An integrated modelling approach to enhance Bali cattle production in the mixed crop/livestock systems of Indonesia

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Media summary

A farming systems research approach to investigate the benefits of new forages to improve cattle production in mixed crop-livestock systems of Indonesia

Keywords

Farming systems, modeling, forage, Bali cattle

Abstract

Many forages suitable for improving livestock production in mixed crop-livestock systems in the tropics have been identified, however their adoption has been limited, even when participatory research has been used. 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 farming systems research approach that investigates the benefits of new forages to improve cattle production in mixed crop-livestock systems of Indonesia, and quantifies these benefits in bio-physical and economic terms.

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 fuelled by increased demand in Java has led to a rapid decline in Bali cattle numbers, including breeders. While the strong growth in demand does provide opportunities for farmers to increase income from livestock production and improve the economic sustainability of their farming enterprises, some major constraints (e.g. animal feed, management and health) need to be addressed. Use of improved forages has the capacity to address these constraints, but also introduces conflicts with resource demands 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 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 unacceptable 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.

Method

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 selected villages in Sulawesi and Sumbawa. 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. 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 Napier 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). 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. A whole farm economic model (spreadsheet) was developed to identify economic returns and resource constraints associated with new forage-livestock opportunities which covered the key resource pools of labour, finance, land area, forage and draught. Input data was sourced from the step 1 benchmarking activity, field monitoring, and from the biophysical models.

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 details and; (c) economic performance (cash balance and gross margins).

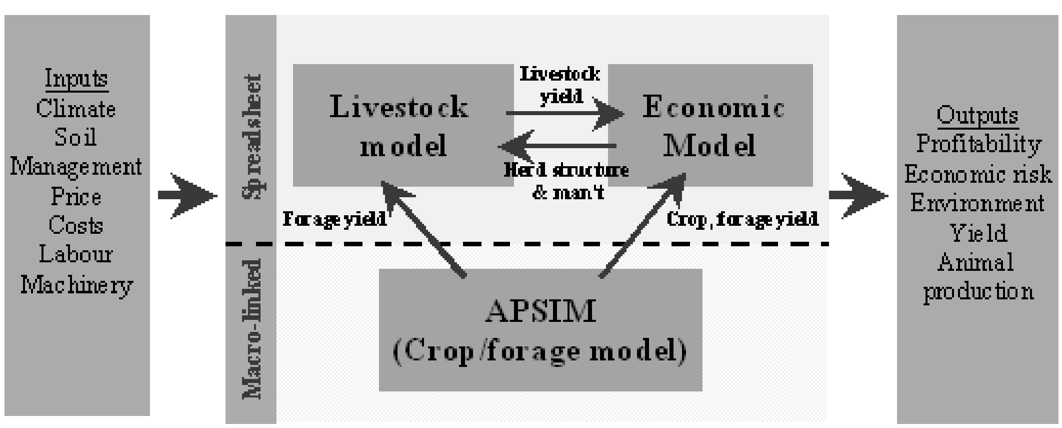

Figure 1. Framework of 'Integrated Analysis Tool'.

Case study: Introducing mucuna and Napier grass into a farm in Harapan, South Sulawesi

Use of the IAT is illustrated with an example to assess the impact of changes in forage supply on a representative mixed farming household in a village (Harapan: 4.8S 119.3E, 2953 mm rainfall in 2002) in South Sulawesi. The changes involve 2 forage improvement scenarios (a) displacement of an existing fallow with mucuna, and (b) cultivation of an additional small area of Napier grass (Table 1). Results for a 12 month simulation are shown in Figure 2.

Baseline

Crop production on the total lowland area (0.6 ha) consists of rainfed rice in the wet season, then fallow for the rest of the year due to insufficient irrigation water. A small portion (0.3 ha) of the upland area (total 2.3 ha), suitable for rainfed crop production, is sown to peanut in the wet season. The household has three animals, including a male weaner, which is sold at the end of the year, a 2 year old female and an older cow. Peanut stover is conserved and used as cattle feed. Pasture and cut and carry are available from all uncropped upland and lowland areas. The system supports a family comprised of 2 children and 3 adults.

