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Identifying determinants, pressures and trade-offs of crop residue use in mixed smallholder farms in Sub-Saharan Africa and South Asia

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ABSTRACT

Crop residues (CR) have become a limited resource in mixed crop-livestock farms. As a result of the increasing demand and low availability of alternative resources, CR became an essential resource for household activities, especially for livestock keeping; a major livelihood element of smallholder farmers in the developing world. Farmers' decisions on CR use are determined by farmers' preferences, total crop production, availability of alternative resources and demand for CR. Interaction of these determinants can result in pressures and trade-offs of CR use. Determinants, pressures and trade-offs are shaped by the specific socio-economic and agro-ecological context of these mixed farms. The objective of this paper is to provide a comparative analysis of the determinants of CR use and to examine some options to cope with pressures and trade-offs in 12 study sites across Sub-Saharan Africa and South Asia. Drawing on socio-economic data at household and village level, we describe how cereal intensification and livestock feed demand influence use, pressures and trade-offs of CR use across study sites, specifically cereal residue. Our results show that in low cereal production and livestock feed demand sites, despite a low demand for CR and availability of alternative biomass, pressures and trade-offs of CR use are common particularly in the dry season. In sites with moderate cereal production, and low–moderate and moderate livestock feed demand, alternative biomass resources are scarce and most residues are fed to livestock or used to cover household needs. Subsequently, pressures and potential trade-offs are stronger. In sites with low cereal production and high livestock feed demand, pressures and trade-offs depend on the availability of better feed resources. Finally, sites with high cereal production and high livestock feed demand have been able to fulfil most of the demand for CR, limiting pressures and trade-offs. These patterns show that agricultural intensification, better management of communal resources and off-farm activities are plausible development pathways to overcome pressures and trade-offs of CR use. Although technologies can largely improve these trends, research and development should revisit past initiatives so as to develop innovative approaches to tackle the well-known problem of low agricultural production in many smallholder mixed systems, creating more sustainable futures.

1. Introduction

Crop residues (CR) have become a limited resource in mixed crop-livestock farms, which form the dominant farming system in the developing world (Herrero et al., 2009, 2010). Persistent low agricultural production, combined with increasing human populations and a decrease or degradation of communal resources have often led to increasing dependence on CR use in these mixed systems. This dependence is critical as CR becomes an essential resource for many household activities including: livestock keeping, obtaining additional cash, cooking, construction and/or soil conservation (Owen and Jayasuriya, 1989; McIntire et al., 1992;

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Williams et al., 1997). Particularly in these mixed systems, livestock keeping is a central livelihood element and CR a fundamental feed source (McIntire et al., 1992; Tarawali et al., 2011).

The use of CR depends on four major interacting factors: farmers' preferences; crop production levels; access to alternative biomass resources; and biomass demand (de Leeuw, 1997; Erenstein et al., 2011). Farmers' decisions on CR use reflect their own needs and preferences (e.g. using or selling residues). Total crop production largely determines the amount of CR available for the household in a growing season. The mix of crops grown also has implications for the quality of the CR; in comparison to legume residues, cereal residues have a much higher carbon to nitrogen ratio. Access to and affordability of alternative biomass resources determine the opportunity costs for a household to sell, use or replace CR. For example, access to communal lands reduces a household's need to collect and use CR as livestock feed or fuel (McIntire et al., 1992; Valbuena et al., 2012). Finally, biomass demand depends on household needs including livestock feed, cash, fuel, construction materials and soil fertility.

Farmers' decisions are also shaped by overall pressures on CR, which occur when crop production fails to meet the household demand for CR. On the production side, crop productivity remains lower than its potential in some parts of South Asia and especially in Sub-Saharan Africa (Koning and Smaling, 2005; Kuyvenhoven, 2008), indicated by considerable yield gaps (Nin-Pratt et al., 2011). Furthermore, communal areas such as grasslands and woodlands are often degraded and/or shrinking and thereby reducing the availability of alternative biomass resources. On the demand side, human populations and their income levels continue to increase, generating ever-greater demand for livestock products and thus feed, as well as biomass resources for fuel, soil improvement through mulching and for construction materials. The nature and interaction of all these influences on CR use are context specific and shaped by the dynamics and interplays of drivers at different levels. Major drivers include agro-ecological constraints and opportunities; human population dynamics; urbanisation/migration; institutional developments; and agricultural policies influencing access to information and markets (Anderson, 1992; Tiffen, 2003; Kuyvenhoven, 2008; Satterthwaite et al., 2010). At the same time, individual households react differently to similar drivers depending on their specific resource endowments and livelihood strategies (Tittonell et al., 2010; Giller et al., 2011b; Homann-Kee Tui et al., 2013).

