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Beef production in crop–livestock systems:

simple approaches for complex problems

Editor: Bill Winter

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ACIAR

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Foreword

Rapidly increasing incomes and urbanisation in Asia since the 1980s have stimulated sustained growth in the demand for livestock products, in some countries exceeding 5% per year. This growth is forecast to continue for at least the next 20–25 years. Within this growing demand, beef production is especially attractive for smallholder crop–livestock farmers as it is often the only means for capital accumulation and utilises a feed base that has no other economic use.

The Australian Centre for International Agricultural Research (ACIAR) has supported cattle health and production research programs in many countries, focusing on component technologies such as forages, epidemiology, vaccine development, nutrition and genetics. From about 2000 onwards, the emphasis shifted from increasing production to considering beef as an element of the farming system. This recognises the interplay between crops, livestock, natural and human resources, and other economic elements of smallholder farming enterprises. It is important to gain some understanding of these elements before selecting the most promising options for improving smallholder cattle production systems.

Improvement of production and profitability in smallholder beef enterprises is typically not limited by a lack of promising feeding and management technologies. It is more due to low access to, and uptake of, these technologies. There has generally been little understanding of how these technologies can be adapted to and integrated into smallholder systems.

The case studies presented in this publication highlight the approaches that have been taken by recent ACIAR-funded projects in Indonesia, Vietnam and China to better understand the social, economic and technical drivers and inhibitors of uptake of these promising technologies. Although it is recognised that these approaches are necessarily context-specific, the lessons and principles drawn from these case studies have broader applications, not just for smallholder beef systems, but smallholder agriculture in general.

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Acronyms and abbreviations

ACIAR	Australian Centre for International Agricultural Research
ADP	Area Development Program (of World Vision)
APSIM	Agricultural Production Systems Simulator
BPTP	Balai Pengkajan Teknologi Pertanian, Indonesia
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Australia
DARD	Department of Agriculture and Rural Development, Vietnam
DM	dry matter
DPI	Department of Primary Industries, Victoria and Queensland
ha	hectare
HUAF	Hue University of Agriculture and Forestry, Vietnam
IAT	integrated analysis tool
JAU	Jiangxi Agricultural University, China
kg	kilogram
LW	liveweight
m	metre
mm	millimetre
NGO	non-government organisation
NIAH	National Institute of Animal Husbandry, Vietnam
PCC	Project Coordinating Committee, Vietnam
RD&E	research, development and extension
Rp	Indonesian rupiah
RUDEP	Quang Ngai Rural Development Program, Vietnam
UNRAM	University of Mataram, Indonesia
VND	Vietnamese dong
WVV	World Vision Vietnam

Successfully implementing crop–livestock research, development and extension projects

Neil MacLeod, Peter Doyle and Bill Winter

ACIAR projects seek to bring changes in monetary wellbeing of individuals and communities.

Crop–livestock farming systems, which are common in smallholder farming communities in many developing countries, are inherently complex. Initially, this can be a daunting prospect for research, development and extension (RD&E)–based attempts to improve system performance, which is typically measured as increased productivity of individual crop and livestock activities or, more generally, as increased household welfare. RD&E in smallholder agriculture often focuses on specific elements of the farming system, sometimes leading to the introduction of a new technological component (e.g. fertiliser, new cultivar, veterinary medicine) or practice (e.g. silage-making, early weaning). However, although this approach may be both realistic and inevitable when limited resources are available to support system improvement, RD&E must also take into account the wider farming system.

A key characteristic of smallholder farms is the interconnectedness of a range of production and consumption activities and practices within the farming enterprise, between the enterprise and the household, and to the wider community or economy. For example, within the farming enterprise, flows of material inputs and services—such as residues, feedstuffs, manures and draught—directly influence the efficiency of the various production activities. The household provides resources (notably cash and labour) for farming activities or for off-farm or non-farm activities. The household is connected to the wider community and economy through the disposal within the local village or regional community of materials and services (including labour and credit) produced on the farm and in the household. The household also connects to the global community when products are exported or paid employment is sourced from more distant locations.

Local customs may influence activities at the household or community level and the range of options available to improve the performance of systems. This interlinked farm–household production system is illustrated in Figure 1.

Previous research has provided information to help RD&E teams design and execute a systems-based approach to improve the performance of crop–livestock farming systems, and hence household welfare, in a smallholder context. This book discusses a range of issues relevant to farming systems research, with a focus on livestock improvement.

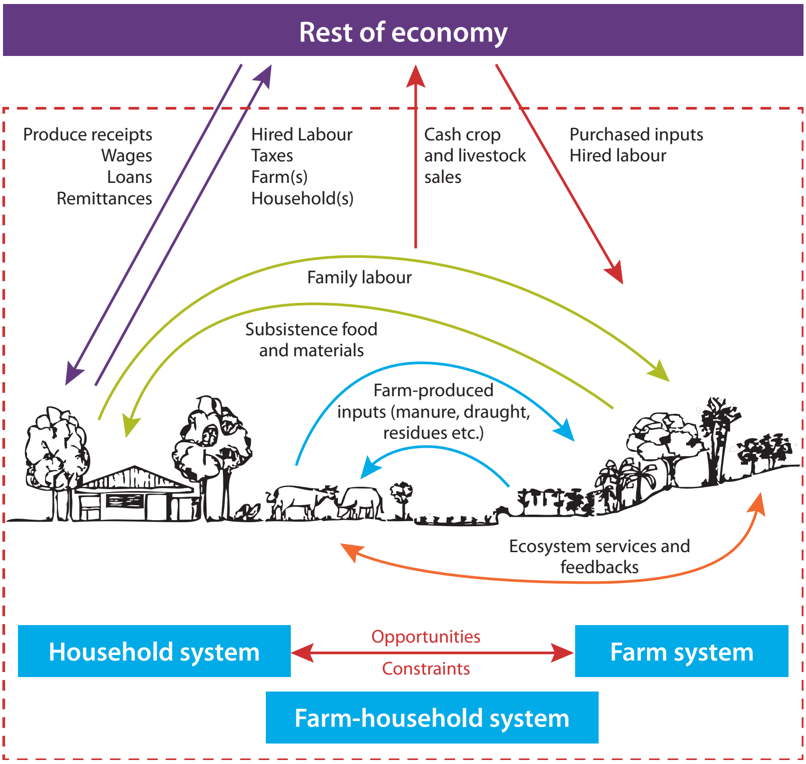


Figure 1. Smallholder farm–household production systems, showing generalised linkages and flows of materials and finances between the smallholder household, farm activities and the rest of the economy

Defining the problem

The nature and scope of the main problems affecting the performance of the farming system should be defined early in the development of a project. This will help determine the objectives of the project. A number of Australian Centre for International Agricultural Research (ACIAR)-funded research and extension teams with experience in participatory research and technology development methods have documented options for achieving consensus on project objectives (e.g. Stür et al. 2000; Cramb and Purcell 2001). These range from simple 'one-on-one' interview techniques (e.g. informed person techniques, rapid appraisal) through to larger group-oriented techniques (e.g. workshops, focus groups, village brainstorming, local consensus data gathering). The secret to gaining consensus on the central project objectives is to seek information comprehensively and from a wide range of perspectives.

Quality leadership, a critical element for project success, needs to be shared between collaborating organisations.

Specifying the farming system

Farming systems are commonly nested within hierarchies of systems. These include village and regional sociocultural systems, agri-food chain systems and public administrative systems. When defining and scoping a problem, it is important to understand the general intricacies of the system, determine the project's likely impacts and determine the constraints relating to the desired outcomes. System elements that should be considered include those over which we have no immediate control and those that are unlikely to have a major bearing on the project outcomes. One example is the lack of control over climatic variability at specific locations. Hence, some judgment must be applied to quickly determine those parts of the broader system that are essential for project scope and design and those that may be safely eliminated from further serious consideration.

Occasionally, this process will identify 'external' constraints that have such profound effects at the farm or community level that they interfere with adoption of any system improvements. In such cases, it may be necessary to address the external constraints first, or at least initiate parallel activities that may require new skills. A typical example is where farmers feel (rightly or wrongly) that they are not receiving a fair price for their product. 'Why should we produce more, or improve the quality of our product, with higher input costs, when we don't get a good price?', they may ask. This issue has been addressed in South Africa[1] where farmers were empowered within the marketing system; there is now a growing demand for on-farm technologies to improve productivity (Burrow 2006).

A key to achieving useful outcomes is to seek 'simple' ones. This is more likely to be possible if the relevant system components are identified and addressed. (Elements of the system are relevant if they are either constraining the performance of existing farm and household activities, or can be modified or replaced to significantly improve that performance.)

Parallel systems

The idea of nested systems highlights a simple, but fundamental, rule of systems approaches: that 'context matters, always'. As well as a hierarchy of interlinking systems moving outwards from the highly local to more global, another contextual dimension of 'systems within systems' is 'systems in parallel'. In a farming systems context, this roughly describes the co-existence of activities or management practices within the enterprise that may have some similar defining characteristics, but operate in a way that leads to quite different performance outcomes.

1 ACIAR project LPS/1999/036: Developing profitable beef business systems for previously disadvantaged farmers in South Africa

These parallel systems, if not recognised at the early phase of defining the problem and system boundaries, can lead to inaccurate framing of the RD&E issues and, ultimately, reduce the scope for successful outcomes. For example, livestock often have multiple roles in smallholder crop–livestock systems, including sale (of animals and produce), providing useful services such as manure and draught, and as vehicles for status, security and facilitating transactions (e.g. Moll 2005). The principal objective for owning and using livestock may therefore vary between smallholder households. This variation may influence livestock management and scope for rapid adoption of new technologies and practices that are intended to promote livestock production and marketing.

Shaun Lisson works with community leader Amaq Sapri in Satuan Pemukiman A village in Central Sumbawa to trial a suite of forages for possible integration into his household–farming system. Amaq has proven an excellent example of a livestock 'producer' and project 'champion'.

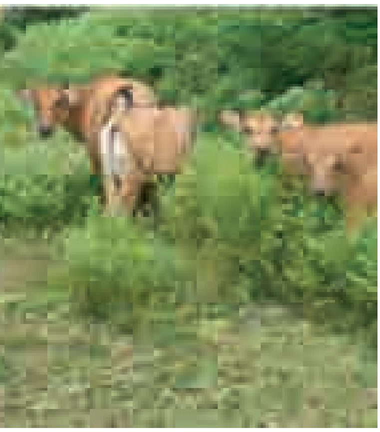
The idea of livestock 'users', 'keepers' and 'producers' has been used to describe this spectrum of interests. Of these categories, producers are the most likely to be receptive to new technologies and practices that focus on commercial efficiency (Neidhardt et al. 1996). Farmers in the 'producer' category who have been exposed to and had success with new technology have the potential to become project 'champions', acting as examples of success for other farmers in this category, while the 'keepers' and 'users' may first require some preliminary communication and training to increase their receptivity to change.

Inaccurate or misleading framing of contexts can also arise when single households hold multiple objectives for keeping livestock, particularly when these objectives specifically relate to different classes of livestock. A common situation in smallholder farming communities moving from a dominant subsistence cropping focus into more specialised livestock-rearing activities is the retention of some older cattle for draught and the raising of younger cattle for breeding and sale. This system can have elements of 'using', 'keeping' and 'producing' sitting side by side on the one farm, and the focus of interest in new production technologies may differ substantially between the different animals.

A smallholder's apparent lack of interest in technologies or practices that emphasise production efficiency may simply reflect the role that particular animals are perceived to play in the overall scheme of the enterprise; communication or extension approaches must allow for this. Alternatively, some smallholder households with this multiple-use characteristic may be seeking a wider range of technologies than those on offer, leading to an apparent lack of interest in new technologies or practices.

Strategic utility of farming activities

In attempting to frame projects to engage smallholder household interest and needs, scientists have considered the 'strategic utility' of different farming activities—the central role that a particular activity might play in meeting the household's broad consumption, investment and welfare security objectives.



Household-farming systems in Satuan Pemukiman A village in Central Sumbawa suffered years of crop failure and hardship because of the marginal prospects for cash cropping. ACIAR projects have helped to successfully integrate improved husbandry of Bali cattle and new forages for better nutrition into these systems.

Different activities can have different strategic roles. For example, a typical activity mix in smallholder communities in eastern Indonesia could include staple crops (notably rice or maize) grown largely for home consumption and food security, secondary cash crops to meet general household cash needs, small livestock (e.g. chickens, goats) for sale to support larger transactions, and large livestock (notably cattle and horses) that are held as a reserve to support major outlays and to deal with emergencies. This mix of strategic roles can explain the apparent reluctance of smallholder households to abandon activities and practices that are notionally 'unrewarding' and to take up others that are supported or championed by the results from well-intended RD&E projects.

Many smallholders have firsthand experience with episodic failure of subsistence crops and the resulting personal, community and financial hardship. Some older householders may have also experienced famine, such as occurred in Lombok and other islands of eastern Indonesia as recently as the mid 1960s. Against this background, it is no surprise that many households are reluctant to risk food security by reducing their commitment to planting staple crops, regardless of the seasonal outlook in favour of cash crops or livestock options that are projected to provide greater income prospects over time.

However, our experiences working with a transmigration community in central Sumbawa, Indonesia, revealed that a sequence of repeated failures of the primary and secondary subsistence and cash rice crops encouraged many households to place a greater emphasis on forages and cattle, thereby promoting both their food security and income prospects. These households are using cash from livestock sales to purchase rice and other staples from less drought-prone areas, recognising that continued subsistence cropping in more marginal and high-risk production areas is definitely detrimental to ensuring food security.

Before this transformation could be effected, it was important to secure households' trust in the forage and livestock systems as a viable alternative to their former systems, and to ensure that they had confidence in their own ability to manage the change successfully.

Introducing new technologies into systems

It is vital to recognise that new technologies and knowledge that emerge from RD&E efforts will operate within a system and may have systemic impacts on smallholder production outcomes and livelihoods. Project workers need to keep in mind the likely effect of a proposed RD&E intervention, particularly if they are less familiar with the smallholder community. Having a working knowledge of the local language is an advantage, and partnering with local people trained or experienced in farming systems is essential.

Researchers must concentrate on the elements of the systems where technology will have a direct impact (e.g. through trialling and adoption). They must also focus on the effectiveness of the intervention within the wider system in which the elements are embedded and through which the impacts will manifest themselves.

Some sidetracking may be essential to make progress on the main project objectives. In many farming systems, improving one component of the system's performance will require addressing and resolving constraints in some other part of the system. These constraints may even lie outside the immediate mandate of the RD&E effort. For example, during our forages work in Indonesia,[2] as we sought to promote the integration of forages into smallholder cropping systems, we recognised that breeding cycles and weaning management of calves needed to be altered to make effective use of the forages (see Case study 2 for more details). However, there was little point trying to achieve these herd management goals until a chronic shortage of bulls and poor availability of drinking water in our study communities were resolved. Thus, arrangements were made to provide bulls and seek assistance to capture fresh water for the stock.

Lack of access to bulls hindered success in introducing forages and improving husbandry of Bali cattle. An ACIAR project established a cooperative bull ownership program to overcome this impediment.

Identifying issues that are constraining the opportunity to improve the system's performance and acting on them is different from getting sidetracked on irrelevant, albeit interesting, issues that should be left outside the system and ignored until they become relevant.

Achieving impacts

Although it is important to focus on where RD&E interventions are likely to have impacts on the performance and welfare of smallholder farming systems, it is also important to have a realistic appreciation of the likely magnitude of these impacts, and whether 'driving forces' might affect the scope for achieving impacts.

Large-scale driving forces

Driving forces include significant structural developments in global trade, economic development or communication that may spur the development or transformation of a particular farming system's context within smallholder regions. Drivers such as these commonly operate at the global or economy-wide level and may not be unique to any one country, let alone region or community. For example, a major driving force for integrating specialised livestock-raising activities into smallholder farming systems has been a marked growth in personal income levels across many developing countries. This economic growth has, in turn, driven an increased per capita demand for meat and livestock produce, which typically have a positive income elasticity of demand (e.g. Longworth et al. 2001).

2 ACIAR project AS2/2004/005: Improving smallholder crop–livestock systems in eastern Indonesia

One measure of success in a project is the extent to which ongoing relationships have been forged.

Accompanying this growth in demand has been a generally upward trend in real prices for these products. Prices have also been influenced by regional shortages of breeding animals and retention of animals (that might normally have been slaughtered) for building up animal stocks. These are classic drivers for livestock-based RD&E to have a positive impact on the welfare of smallholder households. Rising income levels are expected to be sustained over the longer term in developing countries, but future real price levels are harder to project—particularly if livestock numbers eventually stabilise and local markets enter a mature phase.

Strong institutional or policy support is another important driving force that may influence the scope for uptake of RD&E products. For example, in China and Indonesia, there has been a strong recent history of extension and other support (including subsidies) to encourage expanded livestock production (e.g. Longworth et al. 2001; Hadi et al. 2002; Hutasuhut et al. 2002).

Local forces

As well as large driving forces that may increase the potential for smallholders to adopt new livestock management technologies, local forces may also affect impacts for a given smallholder community. We have categorised these as either 'shaping' or 'enabling' forces, although the delineation is not always clear. Shaping forces include specific characteristics of the region or community that might explain the prevalence of a particular farming system or set of cultural practices. One obvious example is the effect of climate, soils and proximity to water resources; where these conditions are favourable, intensive cropping systems based on irrigation may be established, whereas such activity is untenable in areas where resources are limiting.

Another example of a shaping force is religious and other cultural principles within a community that strongly proscribe certain livestock-keeping or dietary practices. Adoption of new practices involving those livestock or by-products is unlikely, regardless of their prospective profitability. Another community in the same location, however, may have a long tradition of pursuing these activities and practices.

Enabling forces are particular characteristics of the local economy, institutions or culture that promote or 'enable' the establishment of activities or practices within a community. For example, proximity to a large urban centre, shipping port or livestock-marketing facility may significantly favour certain livestock finishing and trading activities for a community.

Other examples of positive enabling forces are widely available credit facilities for smallholders, publicly available market information for different livestock categories, and access to public veterinary and advisory services. Many smallholder communities struggle with corrupted markets, power imbalances between smallholders and traders, and limited availability of credit or extension services. Such obstacles must be surmounted as they will surely impede the ability for RD&E to generate lasting impacts.

Understanding the farming system

Although we have stressed understanding the wider context of the farming system as a critical prerequisite to RD&E success, we do not wish to be seen as overstating the case. It is neither necessary nor realistic for RD&E teams acting at the smallholder community level to have an intimate understanding of the global context within which that community is operating. Nor should they know all of the drivers and forces that are shaping the community's farming system and economic destiny. However, we emphasise that the broader context is likely to be extremely important to the ultimate wide-scale impacts of an RD&E effort.

Therefore, researchers should try hard to understand the structure and dynamic nature of the working environment—particularly in the critical project design and initiation stages (MacLeod et al. 2008). Their knowledge need not be comprehensive, but they should know, for example, that market corruption is not stifling development at the smallholder community level, and that the smallholder households are at least in a competitive position to expand livestock production using their available resources (and thus supply livestock and produce according to market demands). Furthermore, they need to ensure that the market for the livestock and produce is viable in the long term, thus avoiding any significant price declines if supplies of animals and produce increase.

A major motivation for scientists in ACIAR projects is the learning that comes from the experience of diverse and sometimes unique farming systems.

In the same context, there is no value in stakeholders beginning a project based on flawed information or insufficient understanding. False hopes and expectations of smallholders and communities are best avoided; they are potentially distressing and do not progress knowledge (apart from the lessons of failure). Working with smallholders' households, communities and institutions where there has been a history of failure is understandably difficult. Understanding the system is one way to improve the chance of success.

All farming systems involve complex interactions, and every farm business is unique. Makeham and Malcolm (1993) have suggested that farm management decisions in developed agricultural systems require consideration of the human, production, environmental, economic and financial components of the business. This is equally true of smallholder systems, but with heightened complexity, diversity and risk because of the different social, institutional, commercial, market and governance environment of smallholder systems. Consequently, understanding the reasons for current production systems and the prevailing trading and business systems is the essential first step in considering changes to these crop–livestock systems.

The case studies described in this book covered a diverse range of crop–livestock systems. They all took into account the system's components and their interactions, including the human components (labour, household structure, ambitions, education, attitude to risk, social systems, customs and norms),

Training is an essential part of achieving long-term success in a project.

business components (wealth, debt, credit), production components (field crops, home gardens, livestock) and the external operating environment (markets and marketing systems, alternative resource uses, local infrastructure, quality of and access to service providers). The positive outcomes achieved by taking this approach reaffirm that many development-oriented activities fail because they give insufficient attention to differences between communities and between farms within communities, and to the interplay of the system's components; and because they use single-issue strategies (e.g. credit, new breed of livestock) without considering the knock-on effects to other components of the system.

Smoothing the pathway to adoption

Creating impact from RD&E efforts is all about adoption, which is rarely universal and instantaneous. A considerable body of literature, citing examples from both severely resource-limited developing countries and more developed, resource-rich economies, probes the chequered adoption record of many agricultural technologies (e.g. Pampel and van Es 1977; Guerin and Guerin 1994; Scoones and Thompson 1994; Rogers 2003; Cramb et al. 2004).

After identifying how the central technologies or practices from an RD&E effort might positively affect the performance of the targeted community and its farming systems, the next step is to identify and present the adoption pathway(s) through which the new technology or improved practice must proceed to create that impact. This will involve establishing a clear understanding among the stakeholders (the project team, any linked collaborating agencies and participating smallholders) of the various roles, responsibilities and resources of each party in realising the proposed outcomes.

Setting goals

Role ambiguity and lack of commitment to specific activities are common killers of otherwise good projects (MacLeod 2000). Therefore, it is imperative that roles and commitments are established early—preferably before the formal project activities have begun. It is also important to avoid role and commitment 'drift' during the project. Waning commitment of some stakeholders is not uncommon, particularly when they have relatively small individual roles or are exposed to a wide range of competing opportunities that divert their interest.

Many livestock-oriented projects now centre on multidisciplinary, multipartner teams operating over several distant sites. The problem of uncertain and ephemeral commitment of team members or partners is a genuine challenge that proactive management must address. 'Projects' have globally become the main structure of industrial research and application over the past 60 or so years, and there is a large body of literature covering effective project management, including team building and maintaining commitment (e.g. Baguley 1995; Gido and Clements 1999, Clements 2004).

One particularly useful approach adopted by ACIAR livestock improvement projects in the Philippines and South Africa focuses on roles and commitment. It involves the use of short-duration goal-setting and reporting practices within a broader continuous innovation cycle framework (e.g. Clark et al. 2005). This process uses a group approach to setting and reviewing goals, tasks and key performance indicators at particular time points: task establishment activities occur after 30 days, general checks of progress after 90 days, a mid-year review after 180 days and an annual report after 360 days. Although considerable effort is required to adhere to such short-duration action and reporting processes, especially where projects are managed partly from Australia, considerable success has been achieved with this approach (e.g. Lawrence 2005).

Learning from farmers is important as the project considers new technologies.

Mapping pathways

Mapping pathways is important. It should be a strong, team-based activity that involves active input from all the major stakeholders, including smallholders. However, pathways often have gateways, obstacles and barriers (MacLeod 2000). Participants in an RD&E project should become aware of and resolve these problems to ensure a successful outcome, but this is usually easier said than done. Many projects, despite careful planning, have unresolved or latent problems within their design or in the local smallholder context that eventually surface to create serious issues for future resolution. In the enthusiasm to develop a project, get contracts signed and start work, project developers either downplay, ignore or earmark for later resolution a number of ambiguities, potential obstacles and barriers—in effect placing a 'hidden hand' (MacLeod 2000) over one eye and pretending that the obstacles and barriers do not really exist.

Two similar processes downplay future problems or misframe a research context: 'group delusion' and 'premature framing'. Group delusion typically occurs when participants become so excited or overconfident at the prospect of pursuing an idea or course of action that they neglect to seriously challenge some of the assumptions or contingencies that underpin its prospective success (Neale et al. 1986; MacLeod 2000). This can occur in the brainstorming and SWOT-type exercises often used during problem identification and project selection.

Premature framing (which can also be associated with group delusion) sets the 'boundaries' around the context of a problem or opportunity before the full range of plausible explanations or options for that context have been explored (Mintzberg et al. 1976; Kahneman et al. 1982). This can contribute to focusing of research on limited elements of a farming system rather than the wider system itself (as discussed above). It may be a significant problem for multidisciplinary

Any opportunity to educate children in low-income societies usually attracts potential participants.

research teams that draw on a relatively narrow range of disciplinary expertise; for example, when either the biophysical or social sciences are under-represented in the team's makeup, or where extension specialists or smallholder household representatives are unfamiliar with the framing process.

Both group delusion and premature framing are common pitfalls in RD&E design and execution, particularly for teams entering unfamiliar territory (which is frequently the case for research in a developing country). In these circumstances, it is beneficial for the final project design to use a wide range of perspectives in the process of framing the problem and opportunities. Drawing on accounts of past successes and failures also helps to streamline the process and test the robustness of plans for future work.

Training and capacity building

Once the issues of setting up a good project (including problem framing, research design, clarification of roles and commitment) are addressed, the next critical issue in the adoption pathway is to ensure that both the extension partners and targeted smallholder communities have the capacity to implement change within the local farming systems context.

A serious commitment to training and capacity building should be a key consideration for effective project design and management. This has been a central feature of many ACIAR-funded projects, including those in Indonesia, Vietnam and China described in the case studies. In these cases, the project team allocated considerable resources to direct training and workshop activities for local extension personnel and smallholders, and sought opportunities to trial technologies and practices under field conditions with sympathetic technical support from local project research and extension staff.

