A WHOLE-FARM SYSTEM APPROACH TO ENHANCING BALI CATTLE PRODUCTION IN THE MIXED CROP/LIVESTOCK SYSTEMS OF EASTERN INDONESIA

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ABSTRACT

Increased demand for beef in Indonesia is providing opportunities for income security through livestock production. However, the ability of smallholder farmers to exploit this potential is constrained by limited resources and adverse climatic conditions. Many forages suitable for improving livestock production in mixed crop-livestock systems in the tropics have been identified, however their adoption has been limited. Before farmers will introduce new forages into their farming system an important prerequisite is that the change will be considered profitable, will have an acceptable level of risk and will not interfere with food security. This paper describes a whole farm systems approach, undertaken to identify opportunities for increasing livestock production within the existing smallholder crop-livestock farming system. Preliminary analyses indicate substantial benefits from sown grasses, tree legumes and retaining residue from grain legume crops for dry season supplementation of livestock.

Keywords: *farming systems, modelling, forage, Bali cattle*

INTRODUCTION

Demand for livestock products is expanding rapidly in the tropics (Delgado *et al.* 1999); and is having a major impact on household and regional economies. These changes have had a profound impact on the cattle industry of eastern Indonesia, where high beef prices particularly fuelled by increased demand in Java has actually led to a rapid decline in Bali cattle numbers, due to excessive turnoff of breeding cows. For example, cattle numbers in South Sulawesi declined from 1.23 million in 1991 to 841,000 in 1997 (FAO 1999). While the strong growth in demand does provide opportunities for farmers to increase their income from expanded livestock production and to improve the economic sustainability of their farming enterprises, some major constraints (e.g. animal feed, management and health) need to be addressed.

Traditionally farmers in many parts of eastern Indonesia grow a rice crop in the rainy season, sometimes followed by a peanut (*Arachis hypogaea*) or maize crop in the early dry season, and fallow the land in the late dry season (Rachmat *et al*. 1992). Mostly, the second crop uses only 15-20% of their arable land (Rachmat *et al*. 1992). They keep 4-5 animals, mostly over 5 years old, grazing them in backyards, roadsides and forests. Little use is made of crop residues, other than rice (Rachmat *et al*. 1992). On irrigated land they will grow a second rice crop. Native pastures (e.g. *Imperata cylindrica*, *Cynodon dactylon*) are generally low yielding and, except in the early wet season, are typically of poor quality for cattle feeding.

Use of improved forages has the capacity to address these constraints, but also introduces conflicts with resource demands (especially capital and labour in the late dry and rainy seasons) and with traditional cropping systems. While previous research has identified many forage species that are well adapted to mixed crop-livestock farming systems, their adoption so far has been limited; even where participatory research has suggested a good fit with farmer's needs (Pengelly and Lisson 2001). The farmers may not be convinced that the advantages of new forages outweigh the costs of such an activity; there may be more attractive options for investment; or perhaps there is a perception of an unacceptable level of risk associated with the change. This paper describes a farming systems research approach used to investigate the benefits of new forages to improve Bali cattle production in the mixed crop-livestock systems of eastern Indonesia, in bio-physical, social and economic terms (ACIAR projects AS2/2000/124&125).

METHODS

The approach involved 3 key steps:

Step 1 - Describe the existing farming systems from biophysical, economic and cultural perspectives.

Interviews were held with individual farmers, village heads and extension staff in 4 selected villages in Sulawesi and Sumbawa that acted as case studies. The key features of the farm-household system included: resource endowments (land, machinery, labour, inputs), crop and livestock activities (area/quantity, inputs, husbandry and marketing), income (input costs, output prices, household expenses, non farm income, credit) and constraints to increasing crop and livestock yields, prices and market access.

Step 2 - Develop and validate the necessary biophysical and economic models.

