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Trade-offs in livestock development at farm level: Different actors with different objectives

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ABSTRACT

The livestock sector in Low and Middle Income Countries (LMICs) is evolving. In response to growing demand for livestock products, it is likely that smallholder production systems will experience varying forms of intensification. Associated decision making is made complex, not only with the intrinsic characteristics of livestock in LMICs (for instance as sources of income, assets, or social symbols), but also by diverse objectives of stakeholders and agricultural development paradigms. This paper discusses trade-offs that are likely to arise in the choice of livestock production systems; with a focus at household and farm level, economic gains, gender equity, environmental concerns, human nutrition and food safety are all considered. We begin by describing trajectories of livestock intensification in LMICs. Then potential trade-offs during such intensification are depicted; with examples concerning environmental, economic and social aspects. Recognising and understanding trade-offs is imperative; therefore we discuss decision making methods, the management of trade-offs and the balance between providing an average benefit for a population and the variation in benefit for individuals. Finally, a (partial) trade-off analysis is illustrated by use of a case study on household dairy cattle enterprises in Senegal. The discussion advocates for holistic approaches to agricultural development efforts, which include recognition of the multiple objectives and the associated trade-offs.

1. Introduction

Livestock production is important for improving the livelihoods and survival of human populations in Low and Middle Income Countries (LMICs) (FAO, 2009; Herrero et al., 2013a, 2014). It is estimated that up to one billion smallholders are supported by livestock globally, whilst the sector's market chains employ many millions more (Herrero et al., 2009; Thornton et al., 2002). The functions of livestock in LMICs are diverse and varying, these are summarised in Table 1.

The demand for livestock produce in LMICs is expected to continue to increase significantly (WHO, 2003; Alexandratos and Bruinsma, 2012). For instance, according to recent Food and Agriculture Organization (FAO) projections, with business-as-usual scenarios LMIC demand for meat will increase by 80% by 2030 and by more than 200% by 2050 (FAO, 2018). This growth is largely attributed to increasing populations, economic growth and urbanisation; and with such drivers concentrated in sub-Saharan Africa this is where the greatest demand increases are expected (Baldi and Gottardo, 2017; Hassen et al., 2016; UN, 2017). Smallholders are currently responsible for large proportions of LMIC livestock production (FAO, 2015; IFAD, 2015; The World Bank, 2007), and with suggested yield gaps there is potential for increased production (Van Ittersum et al., 2016; Mayberry et al., 2017). Therefore, with varying levels of intervention and intensification smallholders are likely to remain a significant contributor, alongside more industrialised systems, in meeting the aforementioned demand (Herrero et al., 2014; McDermott et al., 2010; The Montpellier Panel, 2013; Thornton, 2010; Staal et al., 2009).

Livestock production is complex. The sector provides human populations in LMICs with important services and resources (including nutrition, livelihood support and ecosystem services) (FAO, 2012, 2016). However, there is also a global recognition that livestock production plays a significant role in human induced negative environmental impacts (including greenhouse gas emissions, water depletion and pollution, land use change, and biodiversity impacts)

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Table 1
A summary of the recognised functions of livestock in low and middle income countries.

Livestock function	Further information
Source of food and nutrition	(Moll et al., 2007; Ndlovu, 2010; Gupta, 2016; Wu, 2016)
Source of income through the sale of products, services or livestock; and as savings and insurance assets (for risk management and credit access)	(Ejlertsen et al., 2013; Weiler et al., 2014; Thompson et al., 2009)
Provision of manure fertilizer and draught power, as well as a use for crop by-products, within mixed crop livestock systems	(Moll et al., 2007; Udo and Cornelissen, 1998)
Climate-change and seasonal resilience	(Wilson et al., 2005)
Social functions including symbols of prestige and status, dowry value, and for ceremonies	(Crane, 2010; Pica-Ciamarra et al., 2011; Ejlertsen et al., 2013; Moll et al., 2007)

(Steinfeld et al., 2006; Rivera-Ferre et al., 2016). With cumulatively large animal populations and low levels of productivity, it is likely that smallholders contribute significantly towards these impacts (Herrero et al., 2013b). An increase in demand for livestock products, met by business-as-usual production systems, is likely to increase global environmental impacts significantly (O'Mara, 2011). In acknowledgement, the concept of sustainable intensification (SI) (increasing agricultural yields without further environmental impact) has existed for some time (The Royal Society, 2009; Cook et al., 2015; Godfray and Garnett, 2014). In recent years the original focus of SI on environmentally sensitive production has been criticised for not recognising the true complexities of food production systems, including social and economic aspects (Loos et al., 2014; Cook et al., 2015). It is therefore suggested that the inclusion of environmental, economic and social indicators and perspectives would improve the success of SI efforts, these aspects are now being adapted (Smith et al., 2017; The Montpellier Panel, 2013; Campbell et al., 2014).