Where CR availability is limited and two or more competing uses exist the decisions on CR use have to consider spatial and temporal trade-offs. These are particularly important on mixed farms, especially where crop production does not meet CR demand and alternative resources are not accessible or affordable (Latham, 1997; Tittonell et al., 2007; Rufino et al., 2011). A prominent example of such a trade-off is that between using CR as mulch or as livestock feed. Proponents of Conservation Agriculture (CA) packages promote the use of CR as mulch to enhance medium-term crop production through improving soil fertility, despite the direct and short-term benefits of feeding CR to livestock or selling them (Wall, 2007; Giller et al., 2011a).

The objective of this paper is to provide a comparative analysis of the determinants and pressures on CR use and to examine some potential trade-offs. Particular emphasis is given to the four major factors affecting CR use: farmers' preferences, crop production, alternative resources and biomass demand. This study is based on a trans-regional household-level survey in four regions across Sub-Saharan Africa (SSA) and South Asia (SA) with contrasting conditions. We build on previous work done at village level illustrating the potential of CR use as soil amendment (i.e. mulch) in the same regions (Valbuena et al., 2012). We discuss alternative options for balancing the income and environmental benefits of CR use and ways for increasing biomass production, while reducing pressure and potential trade-offs.

2. Methods

2.1. Data collection

For the purposes of this study 12 sites across 9 countries in 4 (sub-)tropical regions were selected to illustrate the diversity of mixed farming systems in SSA and SA (Fig. 1). The regions include: Eastern Africa (Ethiopia, Kenya), Southern Africa (Malawi, Mozambique, and Zimbabwe), Western Africa (Niger and Nigeria) and South Asia (Bangladesh and India). This site selection was based on regional expert knowledge within the regions where participating research centres are based. Through informed expert discussion and secondary data, mixed crop-livestock systems were selected with contrasting agro-ecological conditions, levels of agricultural intensity and market development (Table 1). In Ethiopia, India and Niger, two contrasting sites were selected in each

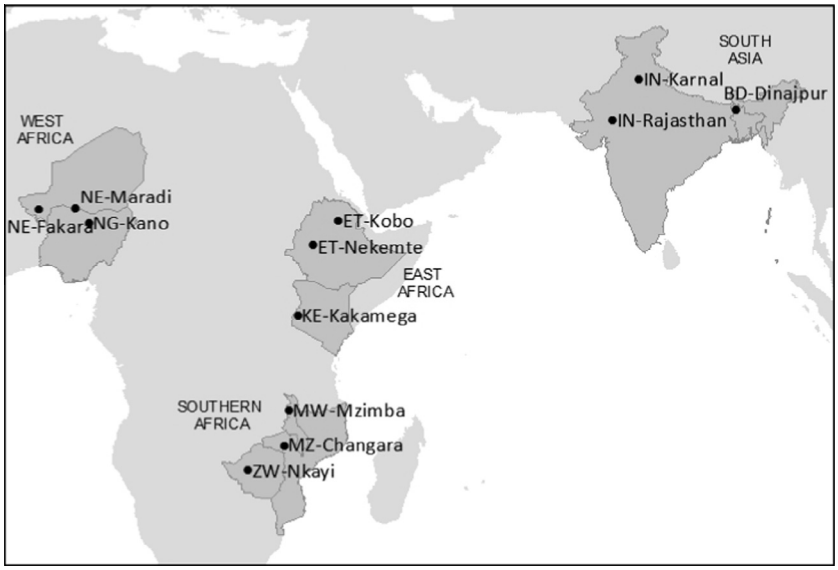

Fig. 1. Location of the study sites.