Understanding the need for training and then providing appropriate opportunities for the diverse stakeholders that will facilitate movement along adoption pathways are genuine challenges. (The under-representation of women at all levels from researcher to farmer in consultation and training, despite their sometimes pivotal roles, is one such challenge.) This approach may appear to conflict with some of the 'farmer first' ideals (see below) that underlie much theory and practice relating to participatory research and technology development (e.g. Chambers et al. 1989; Jiggins 1993). In practice, however, the critical challenge is to sensibly differentiate between the types of barriers to adoption.

Some barriers occur because there is a lack of congruence between the research outputs and smallholder households' motivations and interests; others stem from a lack of technical and management skills required to effectively implement the research outputs. The first can be addressed by appropriate framing of the research context and well-informed design and implementation of the research. The latter requires a firm commitment to training and capacity building—preferably based on sound principles of adult learning, practical demonstration on-farm, and opportunities to trial and adapt various options rather than trying to adopt 'one size fits all' solutions.

Achieving best practice

Encouraging participation and staying realistic

The 'farmer first' movement encompasses various participatory technology development approaches (e.g. Biggs 1995). It gives the primary stakeholders—notably smallholder households—power to choose the nature, scope and location of RD&E interventions. The central tenet is that working purposefully with the main beneficiaries to address problems of direct relevance, encouraging motivation, and locally adapting to deliver solutions that are practical and readily applicable are more likely to enjoy lasting success than RD&E efforts in isolation.

Involvement of women at all levels enhances the prospects of lasting impacts from a project.

Although the track record of some 'farmer first' applications is open to challenge (e.g. MacLeod 2000), we support the common sense associated with working in areas where communities have a genuine desire to implement the project's outputs. An important rider is that the targeted community must have a realistic perspective of what the projects can eventually deliver.

Smallholder agriculture in the developing world is largely entrenched in a situation where large numbers of resource-poor households confront on a daily basis a seemingly unlimited array of demands, challenges and opportunities, but have limited scope to make major and rapid changes to their welfare. The context of smallholder farming systems is complex (Makeham and Malcolm 1993), and many system elements influence the success or failure of production activities, consumption and capital accumulation.

Given this difficult context, the approach most likely to improve smallholder livelihoods is to make changes to existing farming systems. Such changes include introducing novel activities and practices that farmers will find realistic and relatively simple to adapt and implement with their resources and skills. This approach has underpinned the success of many ACIAR-funded projects for livestock and forage improvement that are targeted at smallholder communities.

Keeping it simple

With the large numbers of poor smallholder households in the world and the vast problems they face, few if any projects focusing on them will have surplus resources. It is critical, then, that limited available resources are put to best use by striving for impacts that are relatively easily achieved. Where possible, this should be through interventions that do not require large-scale injections of skill and resources or major structural adjustments to local farming systems (e.g. Pannell 1999).

This 'keep-it-simple' message might seem at odds with the case made for adopting a farming systems approach. However, we have found that gaining a broad understanding of the complexity of the whole system can best identify the appropriate 'simple' interventions, which may be sufficiently robust and flexible to be widely accepted. We have also found that the success of the first simple intervention is often followed by requests for more complex changes (for which we are well prepared). If the simple intervention is not as effective as anticipated, the reasons can be quickly identified and addressed. Regrettably, we have witnessed many development projects supported by governments and non-government organisations (NGOs) that have failed (or will fail) because of the poor understanding of the systems context within which they work (Winter and Doyle 2008).

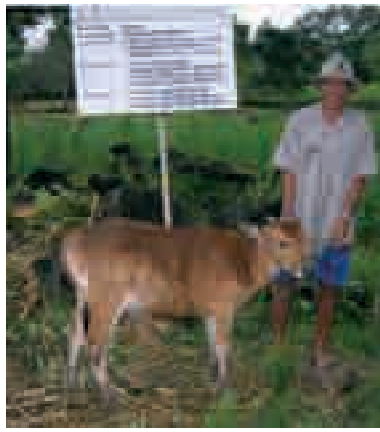
Establishing effective partnerships

The notion of participatory research or technology development based on 'farmer first' ideals may suggest that a research partnership should only begin in response to an invitation from the affected smallholder communities. However, this need not necessarily be the case; there is every reason to believe that well-informed government bodies or NGOs either could or should be able to identify opportunities where research is required to understand or resolve a problem on behalf of the smallholder communities. Since the transaction costs are high for individual smallholder communities searching out effective research partnerships, especially those involving multiple agencies and foreign research providers, most projects would flow from government negotiations.

Most ACIAR-funded projects are established under the broad umbrella of government-to-government negotiations that establish the needs, priorities and opportunities for research in various regions and recipient countries. It is still desirable for these research projects to focus on areas where there is a high potential for adoption. Realising this potential will hinge on the quality of the stakeholder consultation, ensuing research design and implementation, and commitment to capacity building. Much of this emerges after the various public bodies have agreed on the overall engagement in a given region.

Providing options

Recipes for action are acceptable when individuals or groups do not express a particular preference, and everyone is generally satisfied with the limited prospects on offer. In the real world of smallholder farming systems, however, it is likely that a particular technology or recommended practice will be useful only after considerable adaptation to local conditions and circumstances. Some of the key features of an agricultural technology that enhance its potential for adoption include meeting a perceived need, offering cost or revenue advantages, fitting well with existing farming systems and local practices, and having limited need for high levels of skill. The technology also needs to be versatile and capable of adaptation and trial on a limited scale (e.g. Vanclay 1992). Moreover, individuals differ in their willingness to trial, adapt and then adopt a new technology—researchers recognise that there are early adopters, middle adopters and laggards (Rogers 2003).



Pak Lamatta of Harapan village, South Sulawesi, is an example of success from identifying options suited to individual household resources and preferences, rather than prescribing 'recipes' for all. Pak Lamatta displays the extra calf he has gained as a result of trialling improved forages, early weaning and preferential feeding in his household-farming system.

Successful adoption and subsequent impact centre on providing smallholder households with a variety of choices and allowing them to explore whether a technology will suit their unique circumstances (Cramb 2000). Some smallholders, perhaps the early adopters or those with fewer resource constraints, may be keen to make major changes to their current farming and trading systems. Some households may wish to explore just a few simple interventions to suit their immediate interests and circumstances, while others may elect to do nothing at all initially.

The mid- to tail-enders of the potential adoption spectrum may have a range of reasons for limited adoption. These may include less motivation or fewer opportunities to trial the technologies and practices on offer or, importantly, limited skill and confidence (personal capacity) to work alone with them. Capacity building is critical for both smallholders and their immediate support linkages in local extension services.

The key issue is that some smallholders will work with quite elaborate changes to their farming systems and practices; others either cannot or will not—either indefinitely, or until it is evident that the new practices are profitable or a well-entrenched part of the local farming 'culture'.

The strategies adopted for extending the outputs of the livestock–forages projects in eastern Indonesia exemplify the need for a range of options. Through an integrated process of smallholder discussions and workshops, scenario modelling and field trials, the projects identified a broad range of opportunities to incorporate various forage and cattle husbandry options into local farming systems and thereby improve the overall production and welfare levels of the targeted communities (e.g. MacLeod et al. 2007a). The projects identified options, locally called 'best bets', suited to agroecological environments covering a wide gradient of altitude, soil and rainfall from South Sulawesi to Lombok and Sumbawa.

Smallholders from many villages have now trialled these best-bet options in their own fields, under their own management and with some technical support. These trials were established after gauging the specific interests and opportunities of each of the households, then providing them with materials and technical support to build their

Ibu Suarni and her family from Satuan Pemukiman A village, Central Sumbawa, have gained from successfully integrating forages and improved Bali cattle management into their household-farming system; gains include a lower workload for cut-and-carry activities and better education for the children.

confidence and capacity. Where the households encountered problems, the RD&E teams provided further technical assessments and support to identify the nature and likely causes of the problems. This mutual support improved the performance of the options or led to suggestions for alternatives to be explored further.

This process has worked well in identifying a wide range of options to improve the welfare of a broad spectrum of smallholders. It is unlikely that a narrower range of options 'handed down from above' (the technocrats) would have made the same impact. Together with the experience of local extension officers, researchers and smallholders, and the efforts of expatriate personnel, this process has produced a community development program that should reach many thousands of farmers and their households.

In conclusion, it is vital to develop strong, trusting relationships with RD&E partners, including project champions among the smallholder households, and to maintain strong communication linkages within the project partnership. Such observations may seem self-evident, but their central role in underpinning all of the elements involved in establishing and completing a successful RD&E project is unequivocal. Without trust-based commitment and communication, even the noblest of RD&E intentions will quickly encounter difficulties, and in many cases these may be fatal to the success of the project. The prospect of failure is amplified in the context of smallholder agricultural systems with their inherent complexities and ambiguities.

The cases cited here were successful because the teams found a way through the complexity and gave high priority to communication, then skilfully applied the discipline and science of farming systems and the rigour of the component sciences. Diversity in household resources (land, labour, knowledge, water and capital) and the need to integrate livestock production within complex multicropping systems mean that systems modelling is the best approach for understanding the systems and then exploring options. All the case studies are anchored in farming systems to a greater or lesser extent.

At the end of the day, there is an art in making the complex look simple! For example, what might appear to be a simple single-component intervention will be grounded in a thorough knowledge of the farming systems, be sufficiently robust and flexible to be widely accepted, and may be the first step towards a much more comprehensive change process.

Learning from the past

It is extremely important to look at and learn from previous aid-related work. All five case studies in this book tell of successful outcomes that followed previous failed attempts to solve perceived problems. In part, these successes were built upon understanding of the previous failures, better problem analysis and the deployment of appropriate knowledge and skills from elsewhere. Taking a farming systems approach was unique and ultimately underpinned the success of each project.

Case study 2 cites a good example of learning from the past and not making the same mistakes again. Before this work, projects had concentrated on animal health and the use of feed supplements to solve the high calf mortality problem; the original request for help was for more of the same. But careful study of the previous work by people with experience in farming systems and herd management indicated that high calf mortality was just a symptom and that the problem and solution lay elsewhere. The real value of working collaboratively was in maximising the value of previous work, local knowledge and experience, and the introduction of new skills and approaches.

Development in farming systems helps to stimulate activity in the marketplace.

Building capacity

An important common thread throughout the case studies is the emphasis on capacity building. Although this element is common to all ACIAR investments, it was given greater prominence in these studies, primarily because the concept of farming systems was foreign to the developing-country partners and because this approach had not previously been used in work with a livestock focus. Capacity building was not confined to the developing-country partners, but also applied to the Australian partners who needed to adapt concepts and knowledge to new farming environments.

Capacity development is much wider than training courses and formal education programs. In Indonesia, China and Vietnam, the multidisciplinary farming systems approach led to institutional change in agencies, to sustained interagency collaboration, and to a willingness of previously discipline-oriented scientists to broaden their approach to problem definition and solution. The projects also had significant influence beyond those directly involved, particularly with government and NGO providers of extension services. Undoubtedly, these achievements will help to sustain the development effort well beyond the life of the projects and the input from Australia.

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

Shaun Lisson, Neil MacLeod, Cam McDonald, Jeff Corfield, Rachmat Rachman and Lalu Wirajaswadi

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

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

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

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

Rationale for the projects

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

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

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

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

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

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

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

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

Successful forage adoption

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

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

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

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

Project objectives

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

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

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

Project operations

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

Typical smallholder farming conditions and systems

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

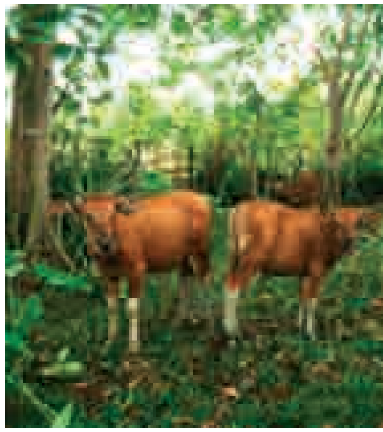
'Cropland', located close to the main residence, is used to grow a range of annual crops such as rice, maize, peanut and soybean. Usually this land is naturally flat or formed into terraces, with deeper, more fertile soils and access to simple irrigation. It may be bunded to retain overland flow. The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

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

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

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

The approach adopted in these projects comprised four key steps:



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

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

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

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

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

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

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

Step 2: Develop and parameterise desktop simulation tools

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

Model systems

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

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

The IAT has three component models:

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

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

Step 3: Identify strategies for Bali cattle improvement

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

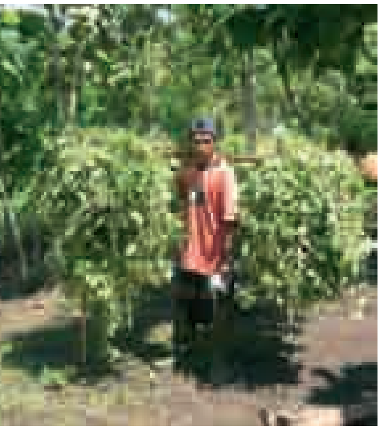
The team presented the results to the smallholders at a second workshop held 1 day later, to identify a shortlist of both feasible (i.e. practically and culturally) and viable (i.e. economically and environmentally) 'best-bet' strategies for improving Bali cattle production in the region. Approximately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

Step 4: Test strategies in the field

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

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

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



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

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

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

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

Results, outcomes and impacts

Factors constraining livestock production, and potential solutions

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

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

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

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

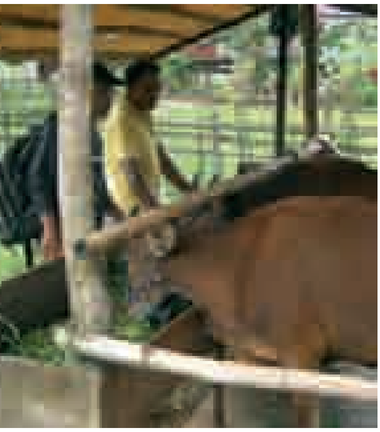
Household labour focused on field preparation and planting of rice when the wet season began; consequently, the cutting and carrying of forages as supplements for tethered or housed animals became a relatively low priority. Furthermore, in the early wet season there was often an overlap between lactation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

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

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

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

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



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

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

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

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

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

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

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

Modelling the potential impacts of these strategies

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

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

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

ha = hectare; kg = kilogram; Rp = rupiah

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

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

ha = hectare; kg = kilogram; Rp = rupiah

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

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

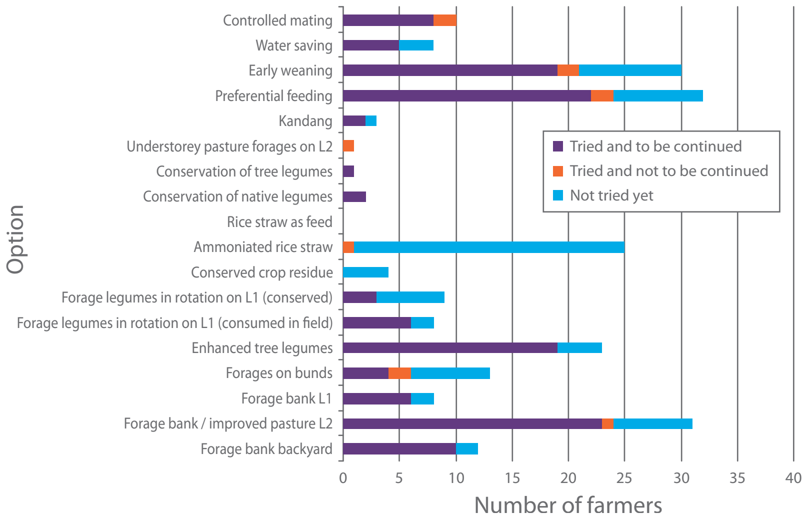
4 At the time of writing A$100 ~ Indonesian Rp850,000

Uptake of options by smallholder households

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

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

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



kandang = communal cattle housing overnight; L = lowland

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

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

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

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

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

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

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

Forage production

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

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

Cattle production

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

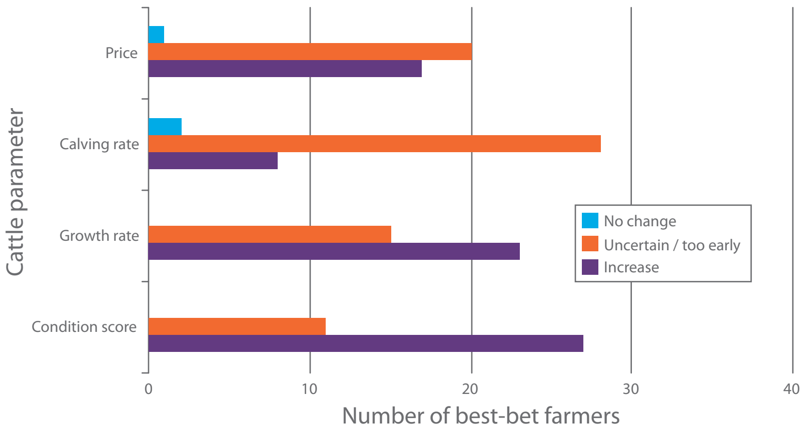


Figure 3. Impact on cattle parameters from best-bet practices at all sites in eastern Indonesia

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

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

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

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

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

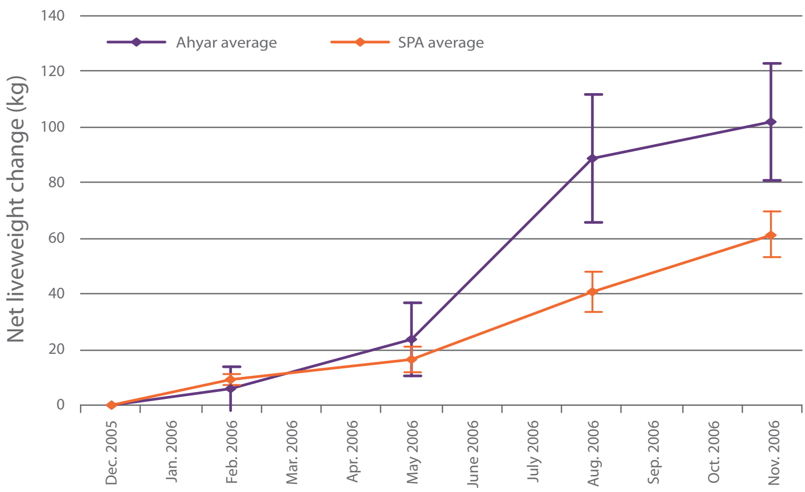


Figure 4. Comparison of average liveweight between Amaq Ahyar's young male cattle and other best-bet farmers at Satuan Pemukiman A (SPA) village, Central Sumbawa, December 2005 to November 2006

Crop production

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

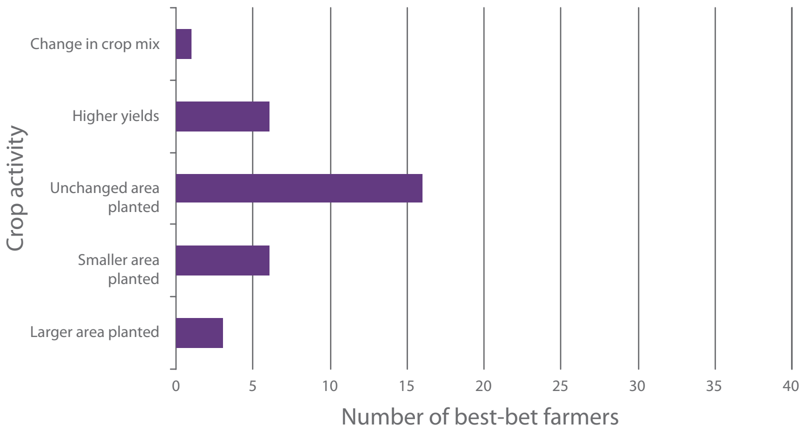


Figure 5. Impact on crop activities from best-bet practices at all sites in eastern Indonesia

Labour

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

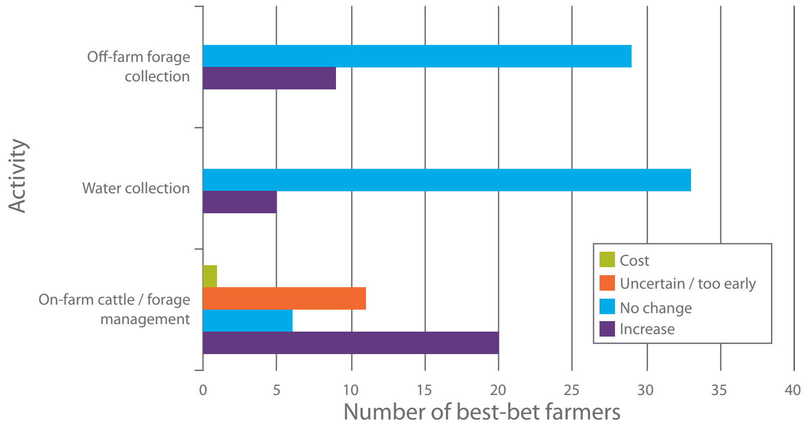


Figure 6. Impact on labour activities from best-bet practices at all sites in eastern Indonesia

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

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

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

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

Household finances

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

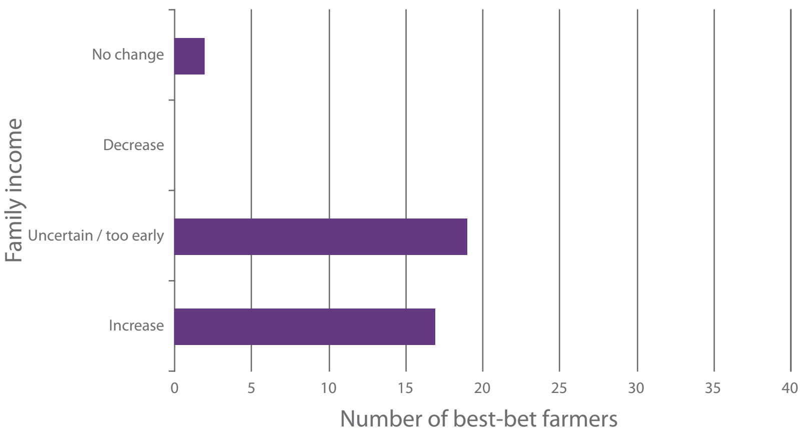


Figure 7. Impact on family income from best-bet practices at all sites in eastern Indonesia

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

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

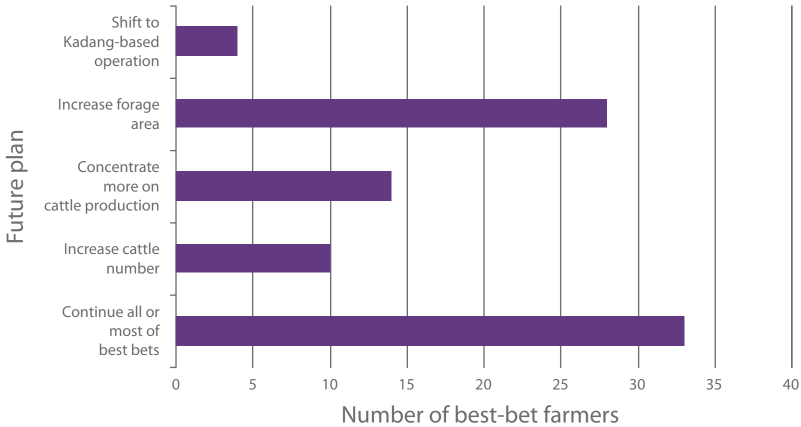
Although several households had previously constructed small kandangs to support their livestock activities, this was not a nominated use for any additional income. Also, while accumulation and the sale of cattle are long-recognised methods of financing travel associated with religious aspirations such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

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

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

Future intentions

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



kandang = communal cattle housing overnight

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

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

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

Extension to other smallholder households

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

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

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

Capacity building

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

Similarly, the results from the household exit interviews clearly show substantial gains in forage and livestock management knowledge by participating smallholder households. Virtually all nominated knowledge gain as the most important benefit they had received from participating in the project. Many households made the comment that the knowledge was now 'part of them' and that they had greater confidence to go forward, try other options and expand their current activity.

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

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

Community and social impacts

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

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

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

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

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

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

Future applications

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

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

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

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

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

Dennis Poppi, Geoffry Fordyce, Tanda Panjaitan, Dahlanuddin and Simon Quigley

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

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

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

Rationale for the project

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

7 ACIAR project AS2/2000/103: Developing an integrated production system for Bali cattle in the eastern islands of Indonesia

Typical farming conditions and systems

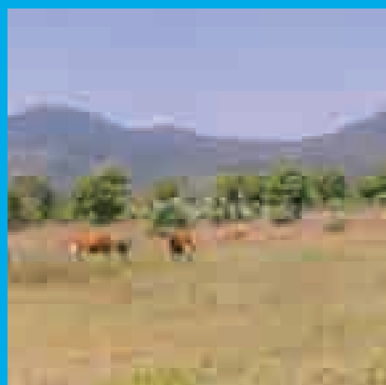
In eastern Indonesia there are two contrasting environments—the wet tropics as characterised by Central Lombok and Bali, and the dry tropics as characterised by parts of Lombok, Sumbawa, Sumba and West Timor. The project focused on two locations in East Nusa Tenggara province: Central Lombok and Sumbawa.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

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

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

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

Bali cattle in a communal village kandang in Central Lombok.