Crop model - The APSIM farming systems model (McCown *et al.* 1990) simulates crop, forage and soil-related processes and the influence of climate and management factors on these processes using local climate and soil characterization data. New growth models were developed for rice and Elephant grass (*Pennisetum purpureum*) to complement existing APSIM models for other locally grown crops including maize, peanut, and forage legumes (e.g. stylosanthes, mucuna, lablab, cowpea and mungbean).

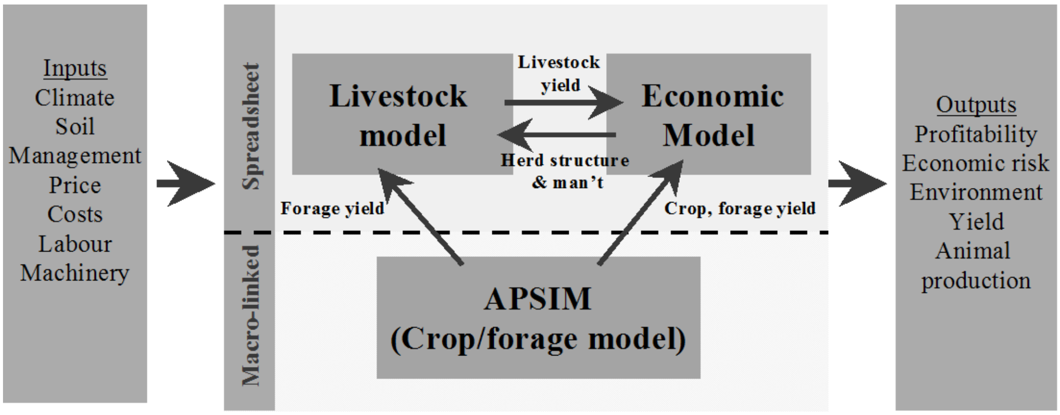
Animal model - A model was developed for predicting liveweight gain of Bali cattle under local feeding and husbandry practices; including grazing and cut and carry systems for forages and crop residues. The model used both published data and data from animal and forage monitoring records collected each 1-2 months on animal condition score, liveweight gain and stage of pregnancy, as well as the quality, composition and quantity of various feed sources. Potential intake is determined from the size of the animal and then adjusted depending on the digestibility of available feed (grazed and/or cut and carry) and for feed availability (grazing). Animal liveweight gain or loss is then determined from the protein and energy content of the predicted intake. Age at first calving and inter-calving interval are determined from the condition of the cow.

Socio-economic model - a model of a small holder farming system was developed to identify economic returns and resource constraints associated with new forage-livestock opportunities. The model covered 5 major resource pools - (1) labour, (2) finance, (3) land area, (4) forage and (5) draught. Input data was sourced from the step 1 benchmarking activity, field monitoring, and from the biophysical models. Any new or alternative activity involves changes in the labour demand, cash inputs and land usage. If any of these requirements exceed the availability of the resource, then a constraint is indicated. The available labour of each family member is identified, including the activities that each member is able to do.

Step 3 – Linkage of the component models within an Integrated Analysis Tool (IAT) that enables a whole of system analysis of alternative forage and livestock options that might be incorporated within the existing farming system.

A user interface within the economic model forms the ‘hub’ of the IAT, with links to the livestock and crop simulation models (Figure 1). Livestock yield and other animal data (temporal liveweight gain, calving dates etc) are exchanged directly between the livestock and economic models within the same spreadsheet. APSIM operates externally to generate data for a wide range of long-term scenarios (based on historical climate data) that are uploaded into the IAT spreadsheet. APSIM forage (crop stover and/or forage crop) yield and quality is an input to the livestock model and APSIM crop yield is also an input to the economic budget. The IAT interface allows users to set up a baseline case against which to ‘design’ alternative scenarios. Once a scenario has been configured, the model is run and the output presented in graph or tabular form describing: (a) biophysical characteristics of the system (i.e. crop and forage yield/biomass and animal liveweight gain); (b) labour requirements and availability and; (c) economic performance (crop and animal revenue, cash balance and gross margins).

