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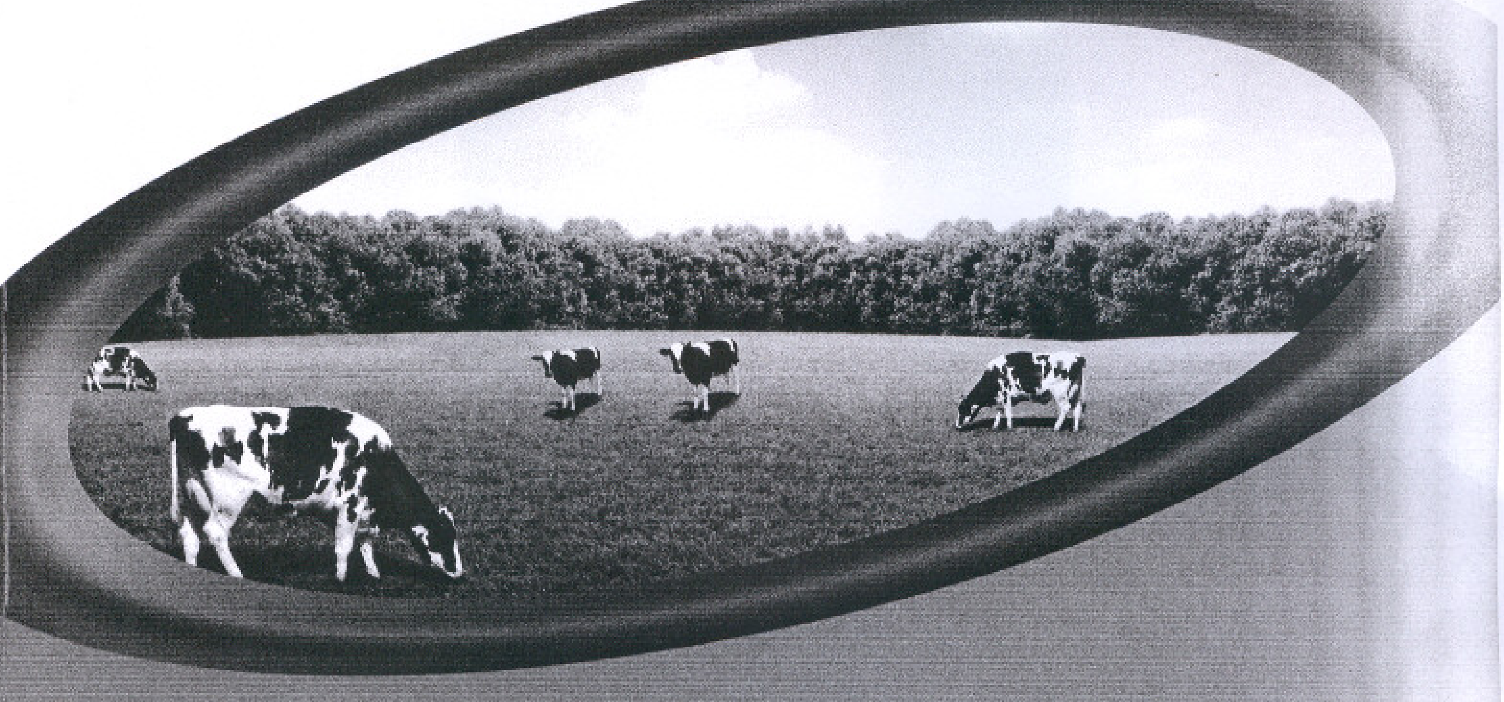
Animal Nutrition Strategies for Environment Protection and Poverty Alleviation



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Livestock: the good and the bad

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Perceptions about livestock

Globally, livestock contribute 40% to agricultural GDP, employes more than a billion people and creates livelihoods for more than 1 billion poor (Steinfeld *et al.,* 2006). From a nutritional standpoint, livestock contributes about 30% of the protein in human diets globally, and more than 50% in developed countries. In many developing countries, livestock have traditionally been considered to be the backbone of agriculture, as they provide draught power and farmyard manure, the sole source of crop nutrition, before promotion of modern agriculture in the middle of the 20th century. As outlined in the livestock revolution scenario (Delgado *et al.,* 1999) consumption of animal products will increase particularly in so-called developing countries in response to urbanization and rising incomes. While the increasing demand for livestock products offers market opportunities and income for small holder producers and even landless thereby providing pathways out of poverty (Kristjianson, 2009), livestock production globally faces increasing pressure because of negative environmental implications particularly because of greenhouse gas emissions (Steinfeld *et al.,* 2006). Besides greenhouse gases, the high water requirement in livestock production each a major concern.