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

Perceived and real problems

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

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

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

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

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

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

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

8 ACIAR project AS2/2000/099: Strategies to improve Bali cattle—eastern Indonesia

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

Project objectives

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

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

Rural scene in Sumbawa, Indonesia

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

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

Project operations

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

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

Phase 1: Integrated management system

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

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

Success relied on three components:

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

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

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

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

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

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

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

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

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

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

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

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

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

Phase 2: Technical extension package

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

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

The villagers deemed that the main focuses of future extension were disease management, improving dry season nutrition and improving cattle fertility. The team considered these needs in developing the extension material. However, these factors were the symptoms of the larger problem of inappropriate management rather than problems in their own right. It was improbable that the villagers or the discipline-oriented extension services could see the problems and potential solutions in the wider context. This made the acceptability of the potential solution, provided mainly be external sources, more problematic.

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

Phase 3: Feeding and supplementation evaluation

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

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

Development of relationships

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

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

Results and observations

Village selection

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

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

Cattle control and diets

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

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

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

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

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

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

Cattle fertility

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

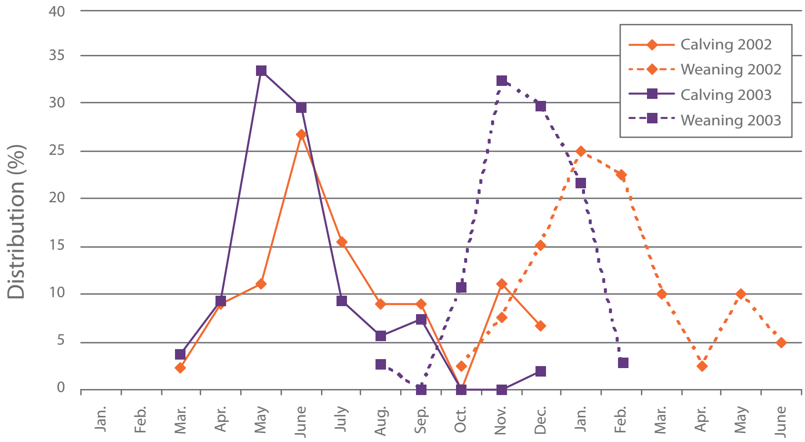


Figure 9. Calving and weaning in Kelebuh before and after the introduction of the new integrated management system, January 2002 to June 2003

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

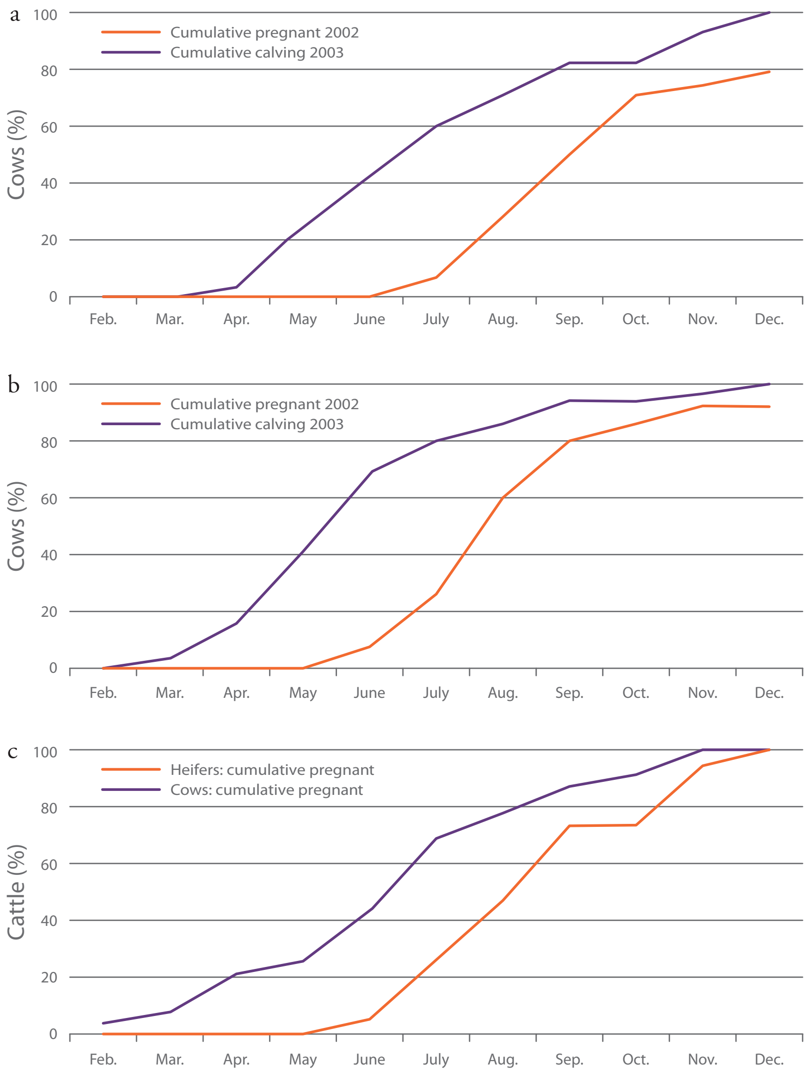


Figure 10. Cumulative calving and reconception patterns for (a) first-lactation cows, (b) mature lactating cows and (c) dry cattle in Kelebuh, 2002 and 2003

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

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

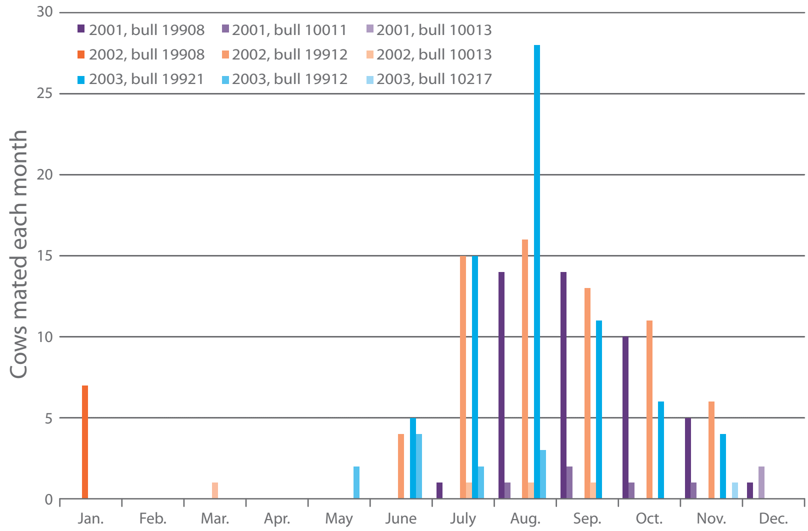


Figure 11. Monthly mating activities of selected bulls for 2001–03 in Kelebuh

Cattle growth

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

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

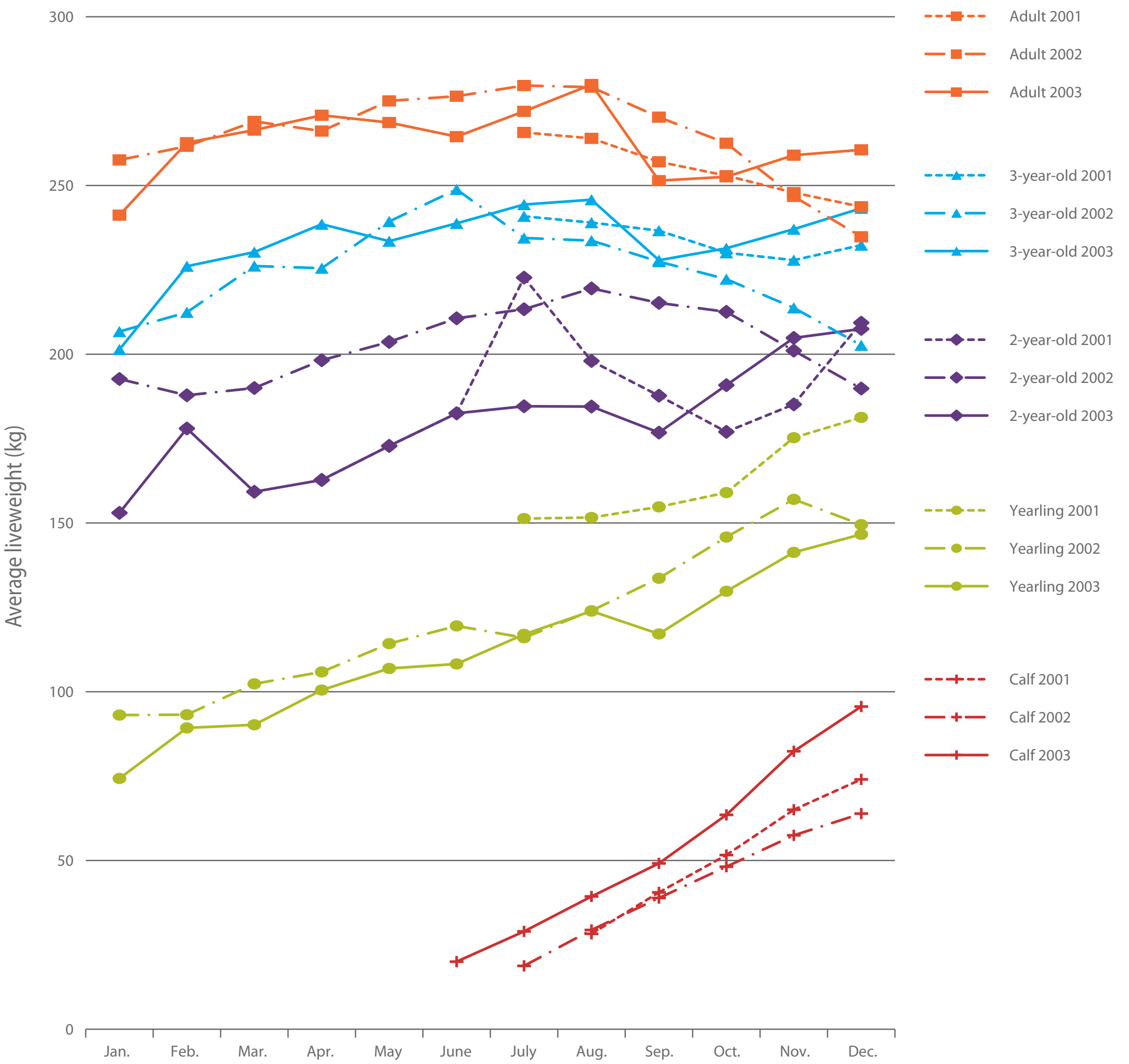


Figure 12. Monthly liveweight of various classes of female cattle in Kelebuh before and after the introduction of the new integrated management system

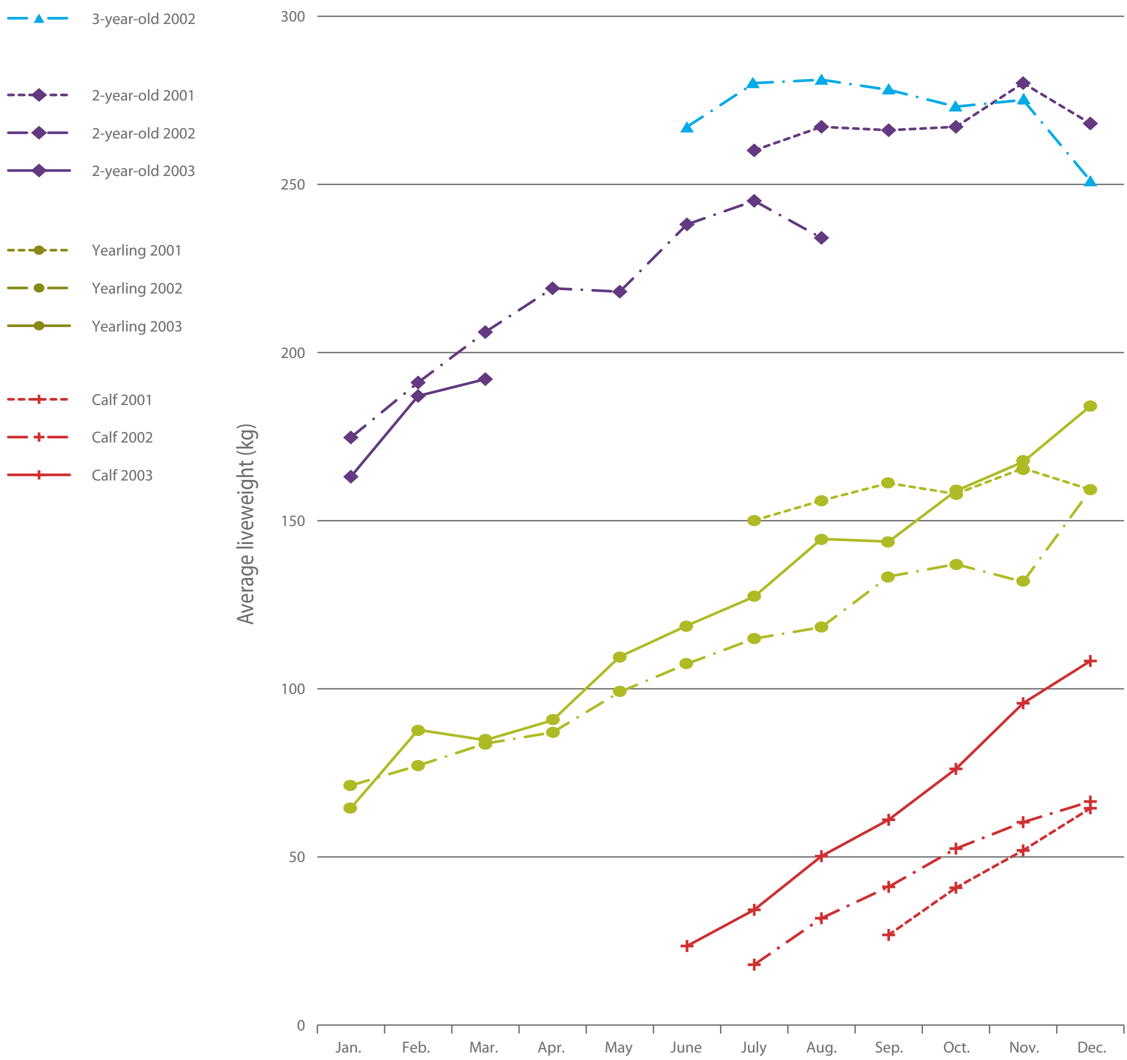


Figure 13. Monthly liveweight of various classes of male cattle in Kelebuh before and after the introduction of the new integrated management system

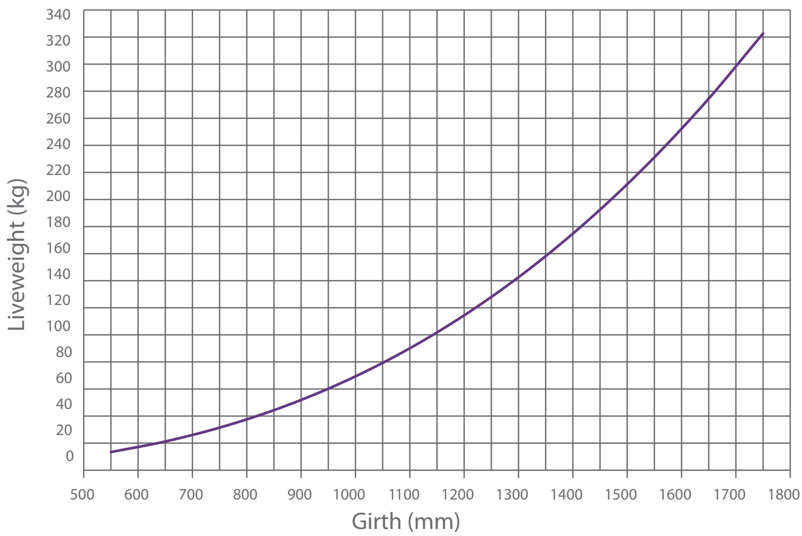


Figure 14. Relationship between liveweight and girth of Bali cattle in Kelebuh

Draught power

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

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

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

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

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

Feeding and supplementation of young Bali heifers

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

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

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

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

Feeding and supplementation of non-lactating Bali cows

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

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

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

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

The treatments in West Timor were:

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

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

The project team on a site visit in Indonesia

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

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

Outcomes and impacts

Integrated village management system

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

Outcomes of implementing the integrated management system

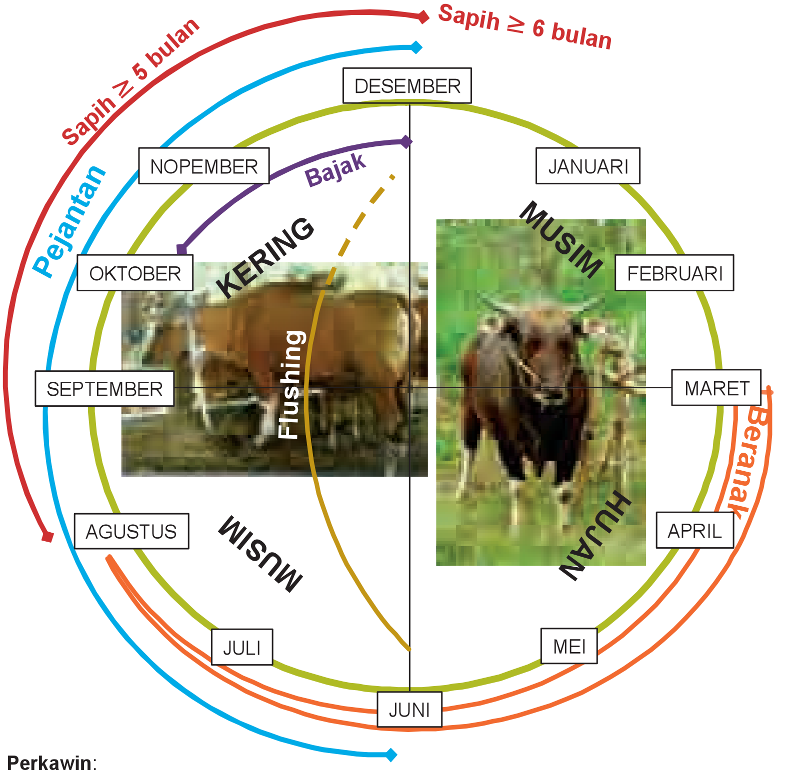
The village herd structure moved towards the earlier mating of heifers, an improved reproductive rate, concentrated calving and higher growth rates of calves, with a better cash flow and market opportunities. Outcomes of the new strategies were:

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

Other benefits include:

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

MANAJEMEN PEMBIAKAN SAPI DI KELEBUH
ACIAR PROJECT AS2 2000 103



Perkawin:
1. Kawin bulan Juli sampai Desember
2. Dara dikawinkan berat ± 180kg
3. Induk dikawinkan kembali 40 hari setelah melahirkan

Penyapihan:
1. Musim kering umur ≥ 5 bulan
2. Musim basah umur ≥ 6 bulan

Figure 15. The management system described to farmers in Kelebuh

Technical extension package

There were two major outputs:

- annual cattle activity calendars
- a technical extension package.

The calendars listed the management activities for Bali cattle (e.g. mating periods, weaning) and were displayed in each village. Separate calendars were developed for Lombok and Sumbawa based on interviews with the villagers about the timing of various events (e.g. wet and dry season) and activities (e.g. cropping, draught requirement, feed supply, religious or cultural observations, cash flow). For example, the best time biologically for cows to calve coincided with draught requirements, and it was not possible to use a cow in late gestation or early lactation for draught. This coincidence dictated the timing of mating and calving.

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

Feed and supplement evaluation

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

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

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

Capacity development

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

Villages: Project members held meetings, workshops and study tours throughout the project involving farmers and agency support staff. All people directly associated with this project, especially in Kelebuh and to a lesser extent at Village B, substantially improved their knowledge and skills in the implementation of the key management practices being used. Participating farmers are now able to better monitor their system and assess and modify management practices in response to changing conditions. Major developments for the Kelebuh villagers were the use of a calendar to record birth dates, mating dates and management activities as a means to manage and anticipate required husbandry, and the use of measuring tapes to estimate liveweight.

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

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

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

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

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

Learning from the project

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

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

Summary of project impacts

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

Despite the limited output-oriented aims, the project achieved substantial impact, particularly in Kelebuh village where the villagers have stated that new practices would persist even if all agency support was withdrawn. The project also had a substantial impact on surrounding villages through the use of some of the management practices, including selection of superior Bali bulls, controlled natural mating, weaning (but there was high resistance to weaning young calves), and better nutritional and disease management. Further, an independent survey by UNRAM staff indicated that news of the benefits achieved at Kelebuh village had reached more distant villagers (through family contacts), prompting the uptake of some of the management practices without any external incentives.

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

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

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

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

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

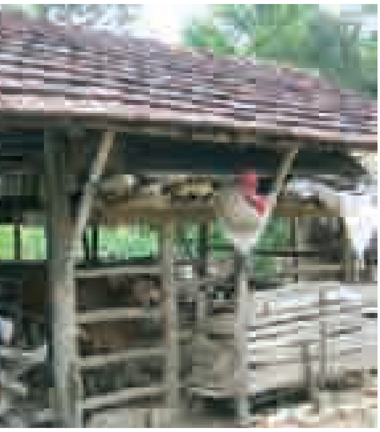
Impact of the technical extension package: The technical extension package (management system and weight prediction) was made into a poster and calendar and distributed to Dinas Peternakan extension officers across the region and to collaborating farmers. The poster has been widely used by BPTP as part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

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

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

Case study 3: Improved beef production in central Vietnam

Clare Leddin, Nguyen Xuan Ba, Nguyen Huu Van, Le Duc Ngoan and Peter Doyle



Cattle confined and fattened for market

Improved cattle production in the lowlands of Vietnam's central coast provinces (including Quang Ngai) is important for increasing and diversifying farm income. This ACIAR-funded project[10] aimed to build local research capacity and improve profitability of cattle production in central Vietnam without displacing food crops or other important activities. The focus was on overcoming the nutrition constraints of profitable cattle finishing.

The project developed feeding strategies using formulated concentrate and tested them on-station and on-farm. The work led to increased profitability per animal as a result of reduced concentrate costs, reduced time to finish animals and lower associated labour inputs.

Project rationale

Sustainable generation of income for smallholder farmers in the central provinces is a major development issue for Vietnam. Demand for beef is increasing, particularly in the major urban centres, as a result of both tourism and the increasing disposable income of the local population. Increasing cattle production is an opportunity to help alleviate poverty in central Vietnam.

Quang Ngai province is one of six provinces in the south–central coast region of Vietnam. One-quarter of the region's cattle population is found in this province, with the majority in lowland districts. In 2005, cattle numbers were estimated to be 244,000. The existing cattle marketing system works well from the perspective of sourcing animals for slaughter, meeting consumer demand and providing an equitable return for farmers. There is also a ready source of store cattle from the adjacent highland areas. Consequently, cattle fattening is considered highly appropriate in this and other central provinces.

The Quang Ngai Rural Development Program (RUDEP) was a planned 10-year development program jointly involving the Vietnamese and Australian governments in Quang Ngai province. A problem-solving census conducted by RUDEP in 2002 indicated that cattle rearing and finishing was the most desirable income-generating activity of households in this province, offering significant market potential and consequent social stability in both lowland and highland zones. A subsequent national workshop, 'Livestock income generation for the rural poor', hosted by Quang Ngai province and RUDEP in February 2003, confirmed this analysis.

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The primary constraints on further development were access to credit and limited farmer knowledge of cattle nutrition, production and health. The ACIAR-funded project described in this case study arose from the workshop and the analysis of household priorities conducted by RUDEP. It reflected ACIAR's desire to use and build on the knowledge and capacity previously developed.[11]

The new project was designed to build local research capacity and generate information to overcome the nutrition constraints on profitable finishing of cattle. It linked with RUDEP and the Quang Ngai Department of Agriculture and Rural Development (DARD) in building extension capacity; the larger development program also addressed the credit issue and animal health.

The Faculty of Animal Sciences of Hue University of Agriculture and Forestry (HUAF), established in 1967, trains undergraduate and postgraduate students, conducts research and applies technologies on-farm in central Vietnam. This faculty and others at HUAF supplied the expertise needed for the project. The project team viewed the linkages between HUAF and RUDEP as critical to the success of rural development in Quang Ngai, since team members could draw on the university's expertise in farming systems, socioeconomic issues and livestock.

Typical farming conditions and systems

Lowland and coastal zones comprise only 20% of the land area of Vietnam but support most of the population, food and livestock production. Improved cattle production in the lowlands of central coast provinces (including Quang Ngai) is important to increase and diversify farm income.

Quang Ngai province is in the monsoon tropics, between latitudes of 14°32′ and 15°25′ north. One-third of the land is lowland, and about 60% of this area is cultivated. Rainfall in the monsoon (October–December) is about 1,400 mm (60% of total rainfall). Average daily temperature is about 26 °C, with temperatures up to 34 °C in the hottest months (July–August), and down to 18 °C in the coldest month (January). Average humidity on the lowlands is more than 80%.

Rice is the major crop, with three crops grown in irrigated paddies and two in non-irrigated paddy fields. Flood damage to crops is common in the wet season. Cassava, sugarcane, corn, peanuts and sweet potato are other major crops. Pigs and poultry are the major livestock.

Cattle, the major ruminant in the lowlands, are concentrated in the more intensive cropping areas, particularly around irrigation systems and along river flats. They are fed native grasses (grazing or cut-and-carry systems) and

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residues from the major crops. Cattle numbers per household are generally one to three, although some farmers keep larger groups in extensive systems (mainly grazing native grasses). In fattening systems, the cattle are housed, and numbers vary between one and three. In these systems, supplements of rice bran, maize or cassava by-products are fed; some farmers cultivate small plots of sown grasses.