Table 1. Key settings for the baseline and alternate forage scenarios

	Baseline	**+ Mucuna**	**+ Napier Grass**
Lowland rotation	Rice/Fallow	Rice/Mucuna (dry)	Rice/Mucuna (dry)
Lowland area (ha, Crop 1/ Crop 2)	0.6/0.6	0.6/0.6	0.6/0.6
Upland rotation	Peanut	Peanut	Peanut
Upland crop area (ha)	0.3	0.3	0.3
No. Livestock	3	4	6
Residue	Peanut conserved	Peanut conserved	Peanut conserved
Family (people)	5	5	5
Cut and carry (all animals)	10kg/day	15kg/day	20kg/day
Backyard forage	Nil	Nil	0.2ha Napier Grass

Wet season rice yields 6t/ha and upland peanut 3.5t/ha. The household gross margin is Rp5.64 million (comparable with estimates derived from the benchmarking activity – Step 1). Primary income sources are from grain sales (Figure 2 AD). Cow growth over the year approaches, follows and then falls below potential production as a feed deficit develops and feed quality decreases. Calves are about 200 days of age (weaner not shown) (Figures 4 AE). The provision of peanut stover (~day 160) partly delays the decline in cattle production (Figure 2 AF). When all available on-farm 'pasture' and other sources of feed (stover etc.) are exhausted, a feed deficit develops and the farmer cuts and carries feed from communal areas (e.g. roadsides etc.). Labour surpluses occur in each of the 3 seasons (i.e. W - wet, D1 - early dry and D2 - late dry). The lowest surplus occurs in the wet season when the family is largely occupied with crop activities (Figure 2 AG).

Scenario 1 - Inclusion of mucuna as a dry season crop in lowland fields

The entire lowland area (0.6ha) currently in fallow after the wet season rice crop, is sown to mucuna, allowing the stock carrying capacity to increase to support another weaner. Total available native pasture biomass declines due to the displacement of the fallow with the sown mucuna (Figure 2 BF). As a consequence, a feed deficit develops prior to the availability of feed from the mucuna crop (harvested at the start of grain fill) and from peanut stover (upland crop). However, the provision of high quality legume feed shifts liveweight gain closer to the potential compared with the benchmark case (above) with consequent increases in condition score and sale price of the yearling (Figure 2 BE). This is reflected by the 18% increase in household gross margin to Rp6.65 million (Figure 2 BD). Although a second feed deficit appears in the late dry season, toward the end of the year sufficient labour remains available throughout the year (in each of the 3 seasons) to collect forage off-farm (Figure 2 BG).

Scenario 2 - Inclusion of Napier grass in the backyard

This scenario extends the previous one, and includes the establishment of 0.2ha of Napier grass in the backyard area of the house. Stock carrying capacity is increased to include 3 weaners (all sold), 2 two-year old females and an older female. The feed deficit (Scenario 1) is substantially reduced as a consequence of the ~2-monthly harvests of Napier grass throughout the year (Figure 2 CF). However, available peanut stover and higher quality mucuna forage is insufficient to maintain potential cattle production, producing yearlings with similar condition and sale value as the previous scenario (Figure 2 CE). The gross margin for this scenario increases by 37% above the baseline to reach Rp7.48 million (Figure 2 CD). There is no labour deficit in any of the seasons (Figure 2 CG).