However, the relationships between livestock and the environment are complex and may be viewed very differently from developed and developing country perspectives. To assess varying perceptions of livestock goods and bads we conducted a survey among different constituencies. The survey was completed by members of the Food and Climate Research Network (FCRN), the International Livestock Research Institute (ILRI), the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and the British Society of Animal Science (BSAS). Essentially FCRN and BSAS are organizations based in the developed world ICRISAT and ILRI and are based in the developing world. BSAS and ILRI are specifically focused on livestock while FCRN and ICRISAT are more broad-based. Mission statements gleaned from websites summarize the overarching goals of the various organizations:

- FCRN: The FCRN's aim is to increase our understanding of how the food system contributes to greenhouse gas emissions and what we can do to reduce them.
- ILRI: A world made better for poor people in developing countries by improving agricultural systems in which livestock are important.
- ICRISAT: To reduce poverty, enhance food and nutritional security and protect the environment of the semi-arid tropics by helping empower the poor through science with a human face.
- BSAS: The Society's aim is to enhance the understanding of animal sciences and to promote its integration into economic and ethical systems.

Table 1. Suggested livestock goods and bads presented in the survey

Livestock bads
Zoonotic disease such as rift valley fever, bird flu, brucellosis, or rabies
Overgrazing and loss of biodiversity
Environmental/water pollution
Climate change
Eating too much meat is bad for people's health
Livestock goods
Livelihood option for the world's poor
Nutritional supplementation for under-nourished people and children
Provision of inputs (draught power, manure) in mixed crop livestock systems
Maintaining biodiversity and providing environmental services – e.g. management of rangeland condition
Cultural value

For the purpose of the survey major livestock goods and bads were categorized as in Table 1. Results were as follows. When asked the question: In South Asian terms do you think livestock are a pathway out of poverty, there was broad agreement across the constituencies. For ILRI, BSAS and ICRISAT almost all respondents agreed livestock to be a pathway out of poverty. When asked the same question in global terms there was less agreement. Both BSAS and ICRISAT respondents still regarded livestock as a pathway out of poverty but the views of ILRI and FCRN respondents were more divided. ILRI respondents seemed to be strongly aware of the negative impacts of livestock in global terms possibly because of many recent debates on

