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Demand-driven crop-ruminant intensification: transregional analysis to understand patterns of change using village level data from three continents

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Introduction The livestock revolution (Delgado *et al*. 1999) promises to drive increased livestock production in developing countries. In the case of ruminants, much of this increase may occur in mixed farming systems, rather than through industrial production. In 1991-93, mixed systems produced 92% of the world's milk, and 54% of the world's meat (de *Haan et al*. 1997). (Delgado *et al*. 1999) predict that by 2020, developing countries will produce on average 38% more meat and 54% more milk per capita than in the early 1990s, much of it in mixed systems. The attention given to these demand-led trends, however, has also underlined the fact that the precise nature of the resulting expected intensification is unclear. The wide variety of ruminant production systems observed globally, differing in both scale and level of intensity, point to the importance of local factors in determining farmer's production choices. Those factors may include not only local agro-climatic conditions and animal disease challenge, but also infrastructure, access to markets, capital and services, nature of local demand and the opportunity costs of labour, but critically on the potential for interaction with crop production and other uses of land. Given this complexity of outcomes and the certainty of coming demand-driven intensification, researchers and planners are currently poorly equipped to predict where and how changes will occur in national crop-ruminant production systems. While the basic driving factors can be identified, the understanding of their effects is not adequate to make predictions elsewhere and in future years. In an attempt to address these issues, this paper presents the analysis of crop- ruminant intensification and interaction at a broad dimension, using farmer-group interviews from sites in 15 countries.

Theoretical background The general model of crop- livestock interactions and intensification originates in the work of Boserup, Pingali (1993) (*in* Powell and Williams 1993) and (McIntire *et al* 1992). The Boserup hypothesis states that population growth brings about technological development because of decreasing land availability. Intensification is thus described as an endogenous process in response to increased population pressure. As the ratio land to population decreases, farmers are induced to adopt technologies that raise returns to land at the expense of higher input of labour. The direct causal factor is relative factor price changes. The effects of the livestock revolution will likely be greater market opportunities for livestock products, and so greater market-orientation of production. Environmental characteristics play a significant role in determining the evolution of crop- livestock systems ((McIntire *et al* (1992) Powell and Williams (1993)). For example, in humid areas with strong animal disease challenge, levels of interactions may be low simply due to fewer livestock. Crop-livestock interactions are sometimes seen as an evolutionary process. As first described by (McIntire *et al* 1992) the effect of population density on crop- livestock interactions can be described by an inverted U relationship. As population density increases, the level of interaction increases and reaches a maximal level at intermediate level of population density, after which specialization and lower interaction occurs at higher density.

Presentation of the sites A total of 48 sites, in 15 countries of Sub-Saharan Africa, Asia and Latin America were surveyed from November 2000 to October 2001. The data collection was realized in one-day visits to specific areas. Farmer- group interviews were used to collect the needed data using a checklist covering a wide range of crop- livestock interactions. Sites were selected to reflect a wide range of agroclimatic characteristics and level of agricultural intensification. A total of 18 sites were surveyed in the semi- arid zone, 8 in the sub- humid zone, 6 in the humid area and 16 in the highlands. Semi-arid, sub-humid and humid area are defined as area with, respectively, 50 to 180, 180 to 270, and more than 270 days of growing period. Highlands are defined as sites above 1,000 m above sea level. This definition follows Jahnke (McIntire *et al* 1992). Data on length of growing period are extracted from the Global AEZ FAO database.

Table 1 Number of sites by agroclimate and feeding system (numbers in parentheses indicate the percentage of sites within agroclimate)

	Semi arid	Sub humid	Humid	Highlands	Total
Grazing	7 (38.9)	2 (25.0)	1 (16.7)	4 (25.0)	14 (29.2)
Mainly grazing	2 (11.1)	3 (37.5)	4 (66.7)	3 (18.8)	12 (25.0)
Mainly stall feeding	4 (22.2)	1 (12.5)	0 (0.0)	3 (18.8)	8 (16.7)
Stall feeding	5 (27.8)	2 (25.0)	1 (16.7)	6 (37.5)	14 (29.2)
Total	18	8	6	16	48