There is agreement that approaches to future agricultural development need to take a more holistic approach. But with a greater number of possible indicators or metrics to measure successful sustainable development, decisions concerning a 'most appropriate' course of action are complicated (Smith et al., 2017). Multiple objectives from stakeholders (varying from livestock keepers to policy makers and national governments) mean trade-offs in agricultural development decisions are likely to exist. This paper contributes towards the discussion by demonstrating the complexity and variation of likely trade-offs in the choice of household livestock production systems. We recognize that other aspects such as policy and market interventions are also important for SI, but these are beyond the scope of this paper. Farm level choices in household livestock production systems are then illustrated through a case study comparing household dairy enterprises in Senegal, where different levels of intensification (choice of livestock breed and management input) are evident.

2. Livestock and sustainable intensification

Livestock will play a key role in LMIC roadmaps to realise the SI of agriculture. The urban demand for livestock products is increasing rapidly, whilst livestock are also important for rural food security. In dry regions, where crops are impractical, livestock can be the only option (Thornton, 2010; Thornton and Gerber, 2010; Turner et al., 2014); whereas with higher-rainfalls mixed crop-livestock systems are dominant, and nutrient cycles and traction rely on livestock (Herrero et al., 2010; Traore et al., 2017; McDermott et al., 2010). Intensification of livestock production can occur through increased and improved feed availability, improved feeding practices and genetic gains (McDermott et al., 2010; Marshall, 2014). In turn the improved management of livestock can also have positive effects on crop production. Improved nutrient recycling of manure and more efficient use of animal traction can make crop focused interventions, like the application of inorganic fertilizer, use of improved seed, conservation agriculture and small-scale mechanization, more efficient (Rufino et al., 2006). In addition many smallholder systems rely on animal traction for both timely planting and good production; differences in access to this resource can be an important factor in explaining variation in crop yields between different farms (Traore et al., 2017).

The livestock SI elements of increased and improved feed availability, improved feeding practices and genetic gains are often interrelated and constraining factors need to be overcome. For example if indeed farmers have access to necessary artificial insemination, improved breeds generally require feed of higher quality and quantity (Klapwijk et al., 2014); which in many cases means the use of improved fodders and their specialised production (White et al., 2013). Whilst a focus on improving feed availability, through the production of dual purpose crop varieties, producing grain and biomass for animal feed (Blümmel et al., 2003), requires as a pre-requisite, animals that have the potential to substantially increase their production. Typically SI of livestock systems in LMIC is a step-wise process in which a production system cannot in one go switch from 'low-input low-output' to 'high-input high-output'. The livestock ladder (Udo et al., 2011) is one example of a theoretical representation of this.

3. Recognising trade-offs between opposing objectives

As in any other economic decision when resources are scarce, the 'most appropriate' action to take is likely to be decided upon using some form of trade-off analysis; where the 'most appropriate' option could be defined as meeting as many recognised objectives as possible through the action. Consideration of the costs and benefits at the multiple levels that have influence on smallholder livestock enterprises in LMICs, in a holistic approach, is likely to improve the success of any chosen interventions (Loos et al., 2014). As agricultural systems often have key objectives (e.g. food production) to some extent they can be designed with this in mind (Tittonell, 2013). However, as livestock systems are tightly linked to the environment, and in LMICs provide numerous other benefits to human populations (Table 1), a trade-off analysis can support a balanced decision to be made and controllable and uncontrollable factors to be recognised. The complexity of agricultural systems, and the need to consider social, economic and environmental aspects, mean the indicators for the 'most appropriate' actions under SI that could be included in a trade-off analysis are countless (Smith et al., 2017). In the following sections we describe some potential objective trade-offs, selected to cover environmental, economic and social aspects, which can arise for livestock development initiatives. As historically the first objective of SI, we start with minimising environmental impact, then discuss how other aspects relate.

3.1. Environmental impact

The environmental impacts of livestock production systems are well recognised; these include both negative greenhouse gas emissions, land degradation, biodiversity loss, and effluent pollution (FAO, 2012), and positive ecosystem services (FAO, 2016). Globally, the measures for ecological stability within intensification are common and considered robust (Smith et al., 2017). Inherently a priority for SI is an increase in production efficiency; with an assumption, largely based on both global