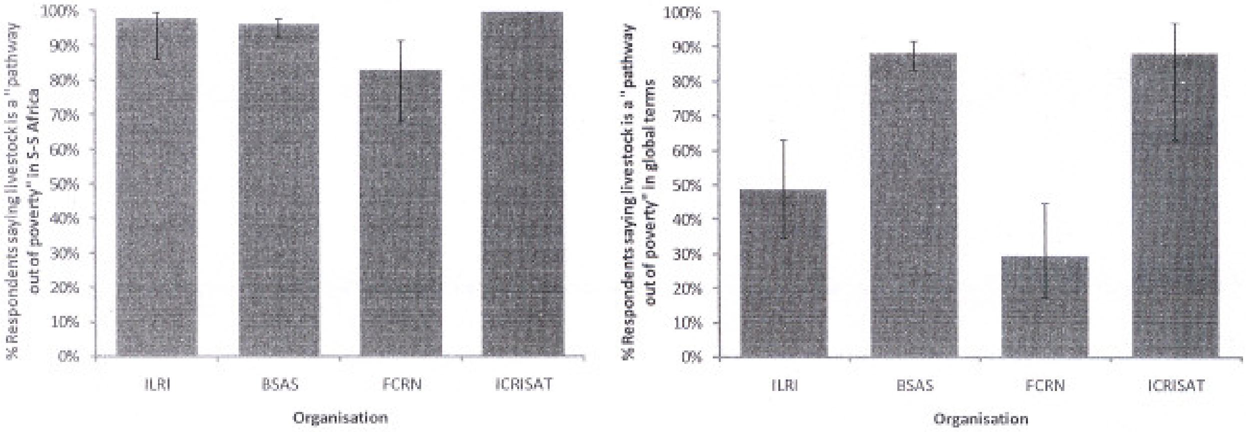

Fig. 1. Varying views on livestock as a pathway out of poverty in S Asian and global terms (error bars denote 95% confidence intervals)

such issues within the organization. FCRN respondents were also unconvinced on the poverty alleviation role of livestock when considered in global terms. When asked to rank the various livestock goods, there was broad agreement across constituencies. Most respondents agreed that the key livestock good relates to their role as a livelihood option for the poor. The two developing world organizations felt this especially strongly. Other benefits for poor people also featured highly; nutritional supplementation and provision of inputs into mixed crop-livestock systems were ranked highly with no obvious differences across constituencies. Biodiversity benefits and especially cultural value both scored low. When asked to rank the various livestock bads the rankings among different categories were less clear and there was more diversity by constituency. Climate change and loss of biodiversity represented the developed world view of FCRN while zoonotic disease featured strongly among the developing world respondents represented by ILRI and ICRISAT. Negative health impacts of meat consumption were higher among ICRISAT respondents than for other constituencies perhaps reflecting the South Asian vegetarian culture. Zoonotic disease and negative health impacts ranked low among FCRN respondents.

The results need to be treated with caution since the sample size was limited but they do reveal some significant variation of opinion for different groups. However, the findings point to more consensus than one might have expected. There is clearly an understanding among the professionals surveyed that livestock have an important poverty alleviation role in the developing world. There is generally a need for more debate to build an understanding of the nuanced nature of livestock goods and bads. There has been plenty of propaganda on both the goods and bads and we now need to a more balanced debate on the different negative and positive impacts of livestock for different situations. We now consider in more detail some recent thinking relating to the interaction between livestock feeding issues and livestock bads, especially climate change.

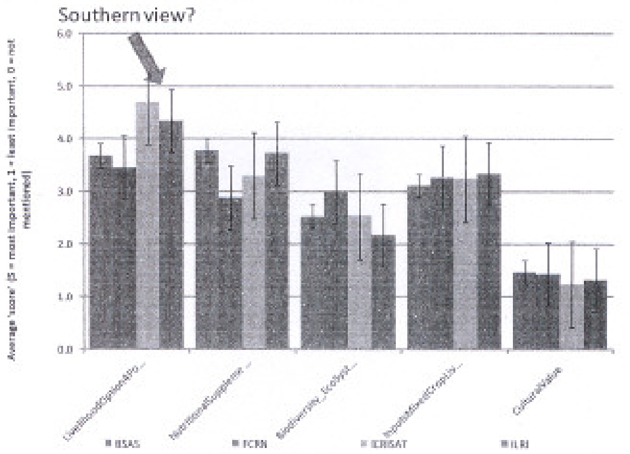

Fig. 2. Ranking of livestock goods by different constituencies (error bars denote 95% confidence intervals).

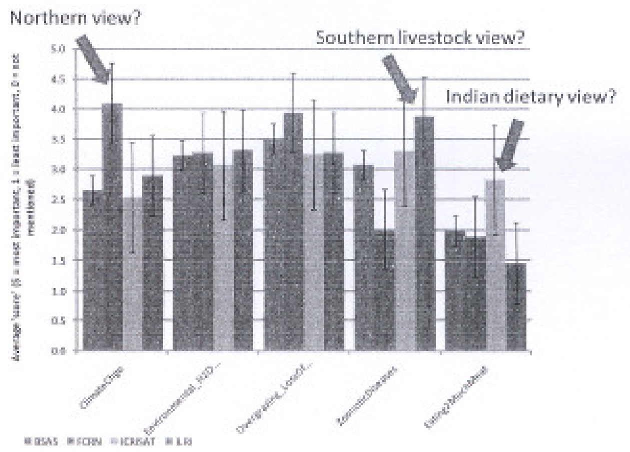

Fig. 3. Ranking of livestock bads by different constituencies (error bars denote 95% confidence intervals).