Figure 1. Framework of the 'Integrated Analysis Tool'.



SCENARIO ANALYSIS

Potential activities for farmers to improve the quantity and quality of forages available for their cattle were developed through collaboration with Indonesian research and extension staff, discussions with farmers in SPA village, Sumbawa, and by conducting workshops with smallholder farmers in Barru district, South Sulawesi. A number of additional activities were identified by farmers and extension workers as practical and achievable.

The activities that were identified included (1) retaining crop residues for dry season feed, (2) growing Elephant grass (*Pennisetum purpureum*) on land not used for cropping, (3) growing gliricidia (*Gliricidia sepium*) as a living fence or hedgerow, or (4) could include a range of these extra activities. The farmer could still keep 2 breeding cows or, if there is sufficient feed available from the extra activities, increase the number of breeding cows. Finally, the effect of (5) seasonal mating and (6) a change in beef price can be assessed.

The outcomes of these activities are shown with the following case study example. A. Initially, a farm can be characterised in terms of available land, feed and labour, crops grown, revenue and cash balances. B. Additional activities can then be added or substituted into the farming system and the effect on labour requirements, feed resources, animal production and cash balances observed.

Case study: Improving livestock production in SPA village, Kempo district, Sumbawa

Farm characteristics at SPA

Table 2 describes a typical farm in SPA and current practice. A farmer grows 0.6ha of rice on his lowland (first land) and 0.3ha of peanuts on his upland (second land) in the rainy season, 0.3 ha of peanuts on his lowland in the first dry season and fallows his upland, and fallows both lands for the second dry season. None of the residue of the peanut crops is retained for feeding to animals. In his backyard he grows a small amount of vegetables for home consumption. The farmer has 2 breeding cows, which means he has 4-5 animals that he grazes on native pasture and feed 25kg dry matter of cut and carry material per day, collected from native pasture also. Weaner animals are sold at 12 months of age.

Table 1. Characteristics of baseline farm, family and animal numbers, cropping sequences and farming practices, and commodity prices.

Farm and family description	
Farm structure	
Family	4 (2 adults, 2 children)
Land	0.75 ha 1st land (L), 1 ha 2nd land (U), 0.25 ha backyard (B)
Initial cash on hand	500,000 Rp
Living costs	500,000 Rp/month
Rainy season crops	0.6 ha rice (L), 0.3 ha peanut (U)
Dry season 1 crops	0.3 ha peanut (L)
Dry season 2 crops	None
Forage crops	None
Crop retention	None
Animals	2 cows + calves/weaners
Cut & carry	25 kg/day
Commodity prices	
Rice	1000 Rp/kg
Peanut	3500 Rp/kg
Beef (weaners)	10000 Rp/kg
Beef (2 year-old)	15000 Rp/kg
Beef (old animals)	12000 Rp/kg

a) Conservation of crop residues.

Farmers in SPA currently conserve little of their peanut stover or their rice crop. The crop residues are either retained on the surface or burnt. There is currently an active extension program being undertaken to increase the awareness of the value of crop residues.

Question for IAT: 'What is the impact of conserving 80% of peanut crop residue on feed and labor supply, cattle production & household profit?'

Baseline scenario: 0.6ha of rice on lowland (first land) during the wet season + 0.3ha of peanut on upland (second land) during wet season + 0.3ha peanut on lowland during the first dry season, a maximum of 2 cows. No peanut residue is conserved and 25kg of cut and carry forage is collected from native pasture per day. Revenue from crop sales varies from 3M to 6M Rp per year, but is the same for each of the following scenarios.

Alternative scenario 1: As for baseline + retention of 80% of peanut crop residues.

