Crop residues in smallholder systems: Pressures and trade-offs

Alan Duncan, Bruno Gérard, Diego Valbuena, Michael Blümmel and Shirley Tarawali

Contrary to the popular view that cereal crop residues are just a low quality by-product of arable production, crop residues are increasingly seen to play a critical role in smallholder mixed crop-livestock systems in the developing world. Crop residues represent biomass, an increasingly valuable resource as these systems evolve. In these systems, crops provide food for the household and the market as well as residues to feed livestock. Livestock provide traction for cultivation and transport as well as converting residues into manure. This interlinking of crop and livestock production is a central feature of mixed crop-livestock systems. However, the equilibrium is increasingly disturbed by various external drivers.

Worldwide, crop-livestock systems are in transition and we expect them to evolve differently in different places and contexts. The challenge is to make this transition a positive one for people, the environment and national economies.

This brief considers the growing pressures on crop residues in mixed systems and highlights ways that ILRI and its partners have developed our understanding of trade-offs and their implications for farm livelihoods and environmental sustainability.

A key milestone in this area of research was the establishment of the CGIAR System-wide Livestock Programme (SLP) in 1995. The SLP was convened by ILRI and has drawn together a consortium of CGIAR ‘crop’ and ‘natural resources management’ centres to properly consider livestock dimensions of their research. Bringing together crop and livestock centres in collaborative research has done much to develop systems thinking within the CGIAR and the research for development community in general.
Research on mixed crop-livestock systems

There are two broad areas of research on crop residues in mixed crop livestock systems. The first is work on crop residues as feed and ways of improving the feeding value of crop residues through breeding and processing. The second is systems work that integrates the contributions of different farming components to overall farming livelihoods and natural resources management. This integrated understanding is important as we seek ways to support a sustainable transition in crop-livestock systems.

Feeds research

A significant area of crop residues research conducted by ILRI and partners has been on food-feed crop improvement. As we have seen, the conventional view of crop residues is as by-products of cereal, legume and tuber production. This ignores the important role of crop residues as a basal feed in smallholder systems across the developing world. Between 40 and 60% of livestock diets are made up of crop residues in sub-Saharan Africa and South Asia. The subsidiary role of crop residues in mainstream thinking in the research for development community is reflected in the stark lack of attention given to crop residue traits in national breeding programmes for staple crops. Such programmes are generally almost entirely focused on grain traits despite the economic importance of residues as livestock feed.

A key research output addressing this lack of attention was a special issue of Field Crops Research in 2003 entitled ‘approaches to improve the utilization of food-feed crops’ (Lenne et al. 2003). More recently, ILRI scientists and partners with expertise in crop science in India have conducted extensive work which demonstrates that variation in residue traits of existing cereal and legume cultivars could significantly improve animal performance through appropriate cultivar selection (Blummel et al. 2009). This work has led to residue traits being included in national breeding programmes for staple crops for the first time (Sharma et al. 2010). The potential long-term benefits to livestock production and smallholder livelihoods through even small increments in residue yield and quality are substantial.

Systems research

From the early emphasis on feeding value of crop residues, recent SLP research focused on developing a systems understanding of crop-livestock farming systems. As far as systems work is concerned, the key inter-linkages between crop and livestock production have long been known (see for example, Renard 1997).

A recent study of crop livestock interactions in the Indo-Gangetic Plains (IGP) of India brought a more nuanced understanding of how gradients of intensification lead to changing pressures on crop residues (Erenstein et al. 2007). This built on the work of McIntire which conceptualized the gradient of interconnections between livestock and crop systems at different stages along the intensification continuum (McIntire et al. 1992).

This IGP work showed how intensification led to different feeding strategies with most pressure on crop residues at intermediate stages of intensification; this is the stage where there is already strong integration of crop and livestock production but technological inputs to raise productivity are not yet exploited. This work also quantified the decoupling of crop and livestock production in high intensity systems and considered the environmental sustainability implications of such decoupling. These themes are further explored in an ongoing study on crop residue trade-offs.

What have we learned – drivers and pressures?

A recent ILRI-led study (Herrero et al. 2010) concluded that “farmers in mixed crop-livestock systems produce about half of the world’s food.” It also identified two major pressures on mixed crop-livestock systems: First, as incomes increase and populations move to urban centres, people in developing countries increasingly favour animal source foods. Second, population growth has led to greatly increased demands for staple cereals, leading to expansion of land under cultivation and a decline in traditional grazing resources. Since crop residues are key feed resources in such systems, the study called for

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1 Optimizing livelihood and environmental benefits from crop residues in smallholder crop-livestock systems in sub-Saharan Africa and South Asia: regional case studies 2009-2010. Supported by the CGIAR System-wide Livestock Programme.
increased effort to enhance the quality and nutritive value of crop residues.

Another study led by CIMMYT considered the expansion of renewable energy sources through biofuel production (Dixon et al. 2010) and the effects this might have on the rural poor in mixed crop-livestock systems. The story is complex and the winners and losers are difficult to predict. It is clear that with rising populations and increasing energy demands, biomass becomes an ever more valuable resource in these smallholder systems. Competition for biomass will become more acute as progress is made towards ‘second generation biofuels’ which will convert cellulose-based resources such as crop residues into both fuel and livestock feed.

An emerging theme in all this work is the growing pressure on biomass in smallholder systems which calls for complex trade-offs in allocating residues for different uses. Crop residues are in demand. They are used to feed livestock, to enhance soil fertility, to provide material for construction and to provide household energy.

Such trade-offs in residue use were the focus of another global study. This looked at the two main potential uses of crop residues - for animal fodder and for soil fertility improvement. Using crop residues to feed livestock provides short-term benefits for farmers and is important for current livelihoods. Retaining crop residues on the soil provides longer-term benefits: Soil fertility, soil health and water-holding capacity are retained, and in the long run, grain and residue yields are maintained, sustaining livelihoods into the future. With increasing pressure on residues there is a growing trend to feed more and leave less. This has worrying implications for the long term environmental sustainability of mixed crop-livestock systems and for long-term staple crop yields.

Early results from the study point to considerable diversity across systems and geographies. A general conclusion is that the greatest pressure on crop residue use occurs at intermediate stages of intensification. In extensive systems, common property resources are the main source of biomass for livestock feeding. In intensive systems there is some decoupling of crop and livestock production, and overall biomass productivity is high enough to relieve pressure on crop residue use. During the transition however, the pressure is intense and much of the harvested residue is fed to livestock. This transition period is where significant opportunities exist for research to support sustainable transitions that benefit people, the environment and national economies.

Future directions

Ongoing research on biomass trade-offs in smallholder systems shows the decision making process at farm level to be influenced by a complex range of factors. It is difficult to suggest simple solutions that balance short-term and long-term benefits at farm level and balance current farm livelihoods and long-term ecosystem health. Teasing out some general principles from this complexity is, however, essential if we are to provide tailored solutions for farms in different contexts.
strong incentives for more efficient use of resources.
Another option is to provide opportunities for farmers to
seek off-farm employment, reducing pressure on land to
deliver livelihoods. The way such problems are tackled
is important. Innovation systems approaches and multi-
stakeholder alliances can help bring together communi-
ties, extension, research, input suppliers, and govern-
ment to co-develop sustainable solutions.

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