Feed at the interface of livestock bads and goods

Feed is at the very interface of the positive and negative effects of livestock, income, livelihoods and the environment. Lack of affordable, adequate feed (quantity and quality) represents a major constraint to smallholder competitiveness and the overall profitability of livestock production systems. Choice of feeds and feeding strategies also has major implications for natural resource usage and greenhouse gas emissions. For example feed production can significantly deplete water, particularly in concentrate and irrigated forage based systems. By-product based feeding systems, for example using crop residues, are

generally more efficient user of water since water needs to be allocated for the production of the primary products such as grains anyhow. However, by-product feeds are often of a fibrous nature promoting high proportional acetate production in the rumen and thus proportionally to the amount of substrate degraded high methane production. Also use of crop residue for feeding can compete with usage for soil improvement in conservation agriculture approaches.

Feed and water

Water required to produce feed to satisfy maintenance energy requirements for one Tropical Livestock Unit is about 100 times greater than the water required for drinking (Peden *et al.*, 2007). In regions with strong competition for land and water resources, land and water scarcity emerge as major constraints for increased feed production in small-holder systems. For instance in Northern India, water-use efficiency was found to be low in systems with high reliance on irrigated forages (Singh *et al.*, 2004). Singh and colleagues reported for Gujarat that on average 3 400 liters of water were required to produce one liter of milk - the world average is 900 liter. Expressed differently, about 10 000 liter of water were required daily to produce the feed for one dairy animal (Singh *et al.*, 2004). Clearly water requirement needs to be a concern to those who work in feed resource development and livestock nutrition. Improving and promoting by-product based feeding systems will increase water use efficiency but this needs to be balanced with the higher greenhouse gas emissions that such roughage based feeding systems are likely to entail.

Roughage versus concentrate feeding and greenhouse gas emissions

Considerable efforts have been expended in reducing carbon emissions from livestock, even before the awareness of climate change took hold, simply because feed carbon losses to the environment reduce feed conversion efficiency. The mechanisms that result in enteric carbon emissions are, therefore, quite well understood. In a simplified manner, digestion in the rumen is characterized by feed conversion into short chain fatty acids (SCFA), the 2, 3 and 4-carbon acids, acetate, propionate and butyrate which provide the primary energy source for ruminants, microbial biomass (MBP) which is the major or even only source of protein and finally the gases, mainly CO_2 and CH_4 which are digestive waste products and obviously of major environmental concern. Since diversion of feed carbon away from gaseous losses has livestock nutritional and environmental benefits, considerable research has been invested in devising feeding strategies that achieve this, and our knowledge about the underlying causes is expansive (Van Soest, 1994). Briefly, high proportional feed conversion into MBP, that is a high efficiency of microbial production (EMP), and high proportion of propionate in the SCFA, reduce digestive carbon losses (see Fig. 4).

Clearly, increasing proportional propionate production will have the most substantial effect on methane emissions relative to feed digested. While under feeding regimes which promote predominantly acetate-based fermentation methane emissions could range from about 45 to 70 liter per kg digested feed depending on EMP, only about 20 to 30 liter of methane are produced when propionate dominates fermentation products (Fig. 4). In other words methane emissions could be halved by adjusting feeding regime. From a mere feed technical

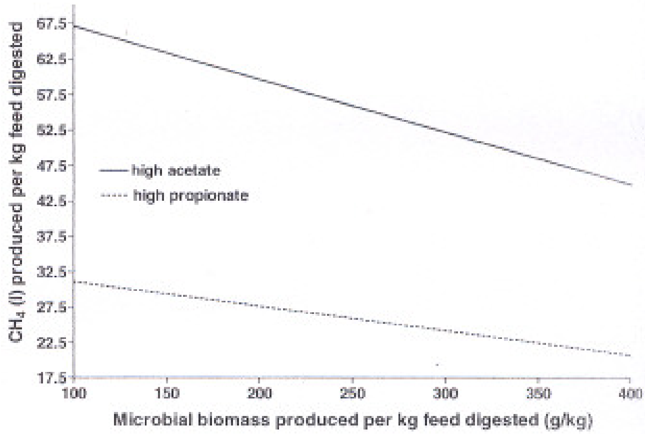

Fig. 4. Methane production from 1 kg of feed truly digested in the rumen in dependence of SCFA proportion and EMP (modified from Blümmel and Krishna, 2003).