The systems of cattle management and production differ considerably between the lowland and highland zones. Farmers in the lowlands are market oriented. They fatten cattle to generate income, encouraged by the growth in demand for beef by local people and tourists. The largely unregulated cattle marketing system works well in sourcing young animals for fattening and sale for slaughter, and thus meeting consumer demand.

In the highlands, agriculture is a subsistence activity, particularly for ethnic minorities and for livestock production. Cattle and buffalo are kept for traditional purposes, including as an easily liquidated asset that provides some security against crop failure, for draught power, for social and customary purposes, to provide manure (important in maintaining soil fertility) and to provide gainful employment for the young and elderly.

Livestock densities are greatest in areas of intensive cropping and high density of people; consequently, livestock are concentrated in irrigation areas and along waterways. The interdependencies in these crop–livestock systems, including labour and land use and the allocation of scarce funds for inputs to either element of the system, mean that any interventions to increase cattle turn-off need to occur in a systems context.

As a result of resource availability and market orientation of farmers, technologies for cattle finishing are more likely to be implemented in lowland farming systems in the immediate future than in highland areas, where there are significant sociological and educational constraints.

Perceived and real problems

Although economic analysis of cattle-fattening options in Quang Ngai indicates attractive returns on labour, input costs require careful management to ensure profitability. Barriers to efficient finishing of cattle include limited farmer knowledge of cattle nutrition, production and health; the seasonal supply and general low quality of available forages; and the limited availability, inefficient use and high cost of supplements.

Access to knowledge by farmers and the service providers, and the competency of veterinary and extension staff at both provincial and district levels are also constraints on increased livestock production; RUDEP is providing training to alleviate this in Quang Ngai.

Project options

Initial discussions in Quang Ngai investigated the possibility of implementing high-molasses feeding systems at a rural household level. The earlier project[12] demonstrated high rates of liveweight gain using molasses-based diets under experimental conditions. However, this approach was precluded by unreliability of supply, high price, and logistics of distribution of molasses from the Quang Ngai City factory.

This earlier project also examined the introduction of sown fodder species to improve livestock production in central Vietnam. At the time of developing the project described in this case study, adoption of these technologies had been poor (although this increased in some communes during the project).

Project objectives

The major project objective was to improve the profitability of finishing cattle by developing year-round feeding strategies using on-farm and off-farm feed resources. This included generating information to overcome nutrition constraints, with a focus on efficient use of forages and energy supplements most commonly available at a household level, and judicious use of purchased supplements.

Knowledge and skills gaps

The project team needed to address fundamental knowledge gaps before any farmer-oriented work could proceed. This involved:

- establishing an inventory of available feeds and their nutritive characteristics as the basis for developing tactical or year-round feeding options
- developing optimal and acceptable combinations of feeds for fattening
- understanding the interactions between feeds, such as the effect of substituting supplements for the basal forage and effects of supplements on forage digestion (substitution refers to the reduction in pasture or forage intake that occurs for each quantity of supplement consumed).

The Faculty of Animal Sciences, HUAF (eight departments and 45 staff) has research expertise in livestock systems—particularly monogastric production systems—in smallholder farms in various agroecological zones in central Vietnam. Before this project, experience and skills in ruminant nutrition and digestion research within the faculty were limited. Infrastructure for feeding experiments with ruminants was lacking, and laboratory facilities were rudimentary.

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A farmer takes care of her fattening animal.

Consequently, a serious effort was made to provide in-country and Australian-based training, and individual mentoring and reinforcement, and to fund infrastructure and equipment.

The project drew on expertise from other faculties in HUAF for socioeconomic research to evaluate the social and economic consequences of interventions in feeding systems on farms, and to analyse the effectiveness of the interface between the farmer and the extension service providers. These skills and analyses are integral in field-testing appropriate feeding strategies with DARD and RUDEP staff.

Project operations

The approach to project delivery was a combination of on-station research and on-farm fieldwork (surveys and trials) in Vietnam and on-station research in Australia. This case study considers activities only in Vietnam.

The project involved five main activities:

Activity 1: Establish a project coordinating committee

As the first step, the project team established a project coordinating committee (PCC), with agreed terms of reference and roles. This group met every 6 months to monitor progress, ensure alignment of project activities with the needs of RUDEP and DARD, agree on the plans for activities and contribute to reports for ACIAR.

Activity 2: Develop an inventory of feeds available in the lowland areas of Quang Ngai, both on-farm and off-farm, including nutritive characteristics of the feeds, and design year-round feed options

The team developed inventories of available feeds in communes in the lowland and highland zones of Quang Ngai, based on information on feed availability from provincial statistics, RUDEP and other relevant sources. In addition, members surveyed 60 households in each of four communes (two in lowland districts and two in highland districts). Four HUAF and six DARD staff conducted the surveys as a joint activity; RUDEP provided input on survey design and interpretation. Information collected on seasonal cropping and feeding practices was used with statistical information on crop production to estimate the seasonal availability of feed resources.

Team members also interviewed factory staff and stakeholders to estimate the by-products generated by the sugar, cassava-processing and milk factories, the current use of these resources and constraints on their use in local cattle production in Quang Ngai.

Feed samples were collected as the inventory was compiled, with samples analysed at HUAF or an accredited national government laboratory. The information acquired on the nutritive characteristics of forages and supplements in Vietnam was compiled into spreadsheets, which were used to create a database. Nutritive characteristics recorded in the database included concentrations of organic matter, crude protein and neutral detergent fibre (NDF); in-vitro digestibility; and estimated metabolisable energy content. The database covers four categories of feed: forages, tree forages, on-farm supplements and off-farm supplements.

Senior HUAF staff members Le Duc Ngoan, Nguyen Xuan Ba and Nguyen Huu Van developed an extension booklet with support from World Vision, 'Feed resources for ruminants in households in central Vietnam' for use in Quang Ngai.

A package of tactical feeding options to finish cattle kept in confinement systems was developed using desktop analysis, based on information on the availability and nutritive characteristics of feeds and animal requirements. This assumed a basal diet of grass fed during the day and straw fed at night, which could be supplemented with cassava powder, maize and rice bran. The applicability of the modelling approach to examining feeding options developed in Case study 5 was also examined.

Activity 3: Conduct on-station experiments to optimise use of feed resources for productivity and profitability

Three pen-feeding experiments with cattle were conducted in Hue to define responses in liveweight (LW) gain for each additional increment of supplement fed.

The hypothesis of the first pen-feeding experiment (experiment 1) was that supplementation with cassava powder (and urea) up to 2% of liveweight (LW)/day would linearly increase digestible organic matter intake and LW gain of Laisind cattle. The experiment involved 20 Laisind bulls assigned to the following treatments: a basal diet of elephant grass (*Pennisetum purpureum*) fed at 1.25% LW (dry matter [DM] basis) during the day and rice straw fed ad libitum at night, or this diet supplemented with cassava powder, containing 2% urea, trialled at about 0.3%, 0.7%, 1.3% or 2.0% LW (DM basis). The five diets were fed for 88 days.

The hypothesis tested in experiments 2 and 3 was that supplementation with a formulated concentrate of rice bran (45% fresh basis), maize (49%), fishmeal (3%), urea (2%) and salt (1%) up to 2% of LW/day would linearly increase digestible organic matter intake and LW gain of Vietnamese yellow cattle.

In experiment 2, 20 young, male cattle were trialled on treatments for 44 days. In experiment 3, 15 cattle were used, and treatments were imposed for 49 days. The basal diet was fresh grass (elephant grass for experiment 2, native grass for experiment 3) at 1.25% of LW (DM basis) fed during the day and rice straw fed ad libitum at night. Other treatments were the basal diet plus concentrate at about 0.3%, 0.7%, 1.3% or 2.0% of LW (DM basis).

In all experiments, feed intake was recorded daily, LW was measured weekly, whole tract digestibility measurements (organic matter and neutral detergent fibre) were made over 7-day periods, and substitution of supplement for forage was calculated.

Activity 4: In collaboration with RUDEP, conduct on-farm trials to evaluate the production and productivity responses, economics and social implications of feeding strategies

The information generated in activities 2 and 3, together with RUDEP and DARD experiences in livestock demonstrations, were used to design an on-farm study.

The first phase of the study was a survey of cattle production systems in Hanh Phuoc, a lowland commune. Sources of advice to farmers were documented, and the interface between farmers and service providers was examined in a series of group discussions with the participating farmers and extension workers. The farmer–extension interface was further assessed by an institutional analysis, using a group meeting of representatives of the commune peoples' committee, village leaders, farmers' union, women's union and cattle producers. The team assessed the perceived value of the advice received from different sources.

The second phase was a study initially involving 20 households, increasing to 31 after the second evaluation meeting. The study began with seminars and training workshops with the farmers, village heads, and provincial and district extension staff. Its purpose was to compare the results of using different amounts of a formulated concentrate (similar to that used in the experiments in Hue), fed 2–3 times daily, with the traditional practice of once-daily feeding, and to examine changes in farmer–service provider relationships.

During participatory planning, the farmers insisted on using their own cassava powder, rice bran and maize, while the project supported the purchase of fishmeal, urea and salt. The concentrate supplement used was modified, based on suggestions by the farmers and extension workers, to comprise cassava powder (34%), rice bran (30%), maize (30%), fishmeal (3%), urea (2%) and salt (1%). Cassava powder was included as it was readily available and cheaper than maize and rice bran.

The farmers decided on the amount of concentrate to be fed; it varied from 0.5 kg/animal/day to 3.0 kg/animal/day, depending on a household's resources. When the study began, 15 households (27 beef cattle) were feeding this concentrate, and 5 other households (9 beef cattle) were feeding their usual concentrate as the control. Forages—mainly elephant grass and native grasses during the day and rice straw at night—were provided according to each farmer's practice.

Information was collected on purchase and sale prices of cattle and feeds used by each farmer, and animals were weighed every 2 weeks. Evaluation meetings were held with the participants after 2 weeks, 2 months and 4 months. The project members recorded farmers' perceptions of animal responses, issues with application of the technique, and whether the farmers would adopt the new feeding approach and continue to use it. The effectiveness of the farmer–research–extension interface was assessed through independent surveys and group discussions with 22 farmers and four commune and village staff members.

Activity 5: Develop the knowledge and technical skills of scientists and extension staff in Vietnam and Australia

Capacity development

The project set out to increase the knowledge and skills of scientists and support staff by:

- exposing them to the science processes used in Australia and Vietnam
- training them in experimental methods
- involving them in systems thinking
- developing a broader range of communication skills, in part by working across cultural groups and across the research, development and extension spectrum
- developing proposals and programs on cattle and rural development.

Capacity building in Vietnam targeted the base research skills (capability) of next-generation scientists. When the project began, only five staff members of the Faculty of Animal Sciences had some expertise in ruminant nutrition, and it was important to develop the skills of these staff. A team activity involving the project leaders in Vietnam and Australia and scientific team members helped to nurture skills in scientific processes, experimental or activity protocols, and peer review of publications.

Training underway

Specific capacity-development activities undertaken by HUAF staff and students included:

- training for Dr Nguyen Xuan Ba and Mr Nguyen Van Phong in experimental techniques (in Australia)
- study tours in Australia by Dr Ba and Professor Le Duc Ngoan, including visits and discussions at the Department of Primary Industries (DPI) Victoria, the University of Queensland, DPI Queensland, and CSIRO Rockhampton
- training in scientific writing in English for Dr Ba and Dr Le Van Phuoc, in Vietnam
- training in participatory approaches to agricultural research and extension in the Philippines for Dr Nguyen Huu Van
- training in laboratory techniques at the National Institute of Animal Husbandry (NIAH), Vietnam, for five technicians
- participation of Dr Ba, Dr Van and Ms Du Thanh Hang in an international conference in Thailand, 'Integrating livestock-crop systems to meet the challenges of globalisation'
- awarding of an ACIAR John Dillon Fellowship to Dr Ba, to hone his leadership and management skills
- postgraduate training of Nguyen Xuan Ba (PhD) and Mr Nguyen Huu Minh, Mr Bui Van Loi, Mr Dinh Van Dung and Ms Huynh Thi Anh Phuong (Masters degrees)
- training of undergraduate students at HUAF—13 students completed projects as part of their course requirements on the project.

These activities were complemented by on-the-job knowledge and skill development.

The research capacity of HUAF was increased through infrastructure development, principally a cattle facility (200 m^2) with capacity for 20 animals and a sample preparation area. In addition, the project provided experimental equipment, including forage-chopping machines, drying ovens, a sample storage freezer, cattle scales and feed weighing scales. Prof Ngoan successfully obtained funding from the Vietnamese Government for the construction and fit-out of laboratory facilities.

Capacity development was also an important aspect of the activities undertaken in Australia. Project facilitator Ms Clare Leddin undertook a Masters of Agriculture (Research) Degree at the University of Melbourne and developed her leadership skills; five University of Melbourne undergraduate students completed work placements to increase their knowledge and research skills in ruminant nutrition to fulfil course requirements; and expanded research networks enabled interactions with scientists in other ACIAR-funded projects.

Project relationships and communication

Developing project relationships

Development of project relationships began in February 2003 at the workshop in Quang Ngai, with participants from RUDEP, DARD, HUAF and NIAH; the ACIAR Program Manager; and Dr Peter Doyle, DPI, Victoria. This initial contact established the strategic relationships between the project agencies (HUAF and DPI) and key stakeholders and collaborators (RUDEP, DARD and NIAH.) Members of these agencies ultimately formed the PCC, whose 6-monthly meetings were essential for building and cementing these higher level relationships. Participants were always frank, open and constructive during meetings, and the associated field visits enabled sharing of perspectives and issues.

Members of the project coordinating committee inspect the new large ruminant facilities at the research farm of Hue University of Agriculture and Forestry.

At the research team level, where most of the communication occurs, reciprocal visits to Australia and Vietnam by project facilitators Dr Nguyen Xuan Ba and Ms Clare Leddin were critical in establishing excellent working relationships. Ms Leddin visited Vietnam within the first month of her employment, and Dr Ba visited Australia in the early stages of the project. These activities helped to build team relationships and to develop a shared understanding of project objectives. The hands-on involvement of senior DPI staff in experiments in Australia and Vietnam set an example of the teamwork, effort and rigour required to conduct complex experiments on digestibility and metabolism.

The Australian Consul based in Ho Chi Minh City visited the project site in Huang Phuoc, Vietnam.

Planning and communication

Project communication and evaluation plans were developed in facilitated sessions with the PCC and were broadly followed throughout the project.

In planning project activities, the team developed and documented protocols for all work. This process was based on an existing preschedule process used in DPI, which was modified in discussion sessions with inputs from Prof Ngoan, Dr Ba, Ms Leddin and Dr Doyle. The process was reviewed mid term, and all protocols were circulated and presented to the PCC and peers within HUAF and DPI.

This process worked well, particularly in accommodating inevitable revisions in experimental timetables or methodology. The protocols proved particularly useful in preparing scientific publications.

The team also established a process for peer review of reports and publications arising from the project. This became more valuable as team members in HUAF became more confident in written English.

For the research team, the face-to-face discussions that occurred during visits were invaluable for completion of activities, publication and reporting. Email communication at other times was useful, but prone to technical deficiencies. This was overcome to some extent by phone hook-ups, where verbal interaction sometimes resolved issues more efficiently. As technology develops and becomes more reliable and accessible, video conferencing and other similar options are worth considering.

Plans for adoption of project findings

The PCC provided a conduit for project information to flow from RUDEP and DARD to farmers in Quang Ngai province, and for information to flow back to the research team. Project personnel from HUAF trained service providers in the province (funded by RUDEP) and assessed them. The linkage was intended to ensure that information generated in the research would be used in livestock development activities undertaken by DARD and RUDEP after the project.

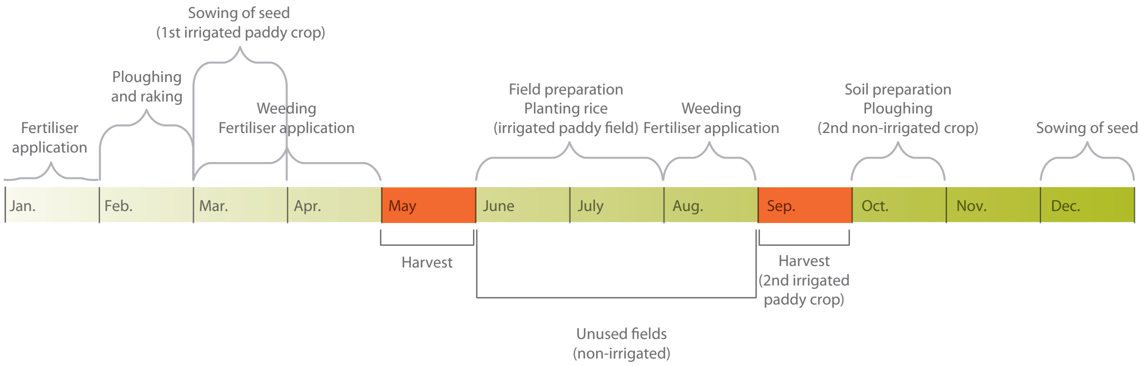
Dr Vu Chi Cuong and Dr Dinh Van Tuyen of NIAH were members of the PCC. They ensured that unpublished information from the previous ACIAR-funded project was available and facilitated the flow of research findings between scientists in Vietnam.

HUAF personnel deliver in-service training of DARD staff in the central provinces, and this provides an avenue to extend research findings beyond Quang Ngai. During the project, team members also became involved in another ACIAR project, which provided a further extension opportunity (described in Case study 4).

Selected results

Activity 2: Develop an inventory of feeds available in the lowland areas of Quang Ngai both on-farm and off-farm, including nutritive characteristics of the feeds, and design year-round feed options

Information on availability of feeds was used in conjunction with cropping calendars (see Figure 16) developed by RUDEP to compile calendars of seasonal availability specific to lowland and highland communes. Table 3 shows how the survey and statistical information were used to develop feeding calendars, based on the availability of the principal feeds (rather than on what was actually fed).



Notes:
Two crops of rice are cultivated in irrigated paddy fields; only one crop of rice is cultivated in non-irrigated paddy fields.
Rice cultivation in Nghia Tho is heavily influenced by limited water availability during the dry season and high floodwater levels during the wet season.
A clear differentiation between irrigated and non-irrigated paddy production was evident; irrigated paddy crops can be cultivated during the dry season (June–September), while non-irrigated paddy crops are cultivated in the wet season (October–January) when the risk of flood damage to crops is high.

Figure 16. Example of a seasonal rice cropping chart for Nghia Tho commune

Table 3. Feed calendar for ruminants in Nghia Tho commune, Vietnam, based on feed availability

Feed	Month											
	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Native grass	++	+++	+++	+++	++	+	+	+	++	++	++	++
Sugarcane tops	+	+	+	+	+	na	na	na	na	na	na	+
Maize stover			+	+	–	na	na	+	+	na	na	
Rice straw	+	+	na	na	na	na	na	na	+	+	+	+
Cultivated cut-and-carry grass	–	–	na	na	na	na	na	na	na	–	–	–

+++ = very available; ++ = average availability; + = some available; – = very small amount available; na = not available

The nutritive characteristics of available feeds varied significantly (see Table 4). There was only limited information on the in-vitro digestibility of feeds, and consequently limited estimates of the metabolisable energy (ME) content of feeds.

Table 4. Crude protein and neutral detergent fibre concentrations of crop residues in Vietnam

Feed	Crude protein (% DM)				Neutral detergent fibre (% DM)			
	No.	Mean	SD	Range	No.	Mean	SD	Range
Rice straw	22	5.7	0.90	4.5–7.6	6	70.1	3.83	62.9–73.2
Maize stover	17	7.9	2.24	1.6–13	12	66.2	4.79	58.8–71.9
Sugarcane tops	11	5.3	2.54	2.5–9.3	5	65.3	12.0	47.4–76.5
Cassava leaves	5	26.5	3.71	20.5–30.4	–	–	–	–
Groundnut vine	8	16.1	3.51	8.5–19.3	–	–	–	–

DM = dry matter, No. = number of samples, SD = standard deviation; – = not determined

The project team developed a range of feeding strategies, some of which were tested in activity 3.

Activity 3: Conduct on-station experiments to optimise use of feed resources for productivity and profitability

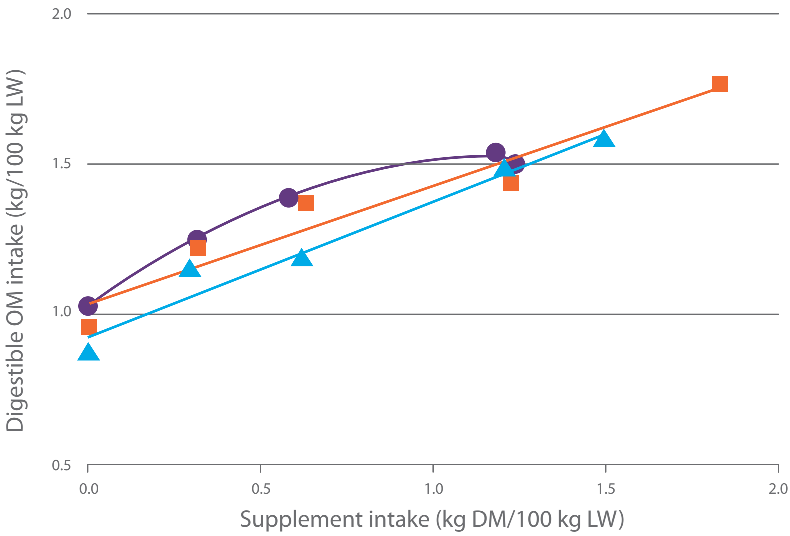
The basal diet used for finishing cattle in central Vietnam is generally rice straw supplemented with green forage from grazed native grass or, in an increasing number of cases, sown grass. Restricted feeding of grass (which has limited availability) with rice straw increased the ME intake of cattle and supported growth rates of more than 0.1 kg/day. This type of diet is appropriate for maintenance of breeding cattle, but supplementation with ME and protein is needed for reasonable growth rates of immature animals and/or finishing systems.

In experiment 1, the cattle fed cassava powder at about 2.0% LW did not consume the entire supplement; their actual intake (2.21 kg DM/day) was similar to that for the 1.3% LW treatment (2.16 kg DM/day). This may have been due to a number of factors, such as palatability, subclinical effects of hydrogen cyanide in cassava, or the effects of the cassava powder on rumen pH and NDF digestibility. There were no problems with intake of the formulated concentrate in experiments 2 and 3.

Increasing intake of cassava powder was associated with curvilinear increases in intake of digestible organic matter (Figure 17). The substitution rate of cassava powder for forage was high (a reduction of 0.5–0.7 kg in forage DM intake per kg of DM supplement consumed) (Figure 18) and was not significantly affected by the amount of the supplement consumed. Most of the substitution was associated with reductions in straw intake; grass intake was only marginally affected.

Interactions between the digestion of concentrates and forages in the rumen may reduce the rate of NDF digestion. While the substitution rate may be influenced partly by negative associative effects, other factors, such as the animal's preference for feeds, are also likely to affect substitution rate when cassava powder is fed.

In experiments 2 and 3, increasing intake of formulated concentrate linearly increased the intake of digestible organic matter (Figure 17), and linearly decreased the intake of rice straw. The intakes of elephant grass or native grass were not significantly affected by concentrate intake.

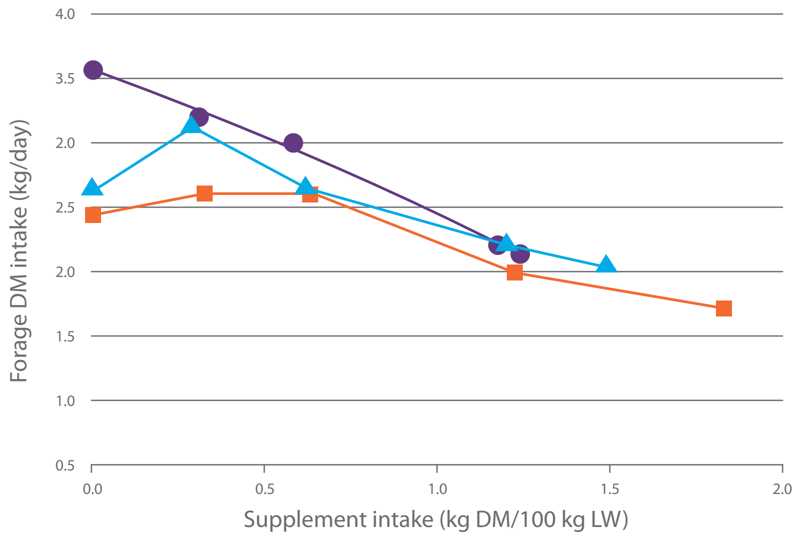


DM = dry matter; kg = kilogram; LW = liveweight; OM = organic matter

Figure 17. Digestible organic matter intake as affected by concentrate intake in Laisind bulls supplemented with cassava powder and urea (experiment 1, ●) or male yellow cattle supplemented with a concentrate comprised of rice bran, maize, fishmeal and urea (experiment 2, ■ and experiment 3, ▲)

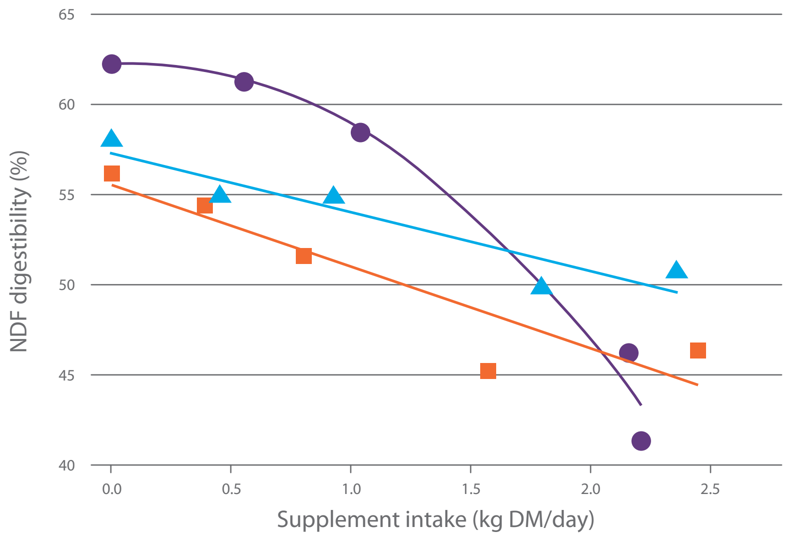
At the lowest intake of the formulated concentrate, forage intake increased (Figure 18). At the next level of supplementation, substitution was less than 0.1 kg reduction in forage DM intake per kilogram of DM supplement consumed. Substitution increased to 0.3–0.5 kg at the highest supplement intake. The increase in forage intake at the lowest level of supplement was probably due to supply of nutrients that were limiting digestion in the rumen or tissue metabolism.

