Integrated crop livestock systems - a key to sustainable intensification in Africa

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Abstract. Mixed crop-livestock systems provide livelihoods for a billion people and produce half the world's cereal and around a third of its beef and milk. Market orientation and strong and growing demand for food provide powerful incentives for sustainable intensification of both crop and livestock enterprises in smallholders' mixed systems in Africa. Better exploitation of the mutually reinforcing nature of crop and livestock systems can contribute to a positive, inclusive growth trajectory that is both ecologically and economically sustainable. In mixed systems, livestock intensification is often neglected relative to crops, yet livestock can make a positive contribution to raising productivity of the entire farming system. Similarly, intensification of crop production can pay dividends for livestock and enhance natural resources management, especially through increased biomass availability. Intensification and improved efficiency of livestock production means less greenhouse gases per unit of milk and more milk per unit of water. This paper argues that the opportunities and challenges justify greater investment in research for development to identify exactly where and how win-win outcomes can be achieved and what incentives, policies, technologies and other features of the enabling environment are needed to enable sustainable, integrated and productive mixed crop livstock systems.

Keywords: Integration, mixed crop livestock intensification, sustainability.

The global importance of mixed crop-livestock systems

Mixed crop-livestock systems produce 50% of global cereals, 34% of beef and 30% of milk. Almost one billion people rely on these systems as their primary source of livelihood (Herrero *et al.* 2009). A recent review and update of global farming systems assessments stressed the importance of including how crops and animals are produced and how they interact if such information is to be used in the context of priority setting and targeting related to livelihoods (Robinson *et al* 2011).

The extent and importance of these systems for livelihoods, food security and natural resource management, against a backdrop of growing demand for food, needs to be balanced against potentially negative impacts on natural resources and the environment. These arise where systems have already reached a limit of natural resource use (Herrero *et al*. 2009), or where the environmental footprint per unit of product is high due to low animal productivity. Key interactions in integrated mixed systems relate to following factors.

Feeding

Straw, stover and other fibrous by-products of cereal and legume production, thinnings and weeds make important contributions to ruminant diets in a wide range of agro-ecologies and farming systems. The role of crop residues in semi-arid areas with low and erratic rainfall is particularly significant; they may be the only source of feed in late dry seasons or drought periods (Valbuena *et al.* 2012).

Organic soil nutrients

Livestock manure can contribute to the nutrient needs of the crops and help to maintain soil organic matter and other beneficial physical properties, such as water and nutrient retention capacities. In remote areas with inefficient supply chains for inorganic fertilisers, livestock manure can be the only source of applied nutrients. Liu *et al*. (2010) estimate that 23% of the nitrogen for crop production in mixed systems comes from livestock.

Provision of power

Draught or dual-purpose cattle and equines ease the drudgery and burden of hand cultivation, harvesting and other cropping operations and increase crop yields. Despite increased mechanisation, animal traction continues to play an important role, especially in sub-Saharan Africa (FAO 2011).

Cash flows

The importance of cash income from livestock, which can be reinvested in another enterprise, is often ignored in considering crop-livestock integration, yet this can be very

significant. In southern Zimbabwe, for example, women sell goats to purchase inputs for their cropping enterprises, amongst other needs (Homann *et al.* 2007).

Integrated systems - key drivers and trends

Integrated crop-livestock systems are under considerable pressure due to rapidly rising human populations in developing countries. In addition, the trend towards increased urbanisation and rising incomes in these regions leads to shift in diets – less reliance on staples cereals and tubers; more demand for better quality and more diverse diets made up of more fruit and vegetables, and much more meat, milk, eggs and fish – the animal-source foods (Delgado *et al*. 1999; FAO, 2011; 2012b).

The rising demand presents environmental, economic and social challenges such as land and water degradation, greenhouse gas emissions and smallholder marginalisation. It also presents opportunities for some (not all) crop-livestock systems to be part of a positive livestock-sector transformation in developing countries (Tarawali *et al.* 2011). Balancing these issues necessitates addressing the current low productivity of mixed crop-livestock systems and their unfavourable environmental footprint, in the context of a complex of both technological and institutional dimensions (Pretty *et al.* 2011). Such a positive trajectory will include a shift from smallholders raising many low-producing animals to fewer, more productive livestock in efficient and market-linked systems. This is what is referred to here as intensification of livestock dimensions – not a shift to industrial style production. In some instances the route will facilitate a transition from agriculture-dependent livelihoods to other options, including establishment of small businesses and access to better educational opportunities for children, which opens a wider range of opportunities than were available to their parents. So, while intensification and greater market orientation can provide additional investments for further crop-livestock intensification, migration and diversification can lead to household labour shortages on the farm. Both, however, can also be drivers for yet further intensification – or, alternatively, facilitate orderly exit from the sector.

Compared to Asia, cereal yields in Africa have increased at a much lower rate; this is due to multiple factors, including poor agro-ecological conditions and governance, lack of efficient input-supply systems and dysfunctional output markets (FAO 2012a). The story is similar for livestock. Africa is still characterized by large numbers of unproductive livestock and high livestock mortality rates, often above 20% per annum. Low off-take rates, typically below 3% per annum, suggest a huge potential for economic benefits if the losses could be prevented and transformed into marketable products (Van Rooyen and Homann 2009).

