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 resource management, especially through increased biomass availability. Intensification and improved efficiency of livestock production mean 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-livestock systems.

Resumen

Los sistemas mixtos cultivos-ganadería proveen el sustento de mil millones de personas y producen la mitad de los cereales en el mundo y aproximadamente 1/3 de la carne y la leche. En África la creciente orientación hacia los mercados y la fuerte y creciente demanda por alimentos son poderosos incentivos para la intensificación sostenible tanto en el componente cultivos como ganadería en sistemas mixtos de pequeños productores. Un mejor aprovechamiento de la naturaleza de refuerzo mutuo de los sistemas mixtos cultivos-animales puede contribuir a un crecimiento que es ecológica y económicamente sostenible. En estos sistemas, la intensificación del componente pecuario a menudo recibe menor atención que los cultivos, a pesar de que puede hacer una gran contribución para elevar la productividad del sistema de producción como un conjunto. Por otro lado, la intensificación de la producción de cultivos puede proporcionar dividendos para el componente pecuario y el manejo de los recursos naturales, especialmente mediante el aumento de la biomasa disponible. La intensificación y el mejoramiento de la eficiencia en la producción pecuaria significan menos gases de efecto invernadero por unidad de leche producida y más leche por unidad de agua. En este documento se sostiene que las oportunidades y los desafíos justifican una mayor inversión en investigación para identificar en forma exacta dónde y cómo se logran resultados que sean beneficiosos para ambos componentes y qué incentivos, políticas, tecnologías y otras características de un entorno propicio son necesarios para el desarrollo de los sistemas mixtos cultivos-ganadería sostenibles, integrados y productivos.

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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, need 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 the 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 agroecologies 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 beneficial physical properties, such as water and nutrient retention capacities. In remote areas with inefficient supply chains for inorganic fertilizers, 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 mechanization, 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 urbanization 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; Otte et al. 2012).

The rising demand presents environmental, economic and social challenges, such as land and water degradation, greenhouse gas emissions and smallholder marginalization. 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 unfavorable 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 production – not a shift to industrial-style systems. 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 – options which will increasingly become available to those who remain part of a vibrant, carefully managed agricultural sector too. While intensification and greater market orientation can provide additional investments for further crop-livestock intensification, migration and diversification can lead to household labor shortages on the farm. Both, however, can also be drivers for yet further intensification – or, alternatively, facilitate orderly exit from the sector.

Compared with trends in Asia, cereal yields in Africa have increased at a much slower 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 2012). 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 US$230 M, 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 2 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 rain-fed 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 provide 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 crop and livestock production is needed

Livestock are often the neglected element of mixed systems; research, development and extension efforts tend to favor intensification of staple crops, despite consistent evidence that 4 out of 5 of the highest value commodities are livestock products (FAO 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 contrasts with policy initiatives in the crop sector, 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 3-fold increases in water productivity for mixed as compared with 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 and other uses. Results from a recent 9-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 but only in the most intensive sites; 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). The 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 liter of milk produced (Tarawali et al. 2011). A large proportion of the water used in livestock production is used to produce feed, so increasing 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 production 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 (Blümmel 2010).

Conclusion and ways forward

Mixed crop-livestock systems make vital contributions to global food supply and livelihoods. The contribution of livestock in these systems is, however, often neglected by research, development and extension organizations relative to crops. There is considerable potential, however, for a win-win situation, 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-livestock systems.

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