Trade-offs of crop residue use in smallholder mixed farming systems in Sub-Saharan Africa and South Asia

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Introduction

One of the three pillars of CA is the use of crop residues (CR) for mulching. However, in smallholder farming systems that combine crop production and livestock husbandry (mixed systems), CR are usually an essential source of feed, restricting their availability for mulching. Additionally in these systems, CR fulfil other functions such as providing fuel and additional income through sale. Smallholder production in mixed systems supports the livelihoods of almost two thirds of the global population, especially in Sub-Saharan Africa and South Asia (Herrero et al., 2010). The integration between crops and animals not only enhances agricultural production, but also improves household food intake and income and provides a buffer against climate risks (Thornton, 2010).

The need to cover their own food requirements and household expenses pushes smallholder farmers to favour practices with positive returns in the short term, which may affect the sustainability of the systems in the long term. Farmers' decisions are influenced by biophysical and socio-economic drivers including climate, population dynamics, market access and other institutional mechanisms. The focus of this paper is on the trade-offs of CR use in a range of smallholder mixed systems in Sub-Saharan Africa (SSA) and South Asia (SA). The objective of this paper is threefold: (i) to describe the different CR farmer uses in these mixed systems; (ii) to understand what biophysical and socio-economic drivers explain differences in CR allocation; and (iii) to include these findings in the broader discussion on long term sustainability issues in mixed systems and constraints for CA practices adoption.

Materials and Methods

A total of 96 villages were selected for this study. The selection of the villages, clusters, countries and regions was designed to cover diversity in agro-ecologies, level of agricultural intensification and market accessibility. In the project, 12 clusters in 10 countries in SSA and SA were selected (www.vslp.org), but this preliminary version only includes clusters in Bangladesh (Dinajpur), Ethiopia (K'obo and Nek'emte), India (Karnal and Udaipur), Kenya (Kakamega) and Zimbabwe (Nkayi); the other clusters will be included in the final version. For each cluster, 8 villages were selected based on distance to the market and distance to a main road. In each village, a group interview was conducted, based on a structured questionnaire including general questions about the village: differences between farmers (wealth), current and past crops, CR and livestock management practices, services and market access, and costs and input/output prices. Village questionnaires were answered by a group of 10-25 farmers in each of the selected villages. The composition of the farmer group was as heterogeneous as possible, including farmers of different age, gender and wealth. For each cluster, the data gathered with the village questionnaire were combined (average and standard deviation) at a cluster level to conduct a comparative analysis between clusters. Descriptive analyses were carried out to compare the different clusters in terms of current farming systems, drivers of change and CR management.

Results and Discussion

The comparative analysis shows some similarities in CR management across clusters (Figure 1). Around 20% of CR are left in the soil in Dinajpur, Karnal and Kakamega, while for K'obo, Nek'emte and Nkayi CR are mainly grazed or collected. CR is commonly used as a stall feed in K'obo, Karnal and Udaipur, while almost 30% residues are used as fuel in Dinajpur. These uses depend on the type of crop. For example in Karnal, most of the wheat CR are used for stall feeding, while rice residues are left in the field, burnt or used for stall feeding (Erenstein and Thorpe, n d).

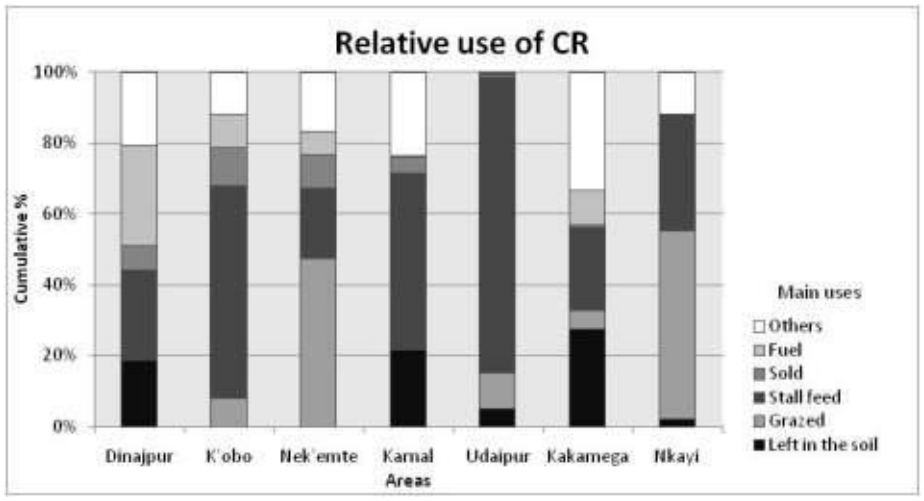

Figure 1. Relative use of CR per cluster.