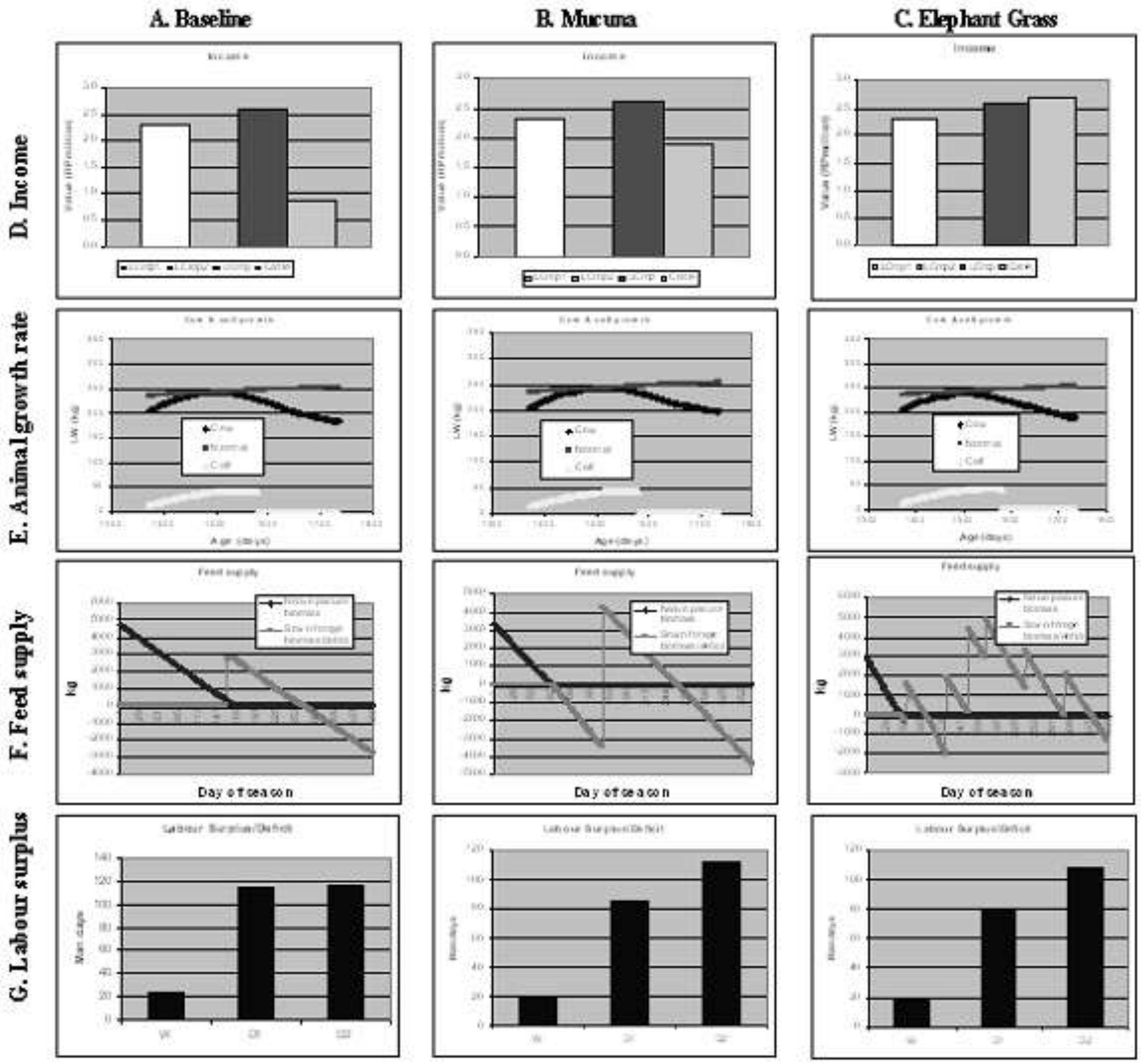

Figure 2. IAT output for benchmark and alternate forage scenarios (see text for details)

Conclusion

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 systems. An extension of this work is currently trialing the IAT with farmers and their advisors in Sulawesi and Sumbawa to gauge their acceptance of both the tools and the associated output, and to further test options revealed by the integrated model through on-farm production and demonstration trials.

Acknowledgements

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