Results: Peanut residue retention lowered the annual fodder deficit from 3000 kg/year to around 2000 kg/year. Over 5 years, cattle sales increased by 3 animals and the cash balance increased from 2.6M to 3.9M Rp. Revenue from crops ranged from 3M to 6M Rp per year. The shortfall in labour in the 2nd dry season was eliminated.

Option	Cut & carry (kg/day)	Cattle sold over 5 years	Cattle on hand after 5 years	Annual fodder surplus (Kg/year)	2nd Dry season labour (days)	Final cash balance (Rp M)
Baseline: Wet season: 0.6ha lowland rice, 0.3ha upland peanut, 2 cows						
	25	6	4	-3000	-20	2.6
Scenario 1: Plus 80% retention of peanut residues						
	25	9	4	-2000	+60	3.9

b) Increase production of existing planted forages.

The primary planted forages grown at present are Elephant grass and gliricidia. Both are perennials and are valued for their persistence into the dry season. Elephant grass is grown along riverbanks, in upland areas and on less productive lowland areas. Gliricidia is grown as a living fence or hedgerow in upland areas. There is opportunity to grow extra forages on unused cropping lands. The increased feed supply will improve the growth rates of animals (Lana *et al*. 1993), and enable growing females to reach breeding age earlier

Question for IAT: 'What is the impact of increased upland Elephant grass and tree legume production on feed and labor supply, cattle production & profit?

Baseline scenario: As above
Alternative scenario 2: As for baseline + 0.4ha of Elephant grass on upland.
Alternative scenario 3: As for baseline + 200m of gliricidia on upland.

Results: The increased forage available from gliricidia reduced the annual forage deficit substantially and, from Elephant grass, eliminated the deficit. Over 5 years, cattle sales did not change but, due to the better animal condition, animal revenue and cash balance increased by approximately 1M Rp. The deficit in labour was relieved in both scenarios. Including all 3 activities (retaining 80% of peanut crop residue, 0.4 ha of Elephant grass on upland, and 200m of gliricidia on upland) increased cattle sales to 9 and final cash balance to 5.2M Rp.

Option	**Cut & carry (kg/day)**	**Cattle sold over 5 years**	**Cattle on hand after 5 years**	**Annual fodder surplus (Kg/year)**	**2nd Dry season labour (days)**	**Final cash balance (Rp M)**
Baseline: Wet season: 0.6ha lowland rice, 0.3ha upland peanut, 2 cows						
	25	6	4	-3000	-20	2.6
Scenario 2: Plus 0.4ha of Elephant grass on upland						
	25	6	4	+400	+90	3.5
Scenario 3: Plus 200m of gliricidia on upland						
	25	6	4	-2000	0	3.6
Scenario 4: all 3 scenarios combined						
	25	9	4	+1200	+90	5.5

c) Change animal breeding.

Farmers have a preference to breed their own cattle rather than buy in calves for fattening. The limitation with the breeding option is the shortage of available bulls and the poor 'strike rate' of AI. To lessen the stress associated with the synchronization of draught activity, calf raising and the dietary shift from dry to wet feed late in the year, there is interest in adjusting the mating and calving schedule. Instead of mating in November or December, consideration might be given to calving in March/April and then mating 2-3 months later in June /July (to make it a 12 month cycle) – Scenario 5. With this schedule, the cow is being used for draft at a safe time of the pregnancy (avoid final 2 months of gestation) and is not raising a calf at the same time. Furthermore, the calf is born about the end of the wet season when there is still plenty of feed available and the cow is in good condition. Such modifications may result in improved growth rates for cattle and faster turnaround times from birth to sale.

While the various scenarios outlined above appear to be highly profitable, they were run using 2004 cattle prices, which are somewhat higher than traditional prices. Hence, to better understand any inherent risk to a management change, it is important to test the better options for sensitivity to changes in cattle prices.

Question for IAT: 'What is the impact of adjusting to a 12 month cycle with calving in March/April and mating in June /July?' 'What is the profit sensitivity to a decline in cattle price by 20%?'