The depression in NDF digestibility by cassava powder (from 62% to 41%; Figure 19) was significantly greater than when the formulated concentrate was fed (depressions from 56% to 46% in experiment 2, and from 58% to 51% in experiment 3). These reductions in NDF digestibility occurred even though straw intake and the intake of less readily digestible NDF declined. As a result, estimated ME contents of forage overestimate the amount of ME actually derived by the animal.



DM = dry matter; kg = kilogram; LW = liveweight

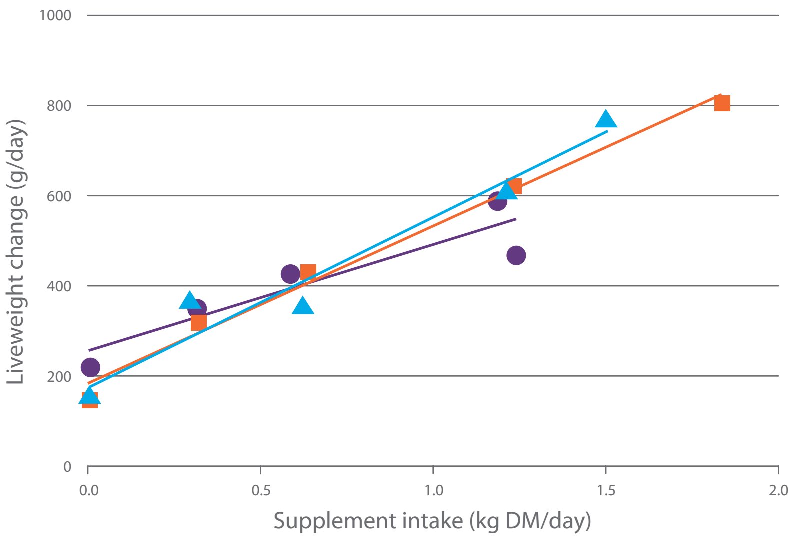
Figure 18. Forage intake as affected by concentrate intake in Laisind bulls supplemented with cassava powder and urea (experiment 1, ●) or male yellow cattle supplemented with a concentrate comprised of rice bran, maize, fishmeal and urea (experiment 2, ■ and experiment 3, ▲)



DM = dry matter; kg = kilogram; NDF = neutral detergent fibre

Figure 19. Neutral detergent fibre digestibility as affected by concentrate intake in Laisind bulls supplemented with cassava powder and urea (experiment 1, ●) or male yellow cattle supplemented with a concentrate comprised of rice bran, maize, fishmeal and urea (experiment 2, ■ and experiment 3, ▲)

LW gain increased linearly with the amount of supplement consumed in the three experiments (Figure 20), but the rate of increase was greater in experiments 2 and 3. In these experiments, the results supported the hypothesis—that is, that digestible organic matter intake and LW gain would increase linearly as the amount of a formulated concentrate based on rice bran and maize increased up to 2% LW.



DM = dry matter; g = gram; kg = kilogram; LW = liveweight

Figure 20. Liveweight gain in relation to concentrate intake in Laisind bulls supplemented with cassava powder and urea (experiment 1, ●) or male yellow cattle supplemented with a concentrate comprised of rice bran, maize, fishmeal and urea (experiment 2, ■ and experiment 3, ▲)

An economic analysis, including sensitivity to cost variations, compared data from use of the formulated concentrate with the current feeding system (a basal diet of forage with little concentrate) (Table 5). Increased profit reflected the reduced time to finish cattle and the greater proportion of the nutrients consumed that were used for LW gain (i.e. lower maintenance energy requirements). Profit was sensitive to labour costs (use of primary versus secondary labour) and whether the farmer needed to purchase concentrate. The cost of the concentrate could potentially be reduced by some substitution of cassava powder for maize and/or rice bran.

Table 5. Analysis of the profitability of feeding formulated concentrate at 2% liveweight per day compared with the current feeding practice, based on finishing one bull (growth from 120 to 170 kg liveweight); values are VND × 10^6 (US$ = VDN18,000)

System	Current	Formulated concentrate	
Labour source	Secondary	Secondary	Primary
Cattle purchase	2.40	2.40	2.40
Labour	0.56	0.10	0.26
Feed	0.53	0.52	0.52
Cattle sale	3.00	3.00	3.00
Profit	–0.09	0.37	0.22

VND = Vietnamese dong

Activity 4: In collaboration with RUDEP, conduct on-farm trials to evaluate the production and productivity responses, economics and social implications of feeding strategies

The cattle production systems in Hanh Phuoc commune focused more on finishing than on breeding cattle. More than 60% of the cattle were Laisind. Most farmers used confinement systems, with cut-and-carry sown or native grass and rice straw comprising the basal diet. Cattle received supplementary feeding with cassava powder, maize or rice bran—usually 1 kg or less per animal irrespective of age, LW and condition. These supplements were seldom mixed and usually fed once daily. The farmers had high market awareness.

Eleven new households joined the field study at the second evaluation meeting, increasing the number of participating households to 31. As farmers were sourcing and selling cattle throughout the study period, the times varied for the application of feeding options on farms. This was the case with feeding practices for animals in households using the formulated concentrate (Table 6) and also for the control group. It reflects differences in resources available to different households.

Evaluation of the farmer–extension interface revealed a complex array of interactions typical of the agricultural extension system in Vietnam. Provincial, district and commune extension workers ('paravets'), as well as 'middle men' from inside or outside the commune, provide technical and market advice to farmers. Middle men sell and purchase stock, trade in feeds and supply veterinary medicines. Most technical and market information on cattle production came from the middle men and commune extension workers; technical information from the provincial and district extension staff reached only some cattle producers.

RUDEP supports agricultural extension services through technical training, and monitoring and evaluation of provincial and district extension activities. Other agencies, such as the Farmers' Union, Women's Union, Bank for Agriculture and Rural Development, and Bank for the Poor also provide agricultural services (but not technical advice). The banks and RUDEP are particularly important as they provide credit.

Members of the Hanh Phuoc commune and some service providers at an evaluation meeting

Compared with the 'control' group, the average costs of concentrate per kilogram of LW gain (Table 6) were lower using formulated concentrate (comprising 34% cassava powder, 30% rice bran, 30% maize, 3% fishmeal, 2% urea and 1% salt fed at 0.5–3.0 kg/animal/day, depending on a household's resources, and 2–3 times/day). Most of the farmers in the control group did not mix the concentrates they used (e.g. a farmer might feed cassava powder one day and rice bran the next. No farmers in this group used protein or non-protein nitrogen supplements, and they generally fed the supplement once per day. For a LW gain of 100 kg, the difference in costs of concentrates would be about VND140,000. The increased rate of LW gain would also reduce the time and labour required to finish a group of animals and open the opportunity to finish more cattle.

The amount of concentrate fed influenced these benefits in LW gain (see Figure 21). However, results were variable because of differences in amounts and nutritive characteristics of forages fed, in starting LW and condition of the cattle, in animal health, and in housing and management. All cattle on the control group of farms had LW gains below the line of best fit.

Table 6. Feeds used, cattle performance and preliminary economic analysis in the on-farm study in Hanh Phuoc commune, Vietnam

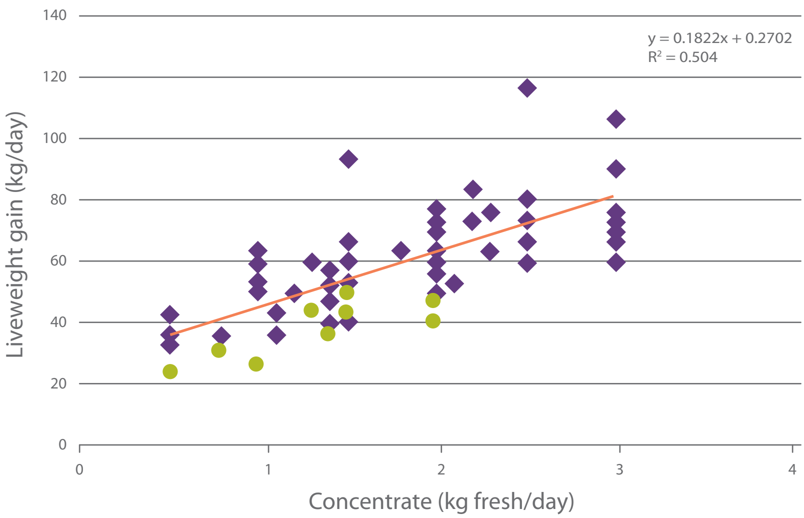
	Test group (n = 57 animals)	Control group (n = 10 animals)
Green grass (kg DM/day)	2.6 (2.0–3.0)	2.6 (2.0–3.0)
Rice straw (kg DM/day)	2.3 (1.8–2.7)	2.3 (1.8–2.7)
Concentrates (kg fresh/day)	1.8 (0.5–3.0)	1.5 (0.5–2.5)
Concentrate cost (VND × 10^3/day)[a]	5.3 (1.5–9.0)	4.0 (1.4–7.0)
Average LW change (kg/month)	18 (10–35)	12 (8–18)
Concentrate cost/kg LW gain (1,000VND)	8.5 (3.5–15.0)	9.9 (6.0–14.0)

DM = dry matter; kg = kilogram; LW = liveweight; VND = Vietnamese dong

[a] Concentrate cost was VND3,000/kg for the formulated concentrate and (on average) VND2,800 for the control group concentrate.

At the final evaluation meeting, farmers reported that the formulated concentrate improved LW gains, the technology was easy to implement and they would continue using the formulated concentrate. However, a small number indicated they would only continue full adoption if the protein and urea were subsidised.

The socioeconomic research conducted by Ms Huynh Thi Anh Phuong found that human and other resources available within a household are important in determining whether the household will adopt the formulated concentrate technology and its profitability. In particular, opportunities for primary labour (for people aged 17–60 years) to obtain off-farm employment and the availability of secondary labour would be major determinants of the number of cattle a household would finish each year, and the times of year they would do this.



kg = kilogram

Figure 21. Relationship between amount of concentrate fed and daily liveweight gain (● are control animals)

At the end of the study, the research team gathered farmer perceptions about the research–extension–farmer interface. Researchers from HUAF had the strongest influence on the cattle producers—through the initial training, frequent discussions with farmers, and the monitoring and evaluation sessions. They were seen as the coordinators who involved provincial and district staff, the 'middle men' and the Commune Peoples' Committee in the activity. However, the relative importance of those providing technical advice was unchanged.

Applications, outcomes and impacts

The project activities provided knowledge on feed availability, current feeding strategies and cattle growth in response to locally available supplements. This knowledge has been used in the following applications:

- the extension booklet, 'Feed resources for ruminants in households in central Vietnam', a training resource for Quang Ngai and in-service training in other central provinces

- a teaching text for undergraduate and in-service training courses (Vu et al. 2008)
- a manual for use by extension staff in highland areas (Nguyen et al. 2007)
- supplementary feeding response data as a basis for predicting LW gain under recommended feeding options and for estimating likely profitability of feeding different amounts of supplement.

Important outcomes include improved capacity of HUAF staff; improved linkages between HUAF staff, RUDEP and provincial and district extension staff; and effective on-farm testing and demonstration of feeding strategies in Quang Ngai.

A number of lessons were learned during activity 4:

- Involvement of farmers, and provincial and district extension staff in the design of the study and formulation of the concentrate was critical to their commitment.
- Participatory involvement of key stakeholders (commune and village leaders) was critical in transferring knowledge and technology to the farmers.
- The researcher was important in assisting farmers, extension workers, commune and village leaders, and 'middle men' in understanding the technology and subsequent adoption.
- Involvement of the provincial and district extension staff was important in ensuring the sustainability of transferring the technology and extending it to other hamlets.
- An understanding of the socioeconomic situation of a household and its resources was critical in determining whether a technology would be adopted and profitable.
- Strategic and tactical feeding options vary between households.

Participant benefits and learning

The following testimonials from three of the scientists exemplify the benefits obtained by the people involved in this project.

Dr Nguyen Xuan Ba—Project Team Leader, HUAF

This project has provided me with the opportunity to develop my research skills and to improve my knowledge of ruminant nutrition. I have learned a lot from Australian experts on scientific processes and have seen the benefits of documenting protocols before commencing experiments and updating them as the work progresses. This has enabled us to ensure the integrity of experiments and has provided efficiencies in reporting and publication. The results of module 2 formed part of my PhD thesis.

During visits to DPI Kyabram Research Centre, CSIRO and DPI Queensland, I gained experience in the use of experimental techniques, such as nylon bag and in-vivo digestibility measurements, and learned how to design our cattle facility. The skills acquired were applied in experiments conducted in Hue.

Attending the conference in Thailand and the course on writing scientific papers gave me the opportunity to improve my English communication skills and to meet scientists working in various aspects of crop–livestock production overseas.

Conducting the five experiments in the new facilities at HUAF provided learning opportunities for 13 undergraduate and three Masters degree students. The infrastructure developed in HUAF will provide opportunities for my colleagues to conduct other experiments.

Dr Nguyen Huu Van—Project Scientist, HUAF

Joining the project team was a great opportunity for me to apply some of the research skills that I learned during my postgraduate studies in Japan, and, importantly, to run experiments under our local conditions. We have faced many challenges in conducting the experiments in Hue, and this provided me with experience that has made me more confident in the conduct and monitoring of digestibility experiments.

Moreover, working with Australian scientists has helped me improve my knowledge of animal science and skills in English communication. In addition, the project gave me a chance to participate in the international conference 'Integrating livestock–crop systems to meet the challenges of globalisation' in Thailand and broaden my knowledge on these systems.

Ms Clare Leddin—Project Scientist, DPI

This project has provided me with the opportunity to develop my research skills and has broadened my knowledge of tropical farming systems.

The preschedule process to document and peer review experimental design and methodology (adopted by the project in its early stages) was more rigorous than any I have been exposed to previously. I have learned that applying this process effectively makes analysing and writing up research results much easier later on.

The experiments I ran in Kyabram as part of the project were the most intensive I have been involved with. In the second experiment, I attempted to build on the technical and management skills I gained in the first experiment, and that I hope to continue to develop throughout the life of this project and beyond. The research I have been involved with in the project will form the basis of my Masters thesis.

Attending the conference in Thailand allowed me to increase my knowledge of agricultural systems and research being conducted, particularly in Asia. It also provided the opportunity to meet scientists working on various aspects of crop and livestock production overseas. Other travel through Vietnam, discussions with RUDEP and project team members and ongoing review of the literature have increased my knowledge of smallholder farming systems and the challenges of disseminating research results and their adoption by these farmers. I have also learned about the benefits and challenges associated with working in a team so geographically spread.

Case study 4: Building capacity for cattle production in Dong Giang district, Quang Nam province, Vietnam

Nguyen Xuan Ba, Le Ngoc Tung, Le Duc Ngoan and Peter Doyle

Training in grass cultivation and feeding through the presentation of information, Dong Giang district, Vietnam

World Vision Vietnam implemented an Area Development Program in Dong Giang district in 1998, with activities in health and nutrition, water sanitation, education and training, food security and livelihood. Participatory planning indicated that the population of Co Tu and Kinh ethnic groups preferred to generate income from livestock. In 2004, the Area Development Program Board formed a project management committee for cattle production and implemented a project in which households can access credit to purchase livestock as a means of generating income.

ACIAR has supported this cattle production activity by supplying funds for Hue University of Agriculture and Forestry staff training in project management and cattle husbandry[13] and training on technical aspects of cattle husbandry.[14]

Project rationale

Dong Giang is a mountainous district in Quang Nam province. The capital P'Rao and most of the district's 10 administrative commune centres are located along district road 604 and the Ho Chi Minh trail (see Figure 22). The population consists of Co Tu and Kinh ethnic groups. Subsistence agriculture predominates, and the ethnic groups have maintained traditional cultural practices and trade by barter, with most people yet to move into the market economy.

The Dong Giang district plan for agriculture and rural development forecasts that income from cattle production will rise to 30% of total agricultural gross domestic product. Recent improvements in transport infrastructure have greatly improved access to markets in P'Rao town and to the larger markets in Da Nang City. Consequently, households now have a real opportunity to generate income from cattle production.

World Vision (WV) Vietnam implemented an Area Development Program (ADP) in Dong Giang in 1998, with activities in health and nutrition, water sanitation, education and training, food security and livelihood. Participatory planning indicated that the ethnic people preferred to generate income from livestock. In 2004, the ADP Board formed a project management committee for cattle production and implemented a project in which households can access credit to purchase livestock as a means of generating income. In 2003, cattle numbers were around 4,800, and the goal for the district was to increase this to 14,000 by 2010.

13 ACIAR project LPS/2004/073: Capacity building on cattle production at Dong Giang district, Quang Nam province, Vietnam

14 ACIAR project LPS/2002/078: Improved beef production in central Vietnam

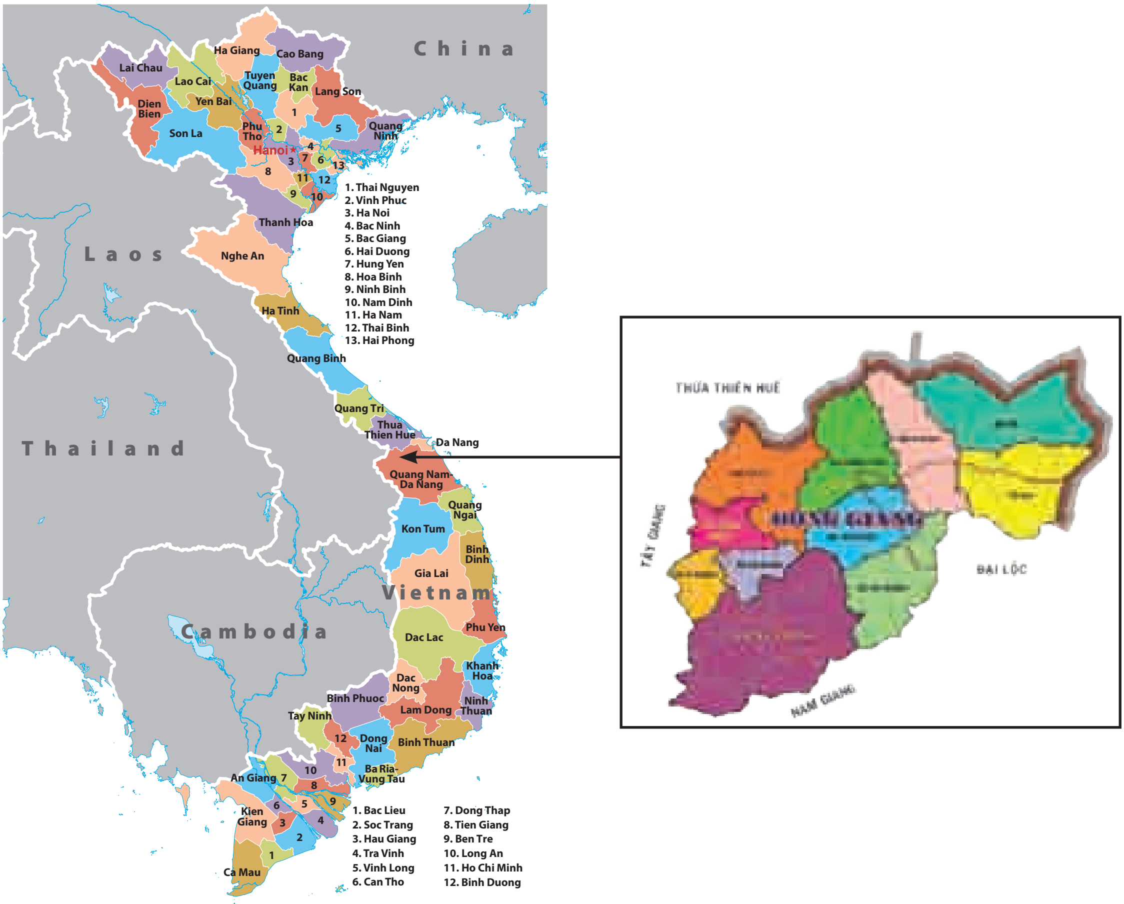


Figure 22. Location of Dong Giang district, Quang Nam province, Vietnam (inset shows communes in Dong Giang)

ACIAR has supported this WV cattle production activity by supplying funds to train Hue University of Agriculture and Forestry (HUAF) staff in project management and cattle husbandry. Research outputs from another ACIAR project have provided training on technical aspects of cattle husbandry in central Vietnam, and the project has also resulted in capacity development in the district.

Typical farming conditions and systems

In the region, education levels are generally low (particularly in ethnic minority groups), poverty is common, and subsistence agriculture and livestock production systems predominate. The ethnic groups maintain traditional cultural practices, and are yet to move into the market economy. They practise shifting cultivation, along with traditional activities such as animal rearing, weaving, fishing, hunting and collecting non-timber forest products.

Pigs and poultry are the major livestock. About 30% of households are cattle 'keepers' (1–3 animals, mainly yellow breed). Livestock are generally kept for slaughter at celebrations—such as the T'Moi festival at the end of crop sowing or feasts at the beginning of the new lunar year—or as an asset that can be liquidated if crops fail.

Cattle are raised in free- or tethered-grazing systems using native grasses. The farmers do not use other feed resources such as crop residues, banana stem, by-products from rice or cassava, or sown grass.

The climate is monsoonal; rainfall is concentrated in the cool, wet season (September–December, with most rain in October and November—see Table 7), and the rest of the year is relatively dry. About 70% of this mountainous district is forest. Cropping areas and plots for cattle grazing are often far from households and difficult to access in the wet season.

Cows calve from November to March. Feed is scarce during the wet season when the terrain and flooding along river flats limit access to grazing areas. Few households have a cattle shed or supply cut grass or salt and water to cattle in the monsoon season. Farmers lack the capital, experience and skills to move to more intensive management of livestock.

Perceived and real problems

Development of cattle rearing or finishing systems in Dong Giang poses many challenges. The number of poor households (29% of the population) is higher than in other districts of Quang Nam province.

Feed is most limiting and diseases occur most often in the rainy season. During this period, cattle can be tethered for days at a time with access only to very short native grass around the household. Most cows give birth during or shortly after this period, and calf mortality is high. The cattle appear generally well adapted to the climate, topography and existing management practices of minimal input, but production is low. Local extension staff believe, incorrectly, that the problems are due to inbreeding, and are keen to promulgate the central government policy of crossbreeding to lift production.

At the beginning of the project, a Technical Service Station with eight staff, under the District Department of Agriculture, was responsible for all extension services, including crop and animal production and animal health/veterinary services. This group had only limited technical knowledge and capacity to service livestock farmers. Furthermore, the terrain and poor access roads limited the ability and willingness of these staff to provide services to remote hamlets.

ACIAR supported a scoping study by WV and HUAF staff, who surveyed A Ting and Za Hung communes and P'Rao town as part of project planning. Their principal findings were:

- Thirty per cent of households in the communes kept cattle.
- Better use of available feed resources could support increased cattle numbers.
- Native grasses were the predominant feed resource. Free or tethered animals grazed on paddy banks, in bare fields, along streams and rivers, in forested areas and on bare mountains.
- Cattle condition and growth were good in the cool season (March–August) when feed was more available (see Table 7).
- Calving was mainly from November to March, with a calving interval of 12–18 months.
- Few households had cattle sheds, or supplied cut grass, other feeds, salt or water to cattle in the monsoon season.
- Slaughter sites in Da Nang City were accessible to these communes and P'Rao town.
- Selling cattle was easy. Price was determined by negotiation between sellers and buyers.
- Farmers had limited skills and practices in veterinary hygiene, including preventing disease.
- The local people believed that cattle suffered less from diseases than other animals, had value, were easily sold and were easy to rear.
- Households lacked capital to purchase cattle.
- Project management skills at district, commune and hamlet levels were low.

