the time of undertaking the baseline assessments, relatively few households actually conserved crops residues and straws from rainy season crops for feeding cattle later in the dry season.

On the basis of the exploratory work undertaken with the 4 sub-sub-villages, the project team subsequently identified 20 households to be considered for further selection as best-bet case studies.

As noted above, the general structure of the households and farming systems in both Sulsel and central Sumbawa are similar to southern Central Lombok and the process for selecting target communities and best-bet cases studies was essentially similar. There are, of course some basic differences between the sites including (for example) terrain, rainfall and availability of irrigation water that may favour late rainy season cropping in some communities (e.g. Lompo Tengga sub-village in Barru Regency, Sulsel) moreso than others that are less endowed (e.g. SPA kampung, Dompu Regency, central Sumbawa). Community and household data of a similar nature to that presented before is contained in the relevant sections of Appendix 1 and 2 (the original benchmark summaries for Barru and SPA).