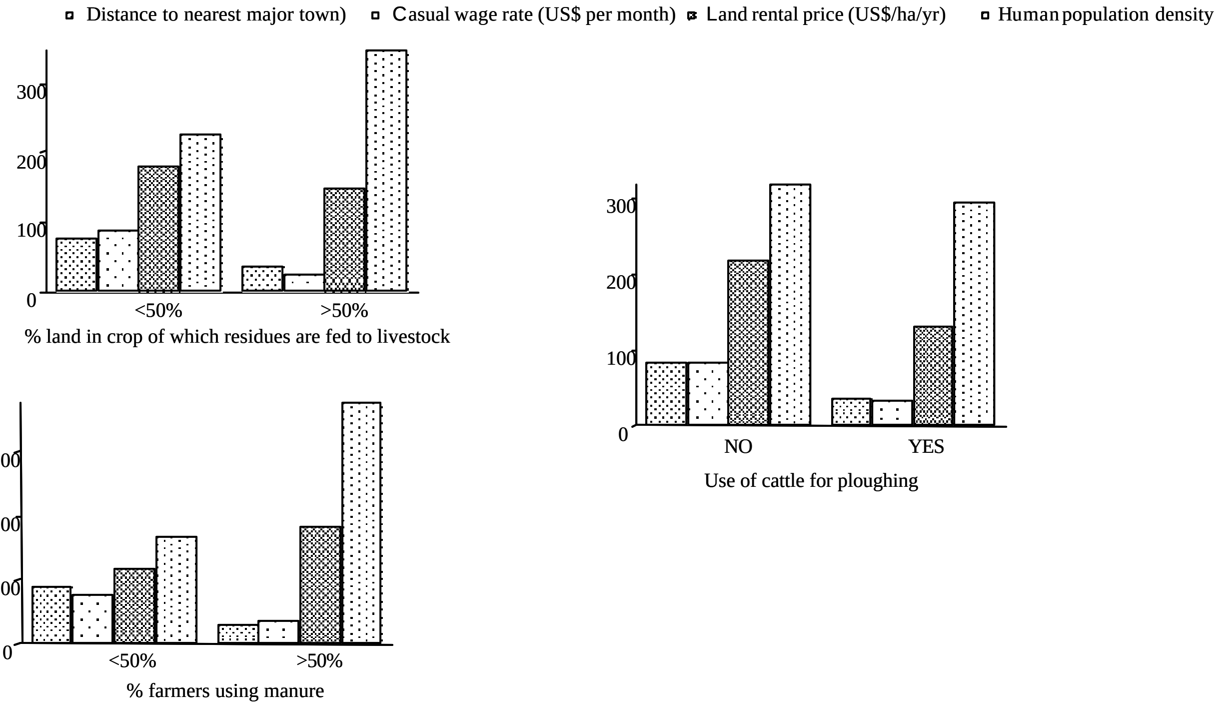
Data analysis The focus of the analysis is on levels of livestock intensification and crop- livestock interactions. The indicator of livestock intensification retained in the analysis is the main type of feeding system. Four types were distinguished: grazing (unimproved and improved) pasture, mainly grazing; (including tethering) with some stall feeding;

mainly stall feeding with some grazing; and stall feeding only. Table 1 presents the distribution of the surveyed sites by agroclimate and main type of feeding system. Although the main type of feeding system in semi- arid areas is grazing, for half of the sites animals are either mainly or entirely stall- fed.

The analysis of the determinants of the main type of feeding system shows that the relationship between education level (percentage of farmers with at least primary education) and intensification level is, as expected, positive. Level of education captures farmers' ability to adopt new technologies associated with the intensification process. The indicator of opportunity cost of family labour and farmers' market accessibility (distance to the nearest urban center) shows that sites where stall-feeding is the dominant system are those closest to a market. As expected, there is a positive relationship between population density and level of intensification since human density is significantly lower in the least intensified sites. The relationship between cost of labour and intensification levels is, as expected negative: the intensification process is labour-intensive and is likely to occur primarily in sites where labour costs are relatively low. Finally, while milk prices are relatively constant across systems, the ratio of wage rate/ milk price is significantly lower in the most intensified sites, a result consistent with the predictions of the conceptual framework.

Three indicators of crop- livestock interactions are used and results are presented in figure 1. The first indicator is the use of own crop residues on farm for animal feeding. Data show that farmers in the semi- arid areas devote significantly more land to crop for animal feeding that in the other areas. Sites where at least half of the land is planted with crops whose residues are fed to the animals are closer to an urban centre and have lower labour costs. The second indicator of crop- livestock interactions is the use of manure on farm. Farmers in the humid zone use significantly less manure. The determinants that differ significantly across the two groups are similar to those identified in the case of use of crop residues. The land rental rate also differs across groups: sites where at least half of the farmers use manure are characterized by higher land rental rates. As the land becomes more valuable, farmers invest in soil fertility maintenance by applying manure. The third indicator of crop- livestock interactions is the use of livestock for ploughing. Farmers in semi- arid areas use on average more cattle for ploughing compared to the humid and highlands areas. Looking at the determinants of crop- livestock interactions, the results are the same for the distance to an urban center and for labour cost. However, human population density does not differ significantly. Also, the land rental rate is higher in sites where cattle are not used for ploughing. This last result can be explained by the relatively lower rental rates in the semi- arid areas where the use of cattle for ploughing is more common. When combined these three indicators were plotted to show that the McIntire U curve can indeed be demonstrated, with variables estimated at 5% level (not shown due to space).

Figure 1: Crop- livestock interactions



Conclusion The driving forces of growing demand for livestock products, coupled with increased population density, are intensifying mixed crop-ruminant systems in developing countries. The results described here show that those changes are occurring in somewhat consistent patterns. Although agro-climatic characteristics are important to understand smallholder crop- livestock systems, socio- economic factors do play a significant role. Costs of the primary factors of production, land and labour, determine partly the structure of crop- livestock smallholder production systems. Also, human population density, education level and access to market are important factors. However, village-level results hide homogeneity at the farm level. Next steps of the trans-regional project aim at analyzing smallholder crop-livestock systems at the landscape and farm- levels, to discompose broad patterns into underlying components.

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