Table 7. Calendar of climatic features and cattle husbandry issues in Dong Giang district, Vietnam

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Cold and rainy									■	■	■	■
Hot and dry	■	■	■	■	■	■	■	■				
Scarce feed	■	■							■	■	■	■
Disease									■	■	■	■
Mating season		■	■	■	■	■						
Calving season	■	■	■								■	■
Stock condition good			■	■	■	■	■	■				
Stock condition poor	■	■							■	■	■	■

Before the scoping study, the focus of the WV cattle development project in Dong Giang was to provide credit and improve the production potential of local cattle through crossbreeding with introduced breeds using artificial insemination, in accordance with central government and provincial policy. The scoping study enabled WV, senior members of communities and the local extension service providers to identify three major gaps that would hinder the success of cattle development under the ADP:

- the limited capacity of community members and service providers to manage the development activity at the grassroots level
- the quality of information available to, and being provided by, the extension services
- a lack of monitoring and evaluation of activities as an accountability measure and as a component of continuous improvement.

Other potential barriers to the success of the approach under the ADP were lack of skill in detecting when cows were in oestrus; difficulty in maintaining viable semen; logistical challenges imposed by communication infrastructure, travel times and staff numbers; and the low level of husbandry skills and knowledge in households.

The project team identified knowledge and skill gaps in Dong Giang at a number of levels: district, commune and hamlet, service provider agency and household. The low education levels in the region also applied to extension staff, who were generally young and inexperienced, had little knowledge of cattle husbandry and, in some instances, lacked motivation. In addition to developing capacity in cattle husbandry, the project aimed to enhance skills to manage the broader cattle development activity and to monitor and evaluate activities that foster continuous improvement.

Project objectives

Harvesting the forage crop, Dong Giang district, Vietnam

ACIAR supported a small project that was intended to add value to the existing ADP. This initiative focused on capacity development at the levels of the district, commune, and hamlet and, to a lesser degree, household.

The aim of the ADP cattle project (and consequently of this initiative) was to improve the income of the poor by sustainable development of cattle production in Dong Giang. The specific objectives were:

- to build the project management skills of project participants, especially commune and hamlet staff
- to improve the capacity of the rural people and extension staff in cattle production
- to monitor, evaluate, document and report on the effectiveness of activities.

The Agriculture and Rural Development Organisations of Quang Nam province People's Committee were also intended beneficiaries, since they were seeking new mechanisms for managing development projects and feasible solutions to improve cattle production in mountainous regions.

HUAF provided strategic inputs into training activities, while staff from the Department of Primary Industries (DPI) Victoria provided advisory support and review activities to ensure linkages with the project discussed in Case study 3.

Capacity development

The primary focus of the ACIAR investment was capacity building. To gain the best return on inputs from HUAF staff, the focus of the training model (see Figure 23) was on:

- the ADP Board and Cattle Project Management Committee
- commune coordinators, and district and WV extension staff
- hamlet facilitators, extension staff and paravets.

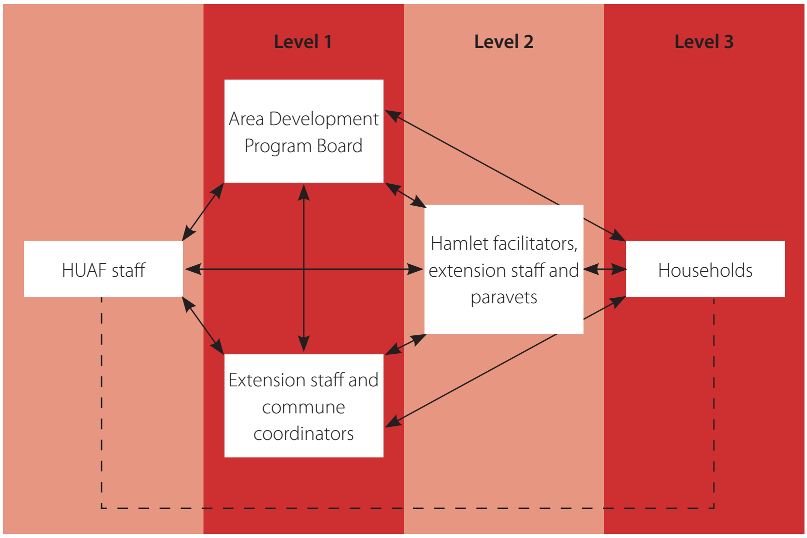


Figure 23. Approach to capacity building, illustrating the focus of Hue University of Agriculture and Forestry (HUAF) activities; the dotted line to households indicates a lower emphasis

Although HUAF staff had direct contact with farmers in training activities, there were constraints on their time for follow-up extension activities. Hence, a 'train the trainer' approach was used: key people identified among commune coordinators and hamlet facilitators, and at the household level, were trained to provide capacity development in extension methodology and cattle husbandry.

This approach was designed to build extension capacity and, in the longer term, to reach farmers who had not taken part in training delivered by HUAF. Commune coordinators and hamlet facilitators were important in this role, since they were motivated and brought knowledge and skills to help the limited numbers of district extension staff. Capacity development of farmers will largely be achieved through these commune and hamlet leaders, in conjunction with the Dong Giang extension staff and WV resources.

Training workshops

Project management was the focus of the first 4-day training workshop. The HUAF staff who designed the course material found the preparatory research valuable. The participants—10 district representatives, 20 commune representatives and 2 WV staff—included members of the ADP Board, members of the Cattle Project Management Committee and commune coordinators. Training in project management, monitoring and evaluation was timely and valuable because of the introduction of interest-free loans for purchasing cattle or for constructing housing within the ADP cattle project. Use of interest-free loans, which was a shift away from normal WV practice, was intended to empower each commune group to manage the allocation of credit by selecting participating households, setting the size of the loans, collecting repayments and then re-allocating repaid funds. Further, the scheme was intended to gain greater commitment from those receiving loans and to reach a greater number of households.

Over the course of the project, 11 training activities, each of 3–5 days duration were held (Table 8) with participants selected according to their level of knowledge, enthusiasm to learn and willingness to try new technologies. Some courses were followed by a 3-day study tour to Quang Ngai to examine cattle production and feeding systems. The strategic linkage to the ACIAR-funded project reported in Case study 3 through HUAF meant that the ADP had direct access to the findings of research from that project and to development activities in the AusAID-funded Quang Ngai Rural Development Program.

Table 8. Training in cattle husbandry and extension methods conducted by Hue University of Agriculture and Forestry

Training activity	Objectives	Timing (days)	Participants
General course in cattle production	Improved knowledge and skills in: • selection and breeding • feeding management • husbandry and housing • disease recognition and vaccination.	Feb.–Mar. 2006 (4)	11 district extension staff 5 commune paravets 7 commune coordinators
Feeding and nutrient requirements	Improved knowledge and skills in: • animal nutrition • storing, conserving and processing feeds • use of rice straw and banana stem • cultivation of sown grasses. Included a practical exercise of establishing demonstration sites in 3 communes.	Mar.–Apr. 2006 (4)	12 district extension staff 3 commune paravets 9 commune coordinators
Quang Ngai study tour	• Changed attitudes and aspirations in cattle production through learning by seeing. • Learning about technologies (e.g. housing construction, sown grass options and feed use). • Acquisition of grass seed and runners for commune demonstrations.	Apr. 2006 (3)	11 district extension staff 2 commune coordinators 3 farmers and 1 Farmer Association representative. Head, Dong Giang Economics Department 2 WV staff

Continued next page

Table 8 *continued*

Training activity	Objectives	Timing (days)	Participants
Extension methods	• Transfer of knowledge of extension method. • Training in 'train the trainer'. • Practical exercises in training to apply learning. • Improved skill in planning and monitoring extension activities.	June 2006 (3)	15 district extension staff 5 commune coordinators
Implementing technologies in households (3 communes)	• Demonstration of semi-intensive cattle rearing (grazing by day, housing at night). • Changed farmer attitudes by seeing in practice feeding management (use of rice straw, sown grasses and banana stem), animal husbandry, housing construction, grass cultivation and disease detection.	July 2006 (3)	3 district extension staff 3 commune coordinators 17 farmers (16 ethnic minority; 50% female) 1 WV staff
Skilling hamlet facilitators (5 communes)	Improved understanding and use of: • semi-intensive system • husbandry and mating of breeding cows • storing local feeds • sown grass cultivation • harvest and feeding • maintaining hygiene.	Sep. 2006 (4)	25 hamlet facilitators 5 commune coordinators 3 district extension staff
Skilling hamlet facilitators (5 communes)	Improved understanding and use of: • semi-intensive system • husbandry and mating of breeding cows • storing local feeds • sown grass cultivation • harvest and feeding • maintaining hygiene.	Oct. 2006 (4)	17 hamlet facilitators 5 commune coordinators 3 district extension staff
Extension methodology (5 communes)	• Transfer of knowledge of extension method. • Training in 'train the trainer'. • Practical exercises in training to apply learning. • Building demonstration sites.	Jan. 2007 (3)	17 hamlet facilitators 5 commune coordinators
Extension methodology (5 communes)	• Transfer of knowledge of extension method. • Training in 'train the trainer'. • Practical exercises in training to apply learning. • Building demonstration sites.	Feb. 2007 (3)	19 hamlet facilitators 2 commune coordinators
Train the trainer in cattle production	• Improved knowledge and skills in training on cattle production. • Effective use of training manual.	Mar. 2008 (5)	10 district extension staff 7 commune coordinators
Animal health	• Improved knowledge and skills in animal disease management and treatment.	May 2008 (4)	11 paravets 7 commune coordinators

Learning by doing

These initial activities included 'learning-by-doing' and 'learning-by-seeing' approaches. It became evident early in the process that training of commune, hamlet and service provider personnel needed to focus on a small number of key points at any time, given the low base level of knowledge and education.

During the training program, it became clear that improving the knowledge of district extension staff and commune coordinators in extension methodology was integral to sustainable improvements in cattle production. This was also the best use of the limited time available from the HUAF staff. Again, those most likely to try or adopt new technologies were identified for this 'train the trainer' activity. The training model evolved to enable training exercises to take place on a farm within a hamlet, and all interested farmer participants implemented simple technologies through 'learning-by-doing' exercises.

Plot preparation and sowing are important training exercises for learning about grass cultivation.

The trainers complemented these learning-by-doing activities with formal presentations and discussions, which occurred at the household being used as a learning platform. Introduced technologies included animal housing, forage cultivation, feeding livestock with locally available feeds, and collecting and using manure on vegetable gardens or forage plots.

Senior team member Dr Ba produced a training manual on cattle production in rural households in Dong Giang for use by extension staff and the commune coordinators. The manual was based on experiences during these training activities, together with information compiled in this project and Case study 3, and extensive consultation with stakeholders. A group of service providers and commune coordinators has since been trained in use of the manual and associated extension materials.

Outcomes

Exercises to evaluate learning outcomes were included in all training activities. These evaluations indicated that the 15 district extension workers and 10 commune coordinators trained in cattle production and extension methodology all improved their knowledge and skills. Most were interested in assisting farmers and applying what had been learned. By mid 2006, five extension workers and three commune coordinators were sufficiently competent and confident to be trainers for farmers.

By mid 2007, 10 of the 42 hamlet facilitators who attended training courses in cattle production and extension methodology had applied what they learned and implemented semi-intensive cattle raising models at their households; others plan to implement similar models. Seventeen trained farmers in three communes (Xa Ba, Jo Ngay and P'Rao) were applying components of the semi-intensive model.

Most of these farmers provided the labour and materials to construct cattle housing, while WV provided some materials (e.g. corrugated iron and cement) as encouragement. The farmers have implemented grass cultivation, using a range of sown grasses (*Pennisetum purpureum*, *Panicum maximum*, *Setaria sphacelata*) and shrubs (*Morus alba*, *Trichanthera gigantea*). The changes in these households, which are located in communities where there was previously no cattle housing or use of feeds other than native grass, are living demonstrations for neighbouring farmers to emulate. There are anecdotal reports that farmers who did not participate in training activities have implemented changes without WV support.

Participant benefits and learning

Many of the participants in the project contributed information on personal benefits attributable to their involvement in the project; two from the Vietnam partners are described here to provide a flavour of those benefits.

Dr Nguyen Xuan Ba indicated that he had personally benefited in a number of ways, including:

- increased income
- experience in conducting surveys to identify key constraints and then progressing to project design
- improved understanding of cattle production systems in upland areas
- improved and new teaching skills for audiences with low levels of education and understanding
- exploring alternative approaches for presenting extension material to different audiences
- developing knowledge to deliver courses on extension methods and project management
- friendships with Le Ngoc Tung and Ngo Tung Lam and others in World Vision (WV).

Le Ngoc Tung identified that this was a new model for WV. In the past, WV had simply provided credit to farmers to purchase cattle, with no expectation of repayment. In this project, credit was provided as an interest-free loan to be repaid. Tung saw the building of good relationships between Hue University of Agriculture and Forestry (HUAF) and WV staff as beneficial, as WV did not have strong technical expertise in cattle husbandry. He observed that capacity development took time, and small steps were a better approach than presenting too much information. From a management perspective, he found it challenging to plan and implement a training schedule, particularly when HUAF staff gave first priority to their university commitments, which sometimes meant that training had to be rescheduled at short notice. The contracts and negotiations were also complex and time-consuming, but provided a valuable learning experience.

Planning and communication

What lessons about planning and communication could help readers planning similar projects? We believe that there are three key messages:

- Good interpersonal relationships are invaluable when change and uncertainty need to be accommodated.
- All stakeholders need to be flexible in the pathway to achieving the project objectives.
- Despite extensive consultation during project development, additional stakeholders can be expected to emerge during the course of the project, including some who believe (rightly or wrongly) that their needs have not been sufficiently addressed.

Excellent relationships and open communication between stakeholders were critical to overcoming challenges encountered during implementation. These challenges included the growing demands on the time of HUAF staff; staff changes within HUAF; a lengthy period to replace the WV agriculturist who led the ADP cattle production project, and time required to train his replacement; and diversion of district extension staff, commune extension workers and paravets to district priorities (such as preventing avian influenza or a foot-and-mouth disease outbreak) and directions for them to focus on new residential areas. The latter problem was resolved through flexibility—the training target was shifted to commune coordinators and hamlet facilitators, without excluding the district extension workers.

Paradoxically, the HUAF and WV team concluded that they needed greater input from the district extension services at the grassroots level when planning and implementing training activities, to foster stronger cooperation and to enhance commitment. Although the district extension staff were an agreed partner from the outset, there was obviously a difference of opinion about their duties. Changes in personnel, different approaches to resolving the problems, and limited funds flowing directly to the district extension service may have contributed to the problem.

Developing project relationships

Project relationships initially developed as ACIAR and World Vision (WV) staff recognised the potential to link Area Development Program (ADP) activities to ACIAR-funded projects in Vietnam. Leaders and members of the ACIAR project described in Case study 3 and their WV counterparts met and agreed that the Dong Giang cattle project could benefit from technical inputs from staff at Hue University of Agriculture and Forestry (HUAF) and the Australian team. Subsequently, Dr Ba and Dr Doyle from the ACIAR-funded project visited Dong Giang to observe cattle husbandry practices and to meet with commune and district extension representatives. HUAF and WV staff jointly conducted a survey in A Ting and Za Hung communes and P'Rao town, to provide baseline information and continue to build the relationships.

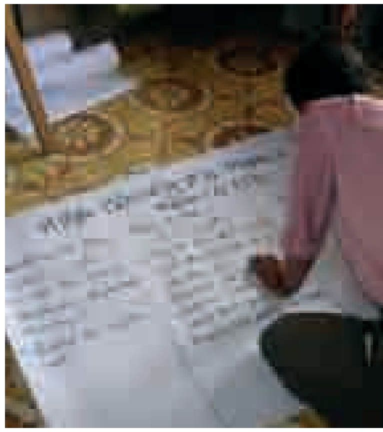
These activities highlighted the heavy workload for the main drivers of any new work. They also highlighted the difference between the perceived and real problems (inbreeding and husbandry, respectively) and the solutions to these problems (crossbreeding and artificial insemination, and training and information on options, respectively). The project developers took these factors into account in designing the activity—particularly the need for good collaboration, understanding and communication.

Despite this excellent preparation, administrative differences in fund management and reporting procedures delayed implementation. As might be expected, adding value to the existing ADP was not a seamless exercise; for instance, the ADP Board wanted to implement the cattle activity in all 10 communes, rather than the recommended staged implementation in three communes. Project development teams should heed these examples and consider such issues in parallel with project scoping and design, to meet partner needs and reduce delays.

Training activities gained pace from February 2006, and strong and positive relationships developed between Nguyen Xuan Ba and Le Ngoc Tung and their colleagues. Mr Do Tai (Vice Chairman, People's Committee Dong Giang, and Chairman of the ADP Board), together with commune and hamlet leaders, observed personal and community benefits from the capacity-development activities, which strengthened their relationships with HUAF.

However, the demands on Dong Giang extension staff to deliver their district responsibilities, as well as inputs into the ADP, remain a challenge. This problem has been addressed by training commune coordinators and hamlet facilitators, who will train farmers in their communes. Advantages of this approach are reduced transport and communication problems and a high level of commitment from the commune-based personnel.

Applications, impacts and challenges



Evaluating learning outcomes from training exercises in grass cultivation and feeding, Dong Giang district, Vietnam

Poor households have taken loans totalling 1,384 million VND since the beginning of the ADP cattle project, and 25% of this has been repaid. At the end of 2006, 425 households had purchased cows, and 133 calves had been born. The mortality rate of purchased animals was about 5%, mainly due to poor tethering and foot-and-mouth disease. Farmer skills in cattle husbandry still vary significantly between hamlets within a commune, and between communes, and this is evident in loan repayments. WV recognises that the sustainability of these cattle enterprises will depend to a large degree on the capacity development activities initiated by this project.

The impact at household level in 2006 was modest, occurring mainly in Xa Ba and Jo Ngay communes and in P'Rao town, where 17 households adopted improved cattle husbandry and feeding practices. During 2007, another 59 households from seven communes adopted semi-intensive cattle rearing practices, and a further 70 households spread across six communes fully adopted these practices in early 2008. Across the district, 223 households were cultivating sown grasses by May 2008. When the project commenced, these communes had no sown forage production and very few cattle houses. Both of these technologies are becoming commonplace, and the farmers who are cultivating sown grasses are increasing herd size; some now have six animals. These farmers are still mainly livestock keepers—that is, accumulating cattle as a means of increasing wealth.

Future challenges exist at the household, community and institution levels. At the household level, a key challenge will be to foster the move to market-driven cattle production or finishing systems; if this outcome is not achieved, resource depletion and failure of the cattle husbandry approach are likely. Anecdotal information indicates that better road access is facilitating trading of cattle to the lowland areas.

At the community level, further capacity building for hamlet facilitators and extension workers is required to ensure the flow of benefits to more farmers. The successful hamlets that have already emerged can provide useful examples to assist in this increase in scale. Uptake and application of the training manual developed for WV by HUAF will be an important component of addressing this challenge.

At the institution level, HUAF is in a unique position to help address the chronic shortage of well-trained extension personnel for central Vietnam. Currently, HUAF is constrained by the commitments of existing staff to university teaching, in-service training in larger centres and research. However, HUAF has an opportunity to establish a livestock development education group for central Vietnam, led by existing staff and based on the recruitment and skill development of a core group of its postgraduate and undergraduate students. Such a model has the potential to provide ongoing capacity building in livestock production for service providers, commune leaders and hamlet leaders, not only in Dong Giang, but in other ADPs and rural development programs.

Government agencies obviously have a role at each of these levels to foster the long-term development of their communities. A particular role not mentioned above is improving infrastructure, particularly roads and bridges, which are critical for farmers to develop market access and for the mobility of public and private service providers. Experience elsewhere in the developing world has highlighted the primary importance to community development of market access, particularly where there is a strong demand for the agricultural commodity, as is the case for beef in Vietnam.

Case study 5:
A profitable forage-based beef industry for the red soils region of China

Bob Hunter, Bevan Robertson, John Nolan, Neil MacLeod and Dick Jones

Better forage varieties for China's red soils enable farmers to improve the nutrition of their cattle.

In 1987, a report compiled by ACIAR, Winrock International and the Chinese Academy of Agricultural Sciences noted that beef production had the potential to provide an economic basis for rejuvenating the red soils agricultural systems in southern China and to increase the standard of living of local people.

Major constraints to achieving these objectives included the poor quality of feed available to cattle and the infertile soils that, when coupled with the climatic extremes, made practical year-round production of higher quality feeds a serious challenge. Further, local knowledge of beef production in smallholder mixed farming systems was limited, and the farmers were themselves in transition from using cattle for draught to growing cattle for sale.

This case study describes how a consortium of Australian and Chinese organisations undertook an ACIAR-funded project in two provinces—Hunan and Jiangxi—to develop forage production and cattle nutrition technologies appropriate to the red soils region and thus improve beef production and farmer income.[15]

Project rationale

The red soils region in southern China is an area of infertile, acidic soils with a total land area of 2.6 million km^2. It includes most of the provinces of Zhejiang, Fujian, Jiangxi and Hunan, and parts of Anhui and Guangxi (Horne 1997), and contains about half of China's population. Most of the people in the region are poor and depend on agriculture.

China's population has increased from 540 million in 1949 to over 1.3 billion. Increases in both the number of people and the average standard of living have increased the need for quantity and quality of food, especially animal protein. With these needs in mind, in 1987 the Chinese Academy of Agricultural Sciences combined with ACIAR and Winrock International to consider options for meeting the increased demand for beef. This project recommended that beef production on the degraded red soils in southern China be given a high priority. If feasible, it would provide economic assistance for rejuvenating the red soils agricultural systems and would increase the standard of living of the people in the area. Another important benefit would be the retention of existing soil on bare, sloping land by the establishment of forages for cattle feed. Widespread tree clearing has taken place in the past, and soil erosion has become an extremely serious problem.

15 ACIAR project LPS/1998/035: Ruminant production in the red soils region of southern China and in northern Australia

ACIAR subsequently funded extensive studies to understand soil and climatic conditions and to test and identify suitable forage species for the red soils region. Since 2000, ACIAR-funded work has progressed on developing forage production and cattle nutrition technologies. This case study describes how a project undertaken by a consortium of Australian and Chinese organisations in two provinces—Hunan and Jiangxi—in the red soils region led to a profitable forage-based beef industry.

Typical farming conditions and systems

The red soils region was originally covered with evergreen, broad-leaf forests. About 1 million km^2 of the area is either hilly or mountainous, and the remaining lowland is mainly used for cropping, principally irrigated rice and an array of cereal and vegetable crops. Clearing of the forests on hills and slopes from around 1950 degraded the landscape, and by 1970 much of the area was cleared of native trees. Widespread natural revegetation occurred, but provided no economic benefits beyond some reduced soil erosion and improved water management.

Both lowland and hilly areas are potentially suitable for forage-based beef production using a cut-and-carry system. The existing beef production 'system' was based on village cattle that are primarily used for draught; they graze over-used communal wasteland by day in the warmer months and are hand-fed low-quality straws and other residues in the colder months.

Rainfall is reliable, with averages of 850–1,200 mm/year. Rain occurs in each month, with the lowest falls of 50–60 mm in December and January. Mean temperatures are typically 5–10 °C in mid winter and 25–30 °C in mid summer. The more inland provinces have occasional light snowfalls in most winters. Coupled with the highly infertile soils, these temperatures make year-round forage production a challenge. The winters are generally too cold for reliable survival of tropical forages, and the summers are too hot for persistence of temperate perennial forage species. However, chemical fertiliser is subsidised by the state and is relatively inexpensive.

The majority of farms are smallholder mixed enterprises. Cropping contributes more to total income than livestock production, which has traditionally been dominated by pigs. Before the project, the typical household had fewer than five cattle (most of which were draught animals) and often none.

The challenge was to find forages that grow on the degraded red soils and have high nutritional value.

Rice straw in storage for cattle fodder

Perceived and real problems

Cattle were often present in the farming systems, mainly as a relic of their previous use for draught. The main breed is 'yellow cattle', which is a genetically diverse *Bos taurus* breed, but there is some evidence of *B. indicus* genetic infusion. Reliable data on productivity of these animals are scarce, but observation of village herd structures and some weight-for-age assessments indicated that reproduction and growth rates were typically low. Feed came from a variety of sources, including conserved rice straw (the main bulk of the ration); and grazing of wasteland, bunds around the crops and cropland after harvest. Crop residues such as rice bran were also fed when available.

Although 'genetics' and health were usually put forward as the main constraints on production, the more obvious reason was poor nutrition, in both the quantity and the quality of forages. Discussions with smallholders, extension officers and scientists revealed a poor understanding of the relationships between feed quality, animal intake and production. The notion that cattle could consume 3% of their body weight per day as good-quality feed was completely foreign, and so demonstration of this simple fact became the principal objective of the first feeding trials.

The second significant barrier to profitable beef production was the notion that rice straw should naturally be the basis of all feed rations. The quality of rice straw varies widely, depending on cultivar, season, growing conditions and postharvest management. However, at best, rice straw will barely maintain the weight of a mature animal. If included as a significant proportion of a mixed ration, it will limit the intake of other components. The reasons for its use are easily understood—it is free, plentiful, and easily stored and handled, and it will keep cattle alive. Rice straw is an appropriate feed for smallholders in 'user' or 'keeper' mode (Neidhardt et al. 1996). A paradigm shift was needed through demonstration—first for the scientists, then for the extension officers—to encourage the smallholders to move into 'producer' mode.