Baseline scenario: As for scenario 4 in previous section.
Alternative scenario 5: As for baseline + seasonal mating of cows.
Alternative scenario 6: As for scenario 5 but with 20% lower beef prices.

Results: The introduction of seasonal mating into the final scenario in the previous section, increased cattle sales from 9 to 11 and the cash balance over 5 years from 5.5M to 6.2M Rp. A 20% decline in beef price would reduce the cash balance from 6.2M to 4.5M Rp, still far superior to the original baseline design.

Option	Cut & carry (kg/day)	Cattle sold over 5 years	Cattle on hand after 5 years	Annual fodder surplus (Kg/year)	2nd Dry season labour (days)	Final cash balance (Rp M)
Baseline: Wet season: 0.6ha lowland rice, 0.3ha upland peanut, 200m of tree legume, 0.4ha of Elephant grass						
	25	9	4	+1200	+90	5.5
Scenario 5: Plus seasonal mating of cows						
	25	11	2	+1200	+90	6.2
Scenario 6: As for Scenario 5 but with 20% lower beef prices						
	25	11	2	+1200	+90	4.5

d) Utilisation of extra forage produced on the farm

Growing Elephant grass and gliricidia and retaining peanut crop residues gives a surplus of 1200 kg/year of feed that could be utilized in either of 2 ways. The farmer could keep extra breeding cows and hence breed more weaners to sell or, alternatively, the farmer could keep weaners until they were 2 year old to benefit from the extra animal growth as well as the higher price/kg paid for 2 year old animals.

Question for IAT: 'What is the impact of increasing the number of cows to 4 or, alternatively, not selling animals until 2 years of age?'

Baseline scenario: As for scenario 5 above.
Alternative scenario 7: As for baseline + 2 extra breeding cows.
Alternative scenario 8: As for baseline but selling animals at 2 years of age.

Results: Keeping an extra 2 breeding cows increases animals sales over 5 years to 21. There is a small fodder deficit but the final cash balance increases to 11.2M Rp. Retaining only 2 breeder cows but not selling animals until 2 years of age has a greater benefit. Animal sales remain at 9 but revenue from animal sales increases from 1-3M Rp per year up to 4M Rp per year. As a result, the final cash balance increases to 21.8M Rp. There is still a small annual fodder deficit.

Option	Cut & carry (kg/day)	Cattle sold over 5 years	Cattle on hand after 5 years	Annual fodder surplus (Kg/year)	2nd Dry season labour (days)	Final cash balance (Rp M)
Baseline: Wet season: 0.6ha lowland rice, 0.3ha upland peanut, 200m of tree legume, 0.4ha of Elephant grass, seasonal mating, 25kg cut & carry						
	25	9	4	+1200	+90	6.2
Scenario 7: Baseline plus 2 extra breeding cows, 40kg cut & carry						
	40	21	4	-500	+40	11.2
Scenario 8: Baseline but selling at 2 year-old, 35kg cut & carry						
	35	9	4	-500	+90	19.6

CONCLUSIONS

The new systems-based analytical toolkit has allowed the economic, social and production benefits of alternative crop and forage production in smallholder farming systems to be explored concurrently. Preliminary analyses have shown that substantial improvements can be made to farm profitability and family welfare from within the resources and constraints of current farming practices. The analyses indicate that retaining crop residues, growing tree legumes as living fences or hedgerows, and Elephant grass all contribute to increased animal production by reducing annual forage deficit. This, in turn, decreases labour requirements in the late dry season as fodder does not have to be obtained from long distances. Additionally, the analyses suggest there may be benefits in growing a lesser number of animals to an older age before selling, rather than increasing animal numbers.

A new project is currently being prepared to further develop and test the tools and approaches described in this paper and to communicate the outputs of the project to smallholder farmers, both in the immediate vicinity of the case study sites and more broadly across eastern Indonesia; and also to other providers of research and extension services.

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