Fortunately, there are islands of success in Africa, such as the Kenya dairy sector. Here smallholders are doing much better: best-practice technology and management options have been adopted, input and output markets function, natural resources are sustainably managed, and high- quality crops and animal-source foods are produced in an appropriate policy environment, generating a net present value of $230 million which is benefiting producers, consumers and vendors (Kaitibie *et al.* 2010).

Coupled nature of crop-livestock interactions – need for sustainable intensification

Herrero *et al*. (2009, 2010) distinguish two classes of crop-livestock systems which differ in their degree of intensification and potential for further growth. Mixed intensive systems have higher population density, high agro-ecological potential, especially through irrigation, and good links to markets with some purchased inputs being regularly used. In contrast, mixed extensive systems have medium population density, moderate agro-ecological potential, are largely dependent on rainfed agriculture and use few purchased inputs. The latter systems have potential for sustainable intensification, the former have in many cases reached limits in terms of biophysical aspects and some may need to de-intensify.

Market orientation and strong and growing demand for food provides powerful incentives for intensification and greater efficiency of both crop and livestock enterprises in smallholder mixed systems in Africa. We also present below some ideas on how to exploit the mutually reinforcing nature of crop-livestock systems to raise productivity in a manner that is both ecologically and economically sustainable.

In mixed systems intensification of both crops and livestock is needed

Livestock are often the neglected element of mixed systems; research, development and extension efforts tend to favour intensification of staple crops, despite consistent evidence that four out of five of the highest value commodities are livestock products (FAOSTAT 2013). A recent study of intensification from 72 villages across the Indo-Gangetic Plain, (Erenstein and Thorpe 2010) illustrated the effects of lagging livestock intensification; although crop production has intensified, livestock systems have not. Lack of intensification of livestock production relates to policy issues, such as heavy subsidies for fertilizer and irrigation. This asynchrony in the pace of crop and livestock intensification has environmental implications; for example, low-producing animals are less likely to be housed and more likely to consume crop residues from the field with implications for both residue and manure management and use – key dimensions of integrated systems. In sub-Saharan Africa, Haileselassie *et al.* (2009) showed that mixed systems have higher water productivity than crop production alone. Descheemaeker *et al.* (2010) reinforced such results, providing examples of threefold increases in water productivity for mixed as compared to single enterprise systems and explored the supporting policy and institutional issues.

Intensification of crop production can pay dividends for livestock and the environment

Crop residues are a key element of the interaction between crops and livestock in mixed systems. However, competing uses for residues are numerous and include livestock feeding, retention as sources of soil organic matter, use as household fuel and for construction, and sales to others for all these uses, amongst other uses. Results from a recent nine-country study spanning sub-Saharan Africa and South Asia showed that, across all locations, livestock feeding

accounted for a major proportion of crop residue use. Evidence showed that some mulching was practiced only in the most intensive sites, but elsewhere there was almost no allocation of crop residues to soil improvement. Continual removal of crop residue biomass will deplete soil organic matter and is unsustainable in the long term (Valbuena *et al*. 2012).This study illustrates the pressure on biomass in smallholder systems and indicates the need to increase biomass productivity. Sustainable intensification (Pretty *et al*. 2011) of mixed crop-livestock systems is one of the answers: although crop residues might be allocated to livestock feeding, manure can then be applied to the soil and income from sales of livestock products can be used to buy fertilizer to drive increases in crop productivity, including of improved dual food-feed crops or even forage crops, with the overall result being increased farm productivity.

Intensification of livestock production can reduce greenhouse gas production

Livestock production is often associated with high usage and pollution of water and greenhouse gas emissions (Steinfeld *et al*. 2006). In smallholder systems, however, livestock intensification will be essential to curb the negative environmental consequences associated with the sector, especially decreasing greenhouse gas emissions and reducing the amount of water used per unit of meat or milk produced (Capper 2011).

In India, increasing the milk yield from the current national average of 3.6 l per buffalo or cow per day to 15 l per day, which is considered attainable with current genetic quality, would roughly halve emissions per litre of milk produced (Tarawali *et al*. 2011). A large proportion of the water used in livestock production is used to produce feed so increasing per animal productivity has a dramatic effect in reducing the amount of water used per unit of livestock product (Descheemaeker *et al*. 2011).

Key considerations in increasing productivity and reducing environmental impacts include reallocation of available feed resources to fewer animals, increased per animal productivity and reduced numbers of animals. Plant breeders can select for improved crop-residue quality without reducing grain yield; this approach has now been adopted in a number of crop-breeding programs to produce better dual-purpose crops (Blummel 2010).

Conclusion and ways forward

Mixed crop-livestock systems make vital contributions to global food suppy and livelihoods. The contribution of livestock in these systems is, however, often neglected by reseach, development and extension organisations relative to crops. There is considerable potential, however, for a win-win in which greater productivity of crops and livestock is achieved in a more environmentally sustainable manner if the integration of crops and livestock in mixed systems is improved. A key challenge is how best to allocate biomass resources in these systems. The opportunities and challenges justify significantly more investment in research for development to identify exactly where and how win-win outcomes can be achieved and what incentives, policies, technologies and other features of the enabling environment are needed to encourage sustainable, integrated and productive mixed crop-livstock systems.

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