Traditional animal management was a constraint on production. Tethering or free-ranging of cattle on bunds, cropland and wasteland for several hours each day is a common practice. Although there are no hard data on feed intake, it is easy to observe from the overgrazed landscape that daily intake would be very low, and that during the winter months more energy could be spent maintaining body temperature than gained from grazing. Obviously, the problem is worse in the cold months than in the hot and humid months, because low temperatures limit forage growth rate on areas that are already severely overgrazed. In general, grazing does not add a great deal to the daily nutritional requirements of the local cattle. This tradition would need to be challenged, at least for cattle in 'production' mode.

When the project began in 2000, a number of interrelated issues needed to be addressed, ranging from policy initiatives by government to personal commitment by officials in Chinese institutions. These issues included technical and scientific aspects of forage production and cattle feeding, and extension methodologies to persuade smallholder farmers of the merits of major changes to their farming systems.

Development of the project was agreed because all levels of the Chinese Government were committed to introducing profitable beef production into the region. Reduced soil erosion, a lower dependence on grains for animal protein production and an increase in living standards for smallholder households were all drivers of government policy.

Project objectives

The negotiated objectives for the project were to:

- benchmark cattle production efficiency and beef production in smallholder herds in Jiangxi and Hunan provinces, so that productivity gains in future years could be measured
- compile an inventory of the availability of local feed resources, and fresh and conserved forage produced on-farm, to enable the design of cost-effective supplements for forage diets
- establish and manage forages suitable for ruminant production
- conserve local forages as winter feed
- produce cattle to market specification
- design and develop a simple spreadsheet model to predict year-round forage supply and cattle growth rate, based on data from the experimental sites in Hunan and Jiangxi
- identify key profit drivers and risks associated with beef production and determine the profitability of beef production within a mixed farming system.

Project operations

Team and site selection

Selection of team personnel was the most crucial issue during project initiation. A lengthy development phase, involving two visits to China about a year apart, enabled significant planning and team building by the project leaders. During the first visit (about 3 weeks duration), extensive discussions were held with government officials and scientific staff in a number of red soil provinces. After these trips, the investigation group invited staff from organisations in Jiangxi and Hunan provinces to join the project.

Dwarf elephant grass, cut at 6–7-week intervals during the warmer months, became one of the major components of recommended rations. It was chopped into about 10-cm pieces before feeding.

Professor Shi Qinghua, then Professor of Agronomy and Director of Research at Jiangxi Agricultural University (JAU) in Nanchang, led the team at the first site. Professor Shi had already established collaborations with the Jiangxi Provincial Extension Service and the Ministry of Science and Technology. As he was fluent in English, communication between the Australian team and the JAU team was not an issue.

At the time of the initial discussions, Professor Shi and his colleagues had already planned and financed an extension strategy. They saw the scientific experimentation that would be funded by ACIAR and designed and co-managed by Australian scientists as a 'nuclear project'. That is, once forage production and cattle feeding technologies were developed, the extension strategy would be implemented and wide-scale adoption on-farm would be achieved through provincial extension networks. In addition, funding had been secured from the Ministry of Science and Technology to build on campus a 20-pen animal house in which the cattle feeding experiments would be conducted.

The second site was at the Red Soils Experiment Station of the Chinese Academy of Agricultural Sciences at Wenfushi Township in Hunan province. Professor Xu Minggang and Mr Wen Shilin had contributed to a previous ACIAR forage agronomy project. Both had worked previously with Australian researchers and spoke fluent English. Professor Xu had established links with the Provincial Animal Husbandry Bureau and had a long track record in managing successful extension from the Red Soils Experiment Station.

The project objectives required an Australian team with a range of disciplinary skills to accomplish the set tasks and to build capacity in China. The Australian project leader had expertise in ruminant nutrition research and project management. Another team member, who had previously worked in developing countries, had experience in cattle management and ruminant nutrition, and skills in building computer models to predict the end products of rumen metabolism and subsequent animal growth. The project also recruited a plant scientist with extensive experience in tropical and subtropical pasture agronomy, and an economist with experience in the production and resource economics of agricultural systems.

A project scientist, also with experience of working in Asian agriculture, was employed to work for extended periods in China with Chinese scientists on their experimental programs. As most of the Chinese scientists were not trained in animal science, the project scientist was responsible for training them in cattle nutrition, cattle husbandry, experimental protocols, data collection and analysis, and report writing. This scientist had an ideal skill set, including a farming background, previous work in developing countries and postgraduate training in cattle nutrition and metabolism.

The three main Chinese scientists at the beginning of the project had skills in agronomy and plant evaluation, and monogastric nutrition. All were trained in Australia in ruminant nutrition before conducting pen studies in China. As the project matured, additional Chinese academics with skills in extension and economics became involved.

Typical yellow cattle used in the metabolism trials. Group feeding trials, as shown, were conducted initially to test experimental systems and to train scientists and technical staff in husbandry techniques.

Capacity development to address knowledge and skills gaps

Although one of the key activities was feeding cattle for improved growth rate, the Australian collaborators realised that none of the Chinese project staff had formal training in ruminant nutrition. Their university training had typically focused on soil and plant sciences, nutrition for monogastric animals, and agricultural or economic extension. Therefore, one of the Australian collaborators arranged training in ruminant nutrition and experimental procedures with cattle, both on the job in China and during visits by the Chinese to Australia for several weeks of more specialised training. The Chinese colleagues were chosen for training on the basis of their leadership capabilities and the strengths of their collaborations with the provincial extension services.

The primary focus of the experimental program was to provide data to support beef production; other major objectives were to demonstrate the principles of ruminant nutrition and provide training in experimental methodologies. The Chinese research and technical staff learned cattle husbandry and ruminant nutrition on the job. Critically, their Australian counterparts encouraged them to question the local assumptions about cattle husbandry and to test these assumptions in well-designed experiments. One experiment, for example, showed that diets of green, 'stemmy' native grasses could not achieve the same liveweight gains in cattle as the more leafy introduced ones. Also fresh astragalus, with its high moisture content, did not cause bloat when fed at more than 20% of the dietary dry matter. The importance of such 'training' experiments cannot be overstated.

Development of relationships

The main purposes of the second visit to China were to ensure that the planning undertaken through correspondence in the previous year remained relevant to the needs of Chinese smallholders, to agree on objectives and milestones that were achievable within the time frame, and to plan activities for the first year of the project. Bringing the whole team together to engender a joint understanding and ownership of project objectives and activities was critically important, particularly because the project involved several Chinese and Australian agencies. During this visit, evidence of a good working relationship between Chinese and Australian scientists began to emerge, and these positive working relationships developed into genuine friendships as the project progressed.

The technical staff, who frequently lived in the animal house, became first-class data managers and animal husbandry practitioners after appropriate training.

With one or two exceptions, team members had never worked within such a wide disciplinary group, comprising specialists in ruminant nutrition, livestock production, plant species evaluation and agronomy, extension and socioeconomics. The focus on achieving impacts for the community was also foreign to the less experienced Chinese team members, most of whom had careers based in component sciences.

Even the Chinese members of previous ACIAR-funded projects, which had primarily focused on the introduction and evaluation of forages, found the new emphasis on outcomes and impacts challenging. However, with the support and mentoring provided by the senior Chinese and Australian members of the team, they successfully rose to the challenge. Their performance exceeded expectations and received public recognition.

There is no doubt that the excellent relationships that developed within the teams arose from the multidisciplinary approach and a clear focus on outcomes and impacts. These were augmented by capacity building through training and mentoring, and encouraging a trial-and-error approach during the early phase of the project. The way that the team dealt with mistakes and failures testifies to the strength of these relationships.

Results and observations

Selecting forage species

Previous ACIAR-funded projects, including LWR1/1993/003,[16] had investigated the establishment, nutritional value, persistence and productivity of forages that might be suitable for use in the red soils region. Hundreds of accessions had been tested, but few showed genuine promise for integration in local farming systems—low soil pH, low soil fertility and the harsh climate limited forage growth and persistence. The few species that had persisted were deemed unsuitable for a cut-and-carry cattle-feeding system, as yields were low and stem was more prominent than leaf. Fortuitously, the leafy grass cultivar dwarf elephant grass (*Pennisetum purpureum* cv. Mott) was discovered growing in a plant nursery, and anecdotal reports suggested that it had high yields and good persistence in that environment.

Taking this background information into account, 14 forage species (7 grasses, 3 legumes and 4 species from other families) were evaluated over 2 years (Wen et al. 2007). Fertiliser was applied at 40 kg/ha phosphorus and 50 kg/ha potassium in March each year. Three levels of nitrogen were also applied: 60 kg/ha for legumes, and 200 kg/ha and 400 kg/ha for grasses and other species. The nitrogen fertiliser was applied in equal amounts each month from March to

16 LWR1/1993/003: Forage management for the red soils of south central China

October. Forages were harvested up to seven times in both years at a height of 10–15 cm. Cut material was separated into leaf and stem, dried and weighed.

Yields of leaf and stem are shown in Table 9. Total yields of leaf were highest for elephant grass, elephant grass hybrid ([*Pennisetum americanum* × *P. purpureum*] × *P. purpureum* cv. Mott) and dwarf elephant grass. The leaf to stem ratios were greatest for dwarf elephant grass, elephant grass hybrid and the four non-grass, non-legume species. Disease and insect damage markedly reduced the productivity of these four species in subsequent years.

Table 9. Annual yield (dry matter) of forage species

Accession	2002			2003		
	Leaf yield (kg/ha)	Stem yield (kg/ha)	Leaf:stem ratio	Leaf yield (kg/ha)	Stem yield (kg/ha)	Leaf:stem ratio
Tropical grasses[a]						
Elephant grass hybrid	13,136	4,938	2.7:1	9,550	3,350	2.9:1
Elephant grass	10,847	7,204	1.5:1	6,783	3,800	1.8:1
Dwarf elephant grass	9,217	2,358	3.9:1	7,100	1,567	4.5:1
Solander setaria	7,737	5,273	1.5:1	3,417	2,183	1.6:1
Mexican forage corn	7,568	5,031	1.5:1	4,000	1,733	2.3:1
Hemarthria compressa	4,789	8,545	1.1:1	4,467	5,833	0.8:1
Premier finger grass	6,918	3,915	1.8:1	2,700	2,750	1.0:1
Tropical legumes						
Wynn cassia	5,170	3,278	1.6:1	1,600	917	1.7:1
Chamaecrista nictitans	4,115	2,127	1.9:1	2,000	967	2.1:1
Lotononis	4,767	0	na	1,617	0	na
Other						
Cichorium intybus	5,750	0	na	6,033	0	na
Silphium perfoliatum	3,434	0	na	5,717	0	na
Rumex K–1	3,967	0	na	433	0	na
Amaranthus cruentus	3,418	1,523	2.2:1	1,217	583	2.1:1

ha = hectare; kg = kilogram; na = not applicable

[a] Yield data for grasses are for 200 kg/ha of nitrogen.

Dwarf elephant grass and dwarf elephant grass hybrid produced prodigious amounts of leafy forage in the warmer months, from late spring (May) to late autumn (November). The yields of the hybrid, fertilised with 200 kg/ha of nitrogen each year over 2 years, are shown in Figure 24.

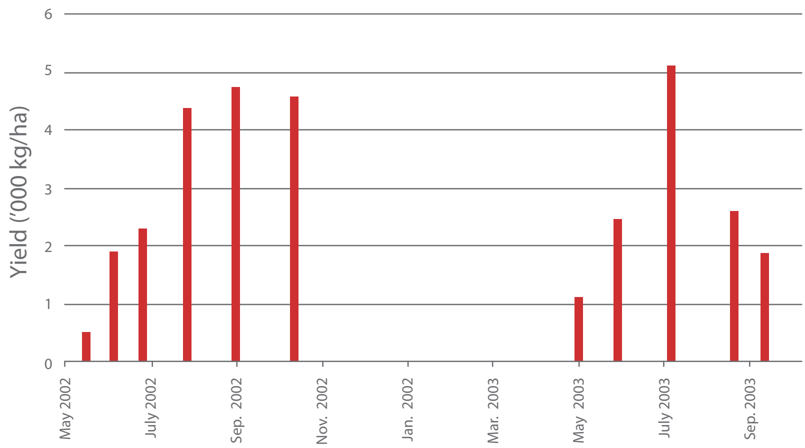


Figure 24. Seasonal yield of elephant grass hybrid, May 2002 to September 2003

Studying forage use and sward management

Fresh forage can be the staple diet of cattle in the region from May to November. The high yields allow frequent harvests over the warmer months and the potential for conservation of surplus fodder. Hay or silage produced on-farm potentially has higher nutritive value than rice straw for feeding over winter. Producing hay and silage using best management practice was another training objective for the project. Experimentation in China showed that feeding cattle with fresh forage plus small amounts of rice bran or cottonseed meal achieved liveweight gains of 0.6–0.7 kg/day.

Other experiments at both sites confirmed that dwarf elephant grass and elephant grass hybrid were superior to other species trialled in their yield of leafy material and persistence. Dwarf elephant grass became the recommended species, as the nutritive value of harvested forage was less sensitive to cutting frequency than that of other forms of elephant grass, which can rapidly become 'stemmy'. Farmers, especially in Hunan province, tended to initially favour elephant grass hybrid because of its higher total dry matter yields. However, with time and experience, they realised that cattle growth rates are higher on the leafy dwarf elephant grass, and plantings of the hybrid progressively decreased.

Survival over winter, when snow can lie on the ground for several days, is problematic for tropical forages. The team studied the effect of protecting dwarf elephant grass bases. Plant tussocks that had been cut back to 5–10 cm in November were either left exposed, covered with 3 cm of soil or covered with 3 cm of straw. Only 10% of the unprotected plants survived to the following spring, whereas the survival rate was 85% for plants that had been covered with straw and 95% for plants covered with soil.

A typical village scene toward the end of the warmer months, with a vacant paddy field, a vegetable patch, rice straw drying in stooks before storage, and a patch of mature dwarf elephant grass that will be harvested as vegetative planting material on-farm and/or for sale.

The winter in question (2002–03) produced more snow than usual. A high percentage of plants covered with soil have survived all subsequent winters. The studies showed that plant survival is unlikely to be a problem if the plants are protected with soil during winter. However, an industry relying almost entirely on monocultures of dwarf elephant grass and elephant grass hybrid is potentially at some risk. *Solander setaria* seemed a promising alternative in the early years of the project, but very few stands survived the severe winter of 2002–03.

Developing feed-year concepts and options

A survey at the start of the project provided an inventory of the seasonal availability and costs of local feedstuffs that form the basis for diet formulations during the harsh, colder months from December to March. The team then conducted experiments to measure the liveweight gains of cattle on diets of these feedstuffs mixed with conserved forages and rice straw. Other experiments were conducted with different inclusion rates of ryegrass and astragalus (*Astragalus sinicus*) as supplements to a basal diet of rice straw. These experiments showed that a dramatic increase in liveweight gain can be achieved using these diets, compared with a diet of rice straw supplemented with urea and sulfur.

A recommended feed-year plan for local application (Table 10) was developed through intensive experimentation at the sites in Jiangxi and Hunan. Over the initial 3 years of the project, the team conducted about 20 cattle-feeding experiments. The scientists recorded the capacity of feeds—fresh forages, conserved forages and straws (including ammonia-treated straws), with and without energy and protein supplements—to support cattle growth.

Table 10. Feed-year plan

Feed	January–March	April–October	November–December
Basal forage diet	Rice straw Ammoniated rice straw Ryegrass Dwarf elephant grass Hay or silage	Dwarf elephant grass hay or silage Elephant grass hybrid	Rice straw Ammoniated rice straw Ryegrass Dwarf elephant grass hay or silage
Supplements	Astragalus Urea Cottonseed meal Rice bran Peanut cake Soya bean cake Maize meal Wheat meal Peanut straw Sweet potato straw		Urea Cottonseed meal Rice bran Peanut cake Soya bean cake Maize meal Wheat meal Peanut straw Sweet potato straw

Astragalus is an interesting plant that was included in experiments at the initiative of the Chinese scientists. It is a legume that is planted in rice paddies before the rice harvest and allowed to grow as green mulch, using residual soil moisture and rainfall. Local folklore is that it has limited value as stockfeed, mainly because it is 'too wet' and can cause bloat. However, it has high nutritive value for cattle and can be fed fresh with straws or made into silage. In one experiment, fresh astragalus included at 50% of dietary dry matter with rice straw enabled young cattle to grow at 0.86 kg/day over 42 days.

Matching capacity for beef production with land area and forage yields

At the beginning of the project, beef production in the red soils region was typically based on grazing of native grassland (common land) during daylight hours in the summer months, and feeding of rice straw, supplemented with small quantities of rice bran and limited grazing, in the colder months, when grass growth was dormant. Animals were marketed at unspecified ages and weights, usually to coincide with festive occasions (e.g. Chinese New Year, Golden Week), when local prices were generally higher. Cattle liveweights were around 250–300 kg at 5–8 years of age.

The shift to a total cut-and-carry system using forages grown and harvested on the smallholders' own land was a radical change. Smallholders needed to accommodate the idea of a feed-year plan, in which they conserved excess summer growth as hay or silage, and planted forage species such as ryegrass and astragalus to provide additional forage in the cooler months, rather than relying on rice straw during this period. However, the use of rice straw in feeding systems was also studied.

Experiments showed that treating rice straw with ammonia increased feed intakes in cattle by about 40% over intakes on untreated straw. Daily liveweight gains doubled because of the additional energy and nutrients supplied above maintenance requirements. The components of feed used for growth and maintenance of cattle at various annual growth rates are shown in Table 11.

The results demonstrate a critical point: with higher growth rates (and lower times to turn-off), less feed needs be cut and carried to grow an animal to market weight. In the example in Table 11 (a steer being grown from 200 kg to 400 kg liveweight), the total feed needing to be harvested for a growth rate of 0.75 kg/day is only 54% of that for a growth rate of 0.25 kg/day. The main inefficiency associated with slow growth rates is the extended period over which energy for maintenance must be provided (800 days compared with 267 days, in the example).

Table 11. Metabolisable energy and feed requirements to grow a steer of small mature size from 200 kg to 400 kg liveweight

Liveweight gain (kg/day)	Total energy requirements (MJ × 10^3)	Maintenance energy requirements (MJ × 10^3)	Energy used for growth (%)	Total feed cut and carried (tonnes dry matter)	Feed cut and carried for liveweight maintenance (tonnes dry matter)
0.25	38.4	30.4	21	5.5	4.4
0.5	24.4	15.2	38	3.5	2.2
0.75	21.3	10.1	47	3.0	1.6

kg = kilogram; MJ = megajoule

This substantial change in feeding management was a serious challenge for the Chinese scientists, extension workers and smallholders. Tools were needed to assist in deciding how many cattle could be raised on the land area available for forage cultivation, taking into account the likely yields of the various forages at different times of the year. Forced sale of cattle in mid winter at a lower price because feed reserves were exhausted could mean financial disaster for many smallholder farmers.

To assist extension workers and smallholders to think through these issues, the team constructed a simple spreadsheet-based cattle nutrition model, based on data from the forage production and cattle feeding experiments conducted by Chinese scientists during the ACIAR-funded project. Potential forage growth was coupled with the feed needs of a projected number of cattle at specified initial age and weight, and an intended growth path to turn-off. Using the model, the forage production from a specified area of land, with average soil fertility, can be predicted for each month of the year. The model is implemented in Microsoft Excel®. A summary of the output is shown on the same screen as the data inputs (Figure 25), so that results from simulations are immediately available.

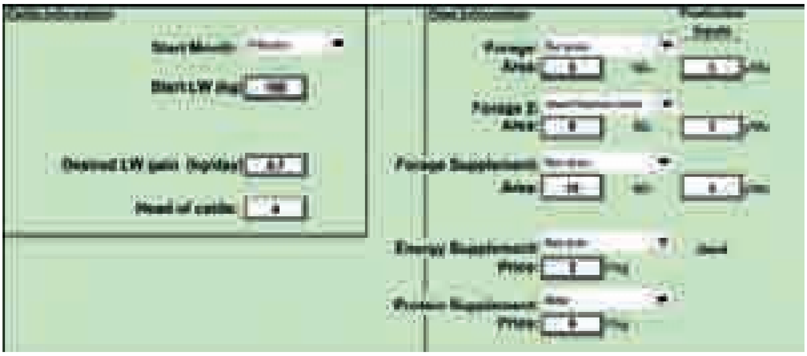


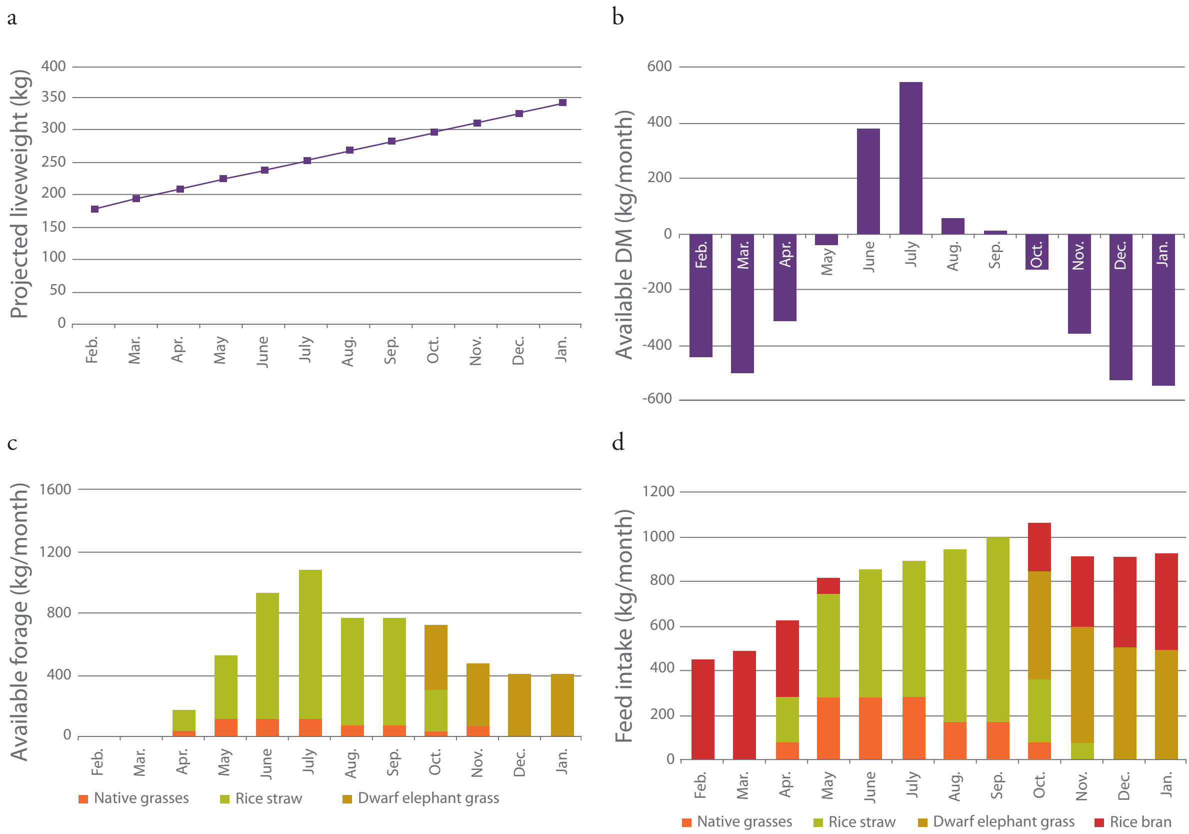
Figure 25. Input screen for nutrition model, showing drop-down boxes for entry of cattle and feed information. Output graphs are placed below the input area on the same screen to enable results generated by changing the inputs to be seen immediately.

Farm and animal data are entered in drop-down boxes, and the outputs are updated automatically. Periods of feed excesses and shortages during the year can be seen at a glance, allowing management decisions on feeding and supplementation to be made accordingly. Examples of use of the model are presented below.

Example 1—nutrition model using rice, native grassland and dwarf elephant grass

Figure 26 shows the model output for a smallholder with 10 mu[17] of rice, 5 mu of native grassland and 5 mu of fertilised dwarf elephant grass (15 mu = 1 ha). The farmer intends to purchase five head of cattle at an initial liveweight of 180 kg in February and grow them at 0.5 kg/day so that they are about 350 kg and ready for sale for Chinese New Year in 12 months (Figure 26a). Figure 26b shows that the farmer has surplus forage dry matter only in June, July and August and can therefore make only about 400 kg of dwarf elephant grass hay for feeding later in the year. The feed needed in each month to grow the five cattle at 0.5 kg/day is also shown (Figure 26c). Native grass makes a meagre contribution to feed requirements in this example, and there is a serious deficit of useful forage for more than half the year. The smallholder would have to invest heavily in energy-dense rice bran or other concentrates to keep the animals growing at the required rate (Figure 26d).

17 A mu is a Chinese measure for cultivated land equivalent to one fifteenth of a hectare.



DM = dry matter; kg = kilogram

Figure 26. Feed production and feed requirements under example 1

Example 2—nutrition model using rice, elephant grass and ryegrass

Figure 27 shows the situation if the smallholder in example 1 replaces the 5 mu of native grassland with 3 mu of dwarf elephant grass and 2 mu of ryegrass (Figure 27a). Excess forage is now available in five of the warm months, and there are smaller forage deficits in all other months (Figure 27b). Almost 2.5 tonnes of hay dry matter can potentially be stored for winter. Fresh forage of high nutritive value is available in most months (Figure 27c), and the feed requirements of the five cattle can be almost met from forage grown on the farm. The 2.5 tonnes of dwarf elephant hay, if cured properly, would be of higher nutritive value than rice straw, and could replace or be mixed with rice straw to deliver higher liveweight gains through November, December and January (Figure 27d).