Similarities and differences in CR management across clusters are related to opportunities and constraints linked to specific biophysical and socio-economic context/drivers in each cluster (Table 1). Biophysical conditions influence the growing season, limiting cropping and CR production in K'obo, Udaipur and Nkayi. Population characteristics exert pressure on resources and CR management differently. Population density is almost 30 times higher in Udaipur than in Nkayi, influencing the amount of grazing land and farm size. The degree of agricultural intensification has a strong influence on CR production. Irrigation and use of pesticides, herbicides and machinery are common in Dinajpur and Karnal, indicating shortages in labour and a higher degree of agriculture intensification. Access to input/output markets differs among clusters, affecting the type of agricultural production. In Kakamega, the high population density has created a local market for milk and so changes in feeding requirements and production practices (e.g. feeding of Napier grass). Finally, local/regional institutions

also influence the ownership and use of CR. In Nek'emte and Nkayi, CR ownership is based on the type of CR: teff and groundnuts are regarded as a private resource while maize is seen as a group- or open-grazing/harvesting resource.

Table 1. General characteristics of study cluster (average of the 8-village cluster).

Characteristics	**Clusters**						
	Dinajpur	**K'obo**	**Nek'emte**	**Karnal**	**Udaipur**	**Kakamega**	**Nkayi**
Country	Bangladesh	Ethiopia	Ethiopia	India	India	Kenya	Zimbabwe
Population density (persons/km^2)*	624.2	243.5	229.1	569.0	420.4	390.6	21.3
Area (ha)	106	350	113	474	434	531	4606
Households with livestock (%)	88	77	83	88	79	89	69
Main crop	rice-	teff-sorghum	teff-maize	rice-wheat	maize	maize	maize
Households tilling with tractor (%)	100	12	0	100	38	12	0
Households using chemical fertiliser (%)	100	2	95	100	68	80	25
Households using irrigation (%)	100	12	27	99	22	0	10
CR left in the soil (%)	19	0	0	22	5	28	2
CR grazed (%)	0	8	47	0	10	5	53
CR used as stall feed (%)	26	60	20	50	84	24	33
Tropical livestock units (tlu)	203	146	486	1377	523	348	401
Ratio tlu/people (tlu/person)	0.3	0.2	1.9	0.5	0.3	0.2	0.4
Shortage of dry fodder (months per year)	2.9	5.6	8.0	1.1	6.1	4.3	7.8
Shortage of grass (months per year)	4.4	4.3	4.0	.0	3.8	8.1	4.9
Use of dung as fuel (%)	13	33	0	39	10	0	0
No use of dung (%)	74	10	56	56	88	53	26
Use of dung as manure (%)	0	58	26	0	2	4	73

* Calculated based on village area.

Livestock numbers and composition vary across clusters, which influences the demands on CR and feed. The ratio TLU/person ranges between 0.2 in K'obo and Kakamega, and 1.9 in Nek'emte. Buffalo dominates in Karnal, while crossbred cattle are more common in Kakamega and Karnal—which is related to a demand for dairy products. Additionally, clusters might face similar pressure on feed requirements. In K'obo, Nek'emte, Kakamega, Nkayi and Udaipur, villages suffer longer feed shortage periods compared to clusters with higher agriculture intensification (i.e. Karnal and Dinajpur). Related to livestock, use of dung is similar among some regions. In K'obo and Karnal, dung is often used as fuel, while a large part is not collected in K'obo and Nkayi—caused by labour restrictions. In contrast, dung is used as organic fertiliser in Dinajpur, Kakamega and Udaipur.

The differences and similarities of mixed systems and CR management across clusters and villages illustrate that despite the complexity of those systems, farmers in different regions appear to face similar challenges. This is related to specific drivers across clusters and countries. Additionally, although livestock production systems are also diverse, livestock are an important component of the whole farming system in all the clusters, supplying traction, manure, food and cash. Furthermore, the growing use of CR as feed and fuel confirms an increasing pressure on biomass, favouring short-term livestock production over long-term improvement/maintenance of soil productivity. The implementation of mulching in smallholder mixed systems in SSA and SA needs to consider the specific context of farming. The preliminary results of this study suggest that famers, villages or even clusters with similar resources and market options might require a similar set of approaches to conserve their soils, specifically mulching. Clusters with a low grain and stover productivity would need to increase biomass production to cover human and livestock demands in the short term first, before implementing mulching in their fields—long term sustainability. Clusters with an increasing demand for livestock products would need to increase both quality and quantity of CR and fodder. Yet, increasing biomass production will depend on the existence of input/output markets and a set of institutions/policies to support it. If farmers can neither cover their basic food/feed demands nor see a short-term benefit of conservation practices, it is unlikely that such practices are going to be implemented in smallholder mixed systems in SSA and SA in the near future.

References

Erenstein, O., and Thorpe, W. (n.d.). Crop–livestock interactions along agro-ecological gradients: a meso-level analysis in the Indo-Gangetic Plains, India. Environment, Development and Sustainability, 12(5), 669-689. Springer Netherlands. Retrieved from http://dx.doi.org/10.1007/s10668-009-9218-z DO - 10.1007/s10668-009-9218-z.

Herrero, M., Thornton, P. K., Notenbaert, A. M., Wood, S., Msangi, S., Freeman, H. A., et al. (2010). Smart Investments in Sustainable Food Production: Revisiting Mixed Crop-Livestock Systems . Science , 327 (5967), 822-825. Retrieved from http://www.sciencemag.org/content/327/5967/822.abstract .

Thornton, P. K. (2010). Livestock production: recent trends, future prospects. Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1554), 2853-2867. Retrieved from http://rstb.royalsocietypublishing.org/content/365/1554/2853.abstract.