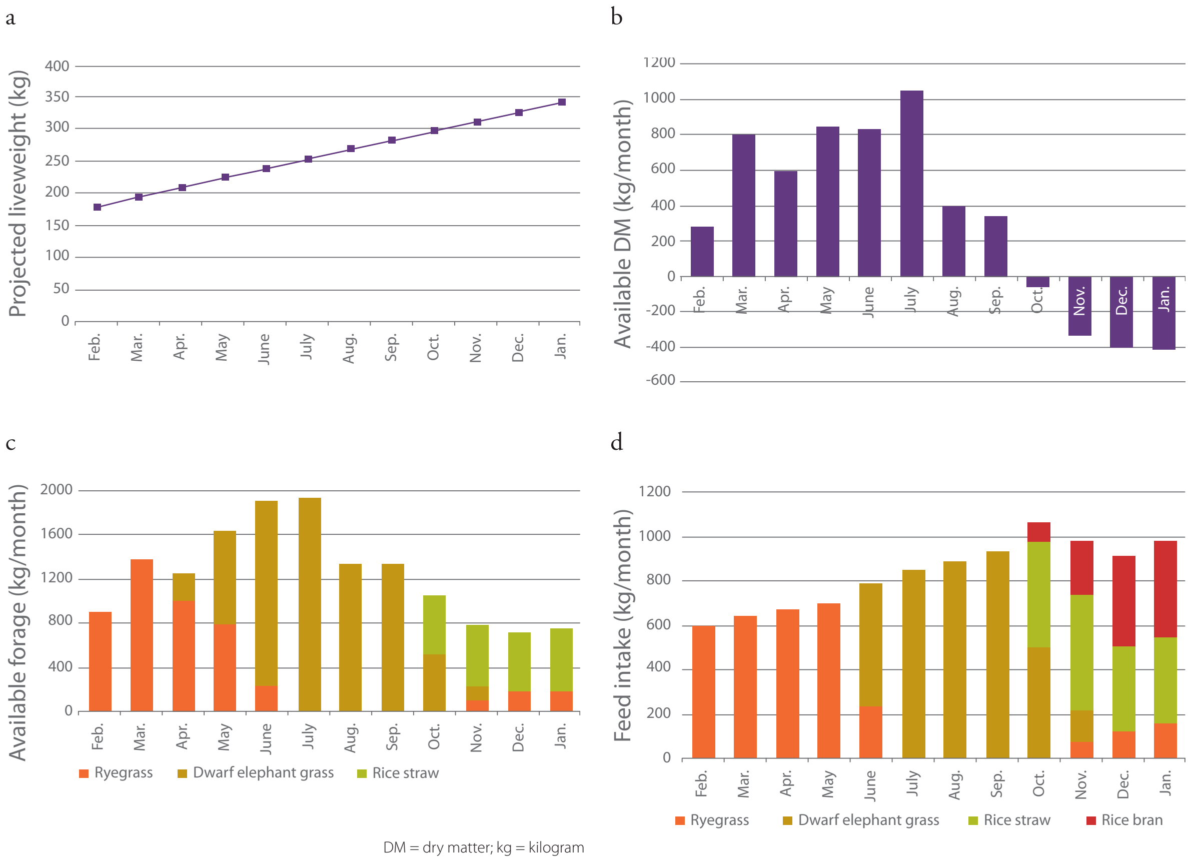
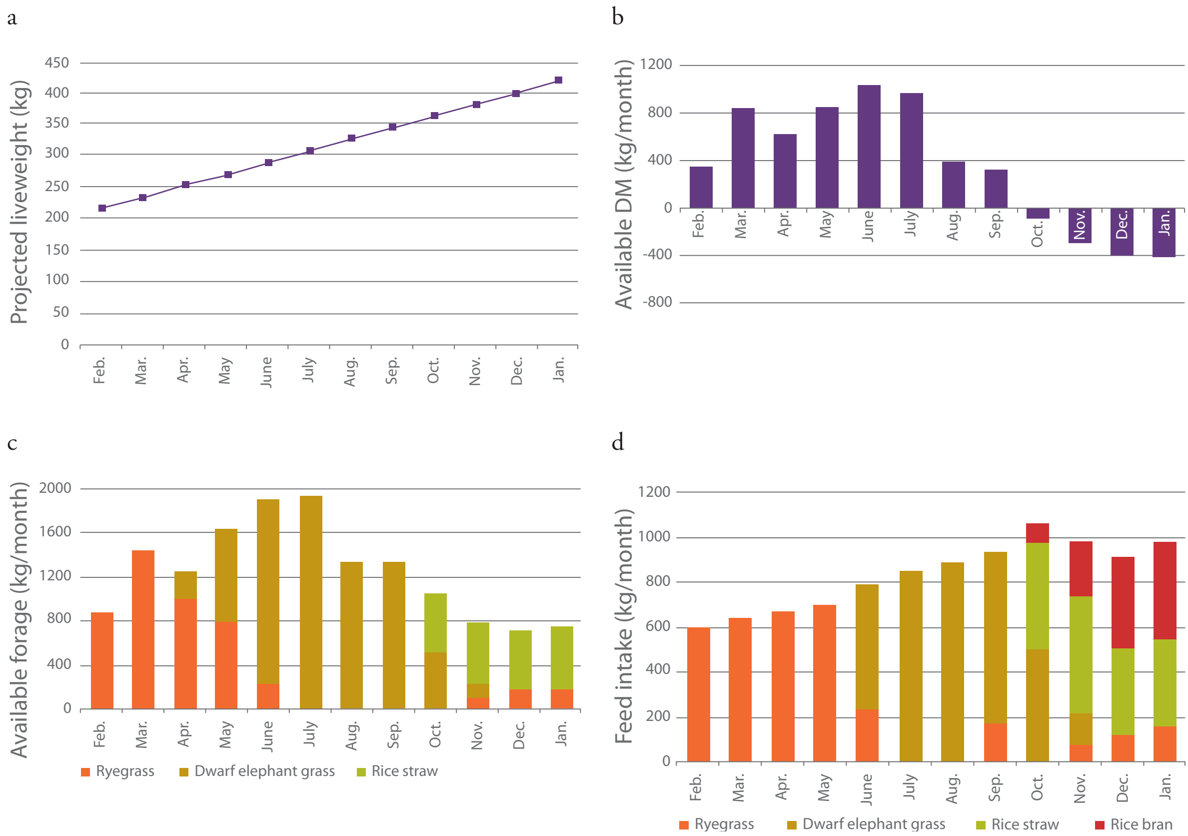


Figure 27. Feed production and feed requirements under example 2

Example 3—nutrition model using a faster cattle growth rate

Once the capacity of a farm to support a certain number of growing cattle is established, the model can be used to explore other options that might be more profitable. Figure 28 predicts feed production and requirements for the same farm for four cattle grown at 0.7 kg/day rather than 0.5 kg/day. A higher proportion of the harvested feed is channelled into growth rather than maintenance. Faster growth rates permit the start of the feeding operation to be delayed, or enable the cattle to have heavier finishing weights of about 410 kg after a year (Figure 28a). Again, excess forage is available in the warm months, and there are smaller forage deficits in all other months (Figure 28b). Forage use is now much more efficient. Again, ryegrass provides the bulk of the feed in the early months of the year (Figure 28c). If conserved, the summer-grown dwarf elephant grass hay can provide most of the forage component of the ration during winter, replacing rice straw (which has a much lower nutritive value) and eliminating the need to include concentrates (rice bran in this example) to maintain growth rates over winter (October–February; Figure 28d).



DM = dry matter; kg = kilogram

Figure 28. Feed production and feed requirements under example 3

Resource use in mixed farming enterprises and economics of beef production

Smallholder households in Jiangxi and Hunan provinces traditionally operated mixed farming enterprises, centred on the cultivation of rice and vegetables and raising of monogastric livestock, such as pigs and chickens. Household income frequently needed to be supported by off-farm labour. Smallholders were willing to introduce beef production into their farming systems only if they were convinced that it would be profitable to do so.

Initial capital costs for beef production, including livestock purchases, are generally substantial compared with normal farm income. As well, harvesting feed and tending cattle are labour-intensive activities that compete with other farm and household activities for the available labour. It is often difficult to determine the true labour inputs, family consequences and profitability of individual farm and non-farm activities. The relationships between activities of a typical smallholder household in the red soils region are shown in Figure 29.

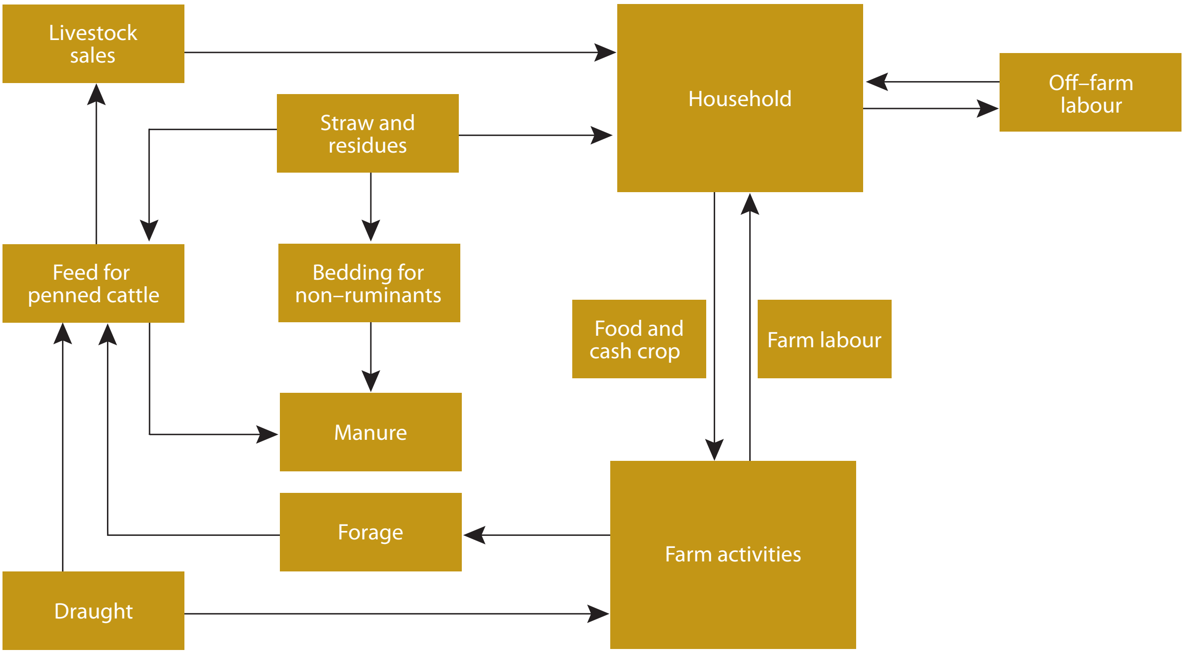


Figure 29. Linkages between the farm household, farm activities and the wider community

A second model (MacLeod et al. 2007b) was built, incorporating forage production and cattle feeding into the traditional cropping and other livestock activities. The model was calibrated for typical farms in red soils provinces raising 5–8 head of cattle. Various scenarios involving different combinations of cattle growth performance, beef prices and feed costs were explored to test the robustness of the decision to adopt beef production. A previous comprehensive study by Longworth et al. (2001) of the developing Chinese beef sector had concluded that new, unspecialised smallholder beef enterprises had rather limited economic advantages over traditional farming activities. It was therefore crucial to demonstrate the profitability of beef production based on the technologies developed by this project.

The model demonstrated that the key to profitable beef production in these two red soil provinces was to feed high-yielding, appropriately fertilised forages of high nutritive value that would see cattle achieving moderate to high growth rates. This was a crucial message for our project, as the less favourable economic analyses of Longworth et al. (2001) were based on traditional feeding of cattle on low-quality straws, with the associated very slow growth rates. Our model tended to confirm that cattle enterprises based on traditional feeding are not profitable, and extended our understanding of the main profit drivers in higher production systems.

An example of the potential contribution of beef production to whole-farm cash flow and economic profit is shown in Tables 12 and 13. In this example, the household consists of a working couple, a child and an aged adult. Land area is 7 mu, and farming activities include cropping rice and peanuts, and raising chickens and pigs. There is an older cow for draught and three young steers for fattening and sale.

The traditional cattle-raising situation is shown in Table 12. The cattle component is a financial drain on the household and generates a negative cash income and a substantial economic loss. The whole farm also makes an economic loss, relying on money from off-farm labour for financial security.

Table 12. Revenue, costs and profit for a mixed farm raising cattle by traditional feeding methods

	Farm activities		Livestock component		Total farm (yuan)	Off-farm (yuan)	Total house-hold (yuan)
	Crops, fodder (yuan)	Total livestock (yuan)	Cattle (yuan)	Other (yuan)			
Total revenue	6,402	3,915	1,917	1,998	10,317		
• cash revenue	4,818	2,655	670	1,985	7,472		
• internal resource transfers	1,584	1,260	1,247	13	2,844		
Total costs	3,291	3,489	2,124	1,364	6,781		
• cash costs	1,531	1,406	1,136	269	2,937		
• internal resource transfers	1,260	1,583	738	845	2,844		
• depreciation	500	500	250	250	1,000		
Net farm income	3,111	426	-207	634	3,536	3,120	6,656
Value of labour and capital	3,776	1,640	1,080	660	5,416		
Economic profit	–665	–1,214	–1,187	–26	–1,880	3,120	1,240
Net cash income	**3,287**	**1,249**	**–466**	**1,716**	**4,536**	**3,120**	**7,656**

Note: Liveweight gain = 0.15 kg/steer/day; price = 5 yuan/kg liveweight; 1 US$ = 5.3 yuan

Table 13 shows the balance sheet after adoption of forage production and improved cattle feeding strategies. Liveweight gain of the three commercial steers has increased, and a slightly higher price per kilogram is achieved in the marketplace because they are sold at a younger age. The cattle component returns substantial cash income to the family and ensures that the whole-farm enterprise (not including off-farm income) now runs at a slight economic profit.

Table 13. Revenue, costs and profit for a mixed farm raising cattle using technologies developed by the project							
	Farm activities		Livestock component		Total farm (yuan)	Off-farm (yuan)	Total house-hold (yuan)
	Crops, fodder (yuan)	Total livestock (yuan)	Cattle (yuan)	Other (yuan)			
Total revenue	6,511	6,335	4,337	1,998	12,846		
• cash revenue	4,818	5,056	3,075	1,980	9,874		
• internal resource transfers	1,693	1,279	1,262	18	2,973		
Total costs	3,289	3,623	2,309	1,314	6,912		
• cash costs	1,510	1,429	1,211	218	2,939		
• internal resource transfers	1,279	1,694	848	846	2,973		
• depreciation	500	500	250	250	1,000		
Net farm income	3,222	2,712	2,028	684	5,935	3,120	9,055
Value of labour and capital	3,854	1,708	1,049	660	5,562		
Economic profit	–632	1,004	979	25	373	3,120	3,493
Net cash income	**3,308**	**3,627**	**1,864**	**1,762**	**6,935**	**3,120**	**10,055**

Note: Liveweight gain = 0.6 kg/steer/day; price = 6 yuan/kg liveweight; 1 US$ = 5.3 yuan

The increased profitability of beef production with increased cattle growth rates has encouraged the establishment of specialist beef farms where all arable land is dedicated to forage production. Cattle numbers per farm vary from fewer than 10 to several hundred. At the lower end of the scale, an individual smallholder household usually leases the land of one or more of its neighbours. The larger farms that require substantial capital investment in cattle sheds and other infrastructure, however, are usually business partnerships.

Extension activities and technology adoption

Beef production

The national priority for expanding beef production in the red soils region ensured that all tiers of government were committed to the project and to providing resources. From the start of the project, all involved acknowledged that Australian 'know-how' would be invaluable in developing the scientific aspects of the task. Once production of suitable forages and cattle feeding technologies were established, the Chinese extension agencies could lead and manage the on-farm adoption task. Existing interagency plans were implemented once useful technologies became available.

The extension strategy used is depicted in Figure 30. Forage was planted and cattle sheds were built on government research farms and the JAU campus. These were used to train local extension specialists and the early adopting smallholders. The agencies conducted approximately 130 training courses and field days within 2 years of completion of the research work. In addition, some 1,500 person-hours were invested in one-on-one interaction with smallholders in need of further information.

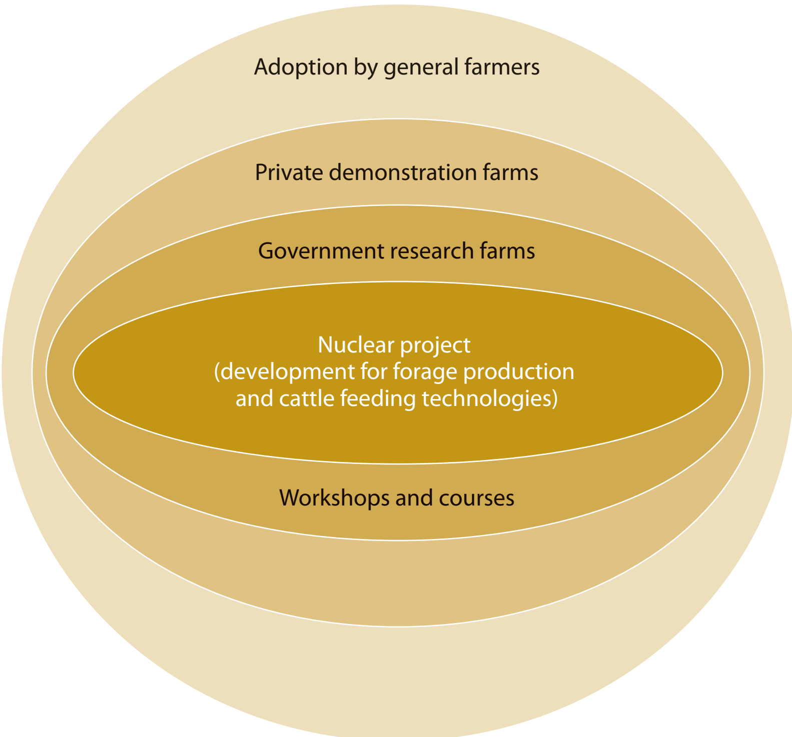


Figure 30. Representation of extension strategy

Smallholder households were supported by the government incentives for expanding forages and cattle. In one year, the Jiangxi Provincial Extension Service grew 600 tonnes of dwarf elephant grass and elephant grass hybrid stems, and more than 100 tonnes of ryegrass, and these were either sold or donated.

The early adopting smallholder holdings were designated as private demonstration farms, and field days that focused on communication between smallholders were organised. Some of these smallholders quickly saw a business opportunity and planted additional areas of dwarf elephant grass for sale as cuttings. The Chinese authorities estimated that 13,000 households in the two provinces had adopted the recommended forage production and cattle feeding strategies in the first

An Australian team member visits one of the medium-scale cattle finishing enterprises that adopted technologies promoted by the project.

2 years of the extension push, with production increasing by 77% from only 15% more cattle in one province (Zhang and Gao 2005).

A minority of smallholders discontinued their involvement with forage and beef production after 1 or 2 years, generally because they had poor understanding of forage agronomy and cattle husbandry. In Hunan province, the abandonment rate was 20%, whereas in Jiangxi province the abandonment rate was only 5%, suggesting that in Jiangxi better ongoing support was provided by the extension agencies. In Jiangxi, the Deputy Director of the provincial extension service was personally committed and was part of the project team from the beginning; extension of the technologies from this project became the top priority of the service. In Hunan, animal health rather than forages and animal nutrition remained the primary focus of the Animal Husbandry Bureau.

Forage-based beef production is associated with increasingly demonstrable economic and social benefits. The rate of technology adoption in the red soil provinces in just a few years has been considerable. The Chinese authorities remain committed, and large-scale adoption is likely to continue. This is supported by an independent review of the project conducted by the Ministry of Science and Technology in Jiangxi. Conclusions from the review were:

- The research on selection of suitable forage species and their agronomic characteristics, and on year-round feed supply and nutrition of beef cattle laid a scientific foundation for the highly effective development of an economically sustainable beef industry.
- The extension model that was adopted was both practical and effective. The achievements were remarkable.
- All project objectives were accomplished. The results have been innovative in nature and of practical value.

Both the Red Soils Experiment Station and JAU received awards from their respective provincial governments for their achievements in developing forage and ruminant production technologies, for their extension successes, and for the beneficial impact of their endeavours on the farming communities.

Spin-off uses of forage technology

Motivated smallholders have devised ways of feeding dwarf elephant grass, elephant grass hybrid and ryegrass to other species, notably fish. Smallholder households often raise grass-eating fish in ponds, and they have discovered that the leafy form of these grasses is suitable fish food. A recent estimate was that approximately 6,000 households in Hunan province and 5,000 in Jiangxi province were using forages for raising species other than cattle.

Lotononis and, to a much lesser extent, Wynn cassia, despite their limitations for cut-and-carry beef production, have found a place in the control of soil erosion, especially in terraced orchards on steeply sloping ground.

Lotononis *reducing soil erosion in an orchard on sloping ground*

Reflections

Capacity building in industrially focused research and development

The ACIAR investment in this project has brought new knowledge and skills in forage-based cattle production to the red soils provinces. Skills have been transferred from key project staff to extension specialists and now on to individual smallholders.

The leaders of the project teams were experienced senior managers in their organisations, and received support from two or three early- to mid-career scientists. The Australian and Chinese leadership clearly defined an expectation that the operational staff would report their research results in scientific journals in a timely way. By the end of the 5-year project, 25 papers had been published in scientific journals. All Chinese project staff, including the project leaders, enjoyed at least one promotion during the course of the project. Towards the end of the project, the key operational staff were asked to consider their top personal development achievements. They listed:

- increased skill as a researcher
- increased capacity for project leadership and management
- a new skill and confidence in working with farmers
- improved knowledge of beef cattle nutrition and cattle feeding technologies, which they used in lectures to students
- improved English, associated with confidence in communicating with foreign scientists.

The newly acquired ability of project staff to challenge local assumptions with scientific data increased their standing in the provincial animal science communities, giving them a new authority to speak at training workshops and field days on subjects about which they were considered inexpert a few years before. Encouraging project members to question unsubstantiated opinion undoubtedly contributed to building their scientific capabilities—this was demonstrated by promotion of most of the team in their parent institutions during the life of the project.

Mr Wen Shilin made an outstanding contribution to the project through his agronomic research, cattle nutrition studies and extension efforts from his base at the Red Soils Experiment Station.

Consideration of adoption

A major reason for the ultimate success of the project was the alignment of the science with clearly enunciated government policy. All tiers of government—national, provincial and local—were committed to forage-fed beef production (albeit with a limited understanding of how that might be achieved). Extension services, embedded in the project from the outset, developed strategies to ensure that the forage production and cattle-feeding technologies developed by the research teams and supported by scientifically validated information were communicated rapidly to the farming sector.

The extension teams used television, radio, workshops and field days at demonstration farms. They supported these activities with printed information in booklets and pamphlets. The comprehensive and focused nature of these extension activities underlined the commitment of government departments. By the conclusion of the 5-year project, 130 training courses for extension workers and smallholders had taken place. Twenty television programs, 60,000 extension booklets and more than 1,500 person-days of one-on-one contact with smallholders ensured that the extension message was widespread.

The political process also played a direct role in encouraging forage-based beef production. Policy incentives included:

- provision of free forage planting material
- availability of low-interest loans and cash grants
- abolition of land tax for 5 years in areas planted to forages
- donation of electric-powered forage-chopping machines.

It is very likely that these government initiatives, supported by scientifically validated information, hastened the development of a forage-based cattle industry in the red soils region. Without these interventions, expansion of beef production would probably have relied on traditional feeding strategies of low-digestibility straws supplemented with energy-dense concentrates—a regime that is more efficiently and effectively deployed in feeding systems for monogastric animals.

Long-term issues for consideration

The technologies developed during the project have had an impact in Jiangxi and Hunan provinces because they met current economic and environmental requirements. The Australian and Chinese colleagues recognise that modifications or refinements may be needed in the future if conditions change.

The forage production system stemming from the project essentially relies on a monoculture of dwarf elephant grass for cattle feed during the warmer months.

Without substantial inputs of fertiliser, which are currently subsidised by the government, forage yields would be considerably lower. However, fertiliser inputs can be reduced if manure, collected from the cattle pens, is returned to the grass stands. Any significant reduction in, or removal of, subsidies would influence the economics of beef production. Fluctuations in the purchase price of young cattle and beef price for the finished animal would also affect the profitability of forage-based production systems.

Australian and Chinese scientists visited the site to review the work.

To date, dwarf elephant grass has survived winters where snow has lain on the ground for several days, provided that the farmers adequately protect the plant bases by heaping soil over them. If the forage production system expanded to colder regions to the north and west of Jiangxi and Hunan provinces, the severity of winters would threaten the survival of plants. Widespread plant death could make dwarf elephant grass an annual plant requiring replanting each year, and could also severely limit the availability of planting material.

Conclusions

The project has been influential in the expansion of beef production in the red soils region of China. High yields of leafy herbage from fertilised dwarf elephant grass and elephant grass hybrid have provided an alternative to the traditional practice of grazing overgrazed native grassland and feeding low-quality straws supplemented with concentrates. Thus the emerging beef industry does not compete significantly for the feeds used by the monogastric livestock industries.

The extension activities that have been rapidly adopted on-farm are continuing. The next challenge is to take the technologies beyond Hunan and Jiangxi to the other red soil provinces.

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