perspective, high propionate production can be "simply" achieved by increasing the proportion of concentrate in the diets. In fact this approach is frequently recommended for reduction of methane emissions from livestock (for review see Martin *et al.*, 2008). There are, however, severe draw backs associated with increased concentrate feeding to ruminants, particularly in developing countries. First, food security might be in jeopardy and food prices might increase, further burdening poor people. Also, natural resource usage of land, water and biomass is more efficient where livestock production (mainly from ruminants but not only) is based on by-products such as crop residues that do not contain human edible nutrients or on biomass harvest – through grazing and otherwise - from areas not suitable for arable land.

Effect of increasing milk production per animal on feed resource requirements and greenhouse gas emissions

'Environment-friendly' development of livestock production systems demands that the increased production be met by increased efficiency of production and not through increased animal numbers (Leng, 1993). Feeding strategies that increase the efficiency of production by producing more from fewer animals and less feed will result in reduced green house gas emissions. This can be demonstrated by analyzing the livestock population in India and their respective level of productivity. Thus, in India in 2005/2006 the proportion of milch animal relative to total livestock numbers was less than 0.25. In addition, the daily milk yield of cross bred cows, local cows and buffalo was low, averaging on a 365 days lactation basis 6.44, 1.97 and 4.3 liters per day, respectively. The mixed herd mean milk yield can be calculated as 3.61 liters per day. This low productivity resulted – across the three types of livestock – in feed metabolizable energy (ME) for maintenance accounting for 65% of overall feed use; see Table 2.

By increasing daily milk production in a herd model (of a mixed cross-bred, local cow, buffalo population) from 3.61 to 6, 9, 12 and 15 liter per day, energy expended for maintenance becomes less than energy expended for production, see Figure 5. As a result the same amount of milk can be produced by less numbers of livestock leading to drastically reduced emissions of methane (see Fig. 5 and 6 adapted from Blümmel *et al.*, 2009).

Table 2. Summary of total livestock population, milch animal and their production and feed requirements for maintenance and production in India in 2005/2006

	Cross Bred Cows	Local Cows	Buffalos	Total
Milch animals	8 216 000	28 370 000	33 137 000	69 759 000
Total animals	28 391 000	155 805 000	101 253 000	285 449 000
Milk yield (kg/d)	6.44	1.97	4.4	3.6 (mean)
ME required (MJ 10^9)				
Maintenance	148.0	423.3	601.2	1172.5
Production	122.6	136.4	370.8	629.8

Adopted from Blümmel *et al.* (2009).

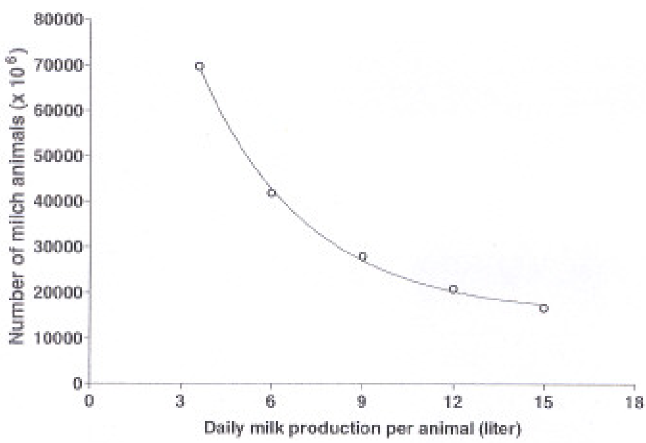

Fig. 5. Relations between average daily milk production and livestock numbers.

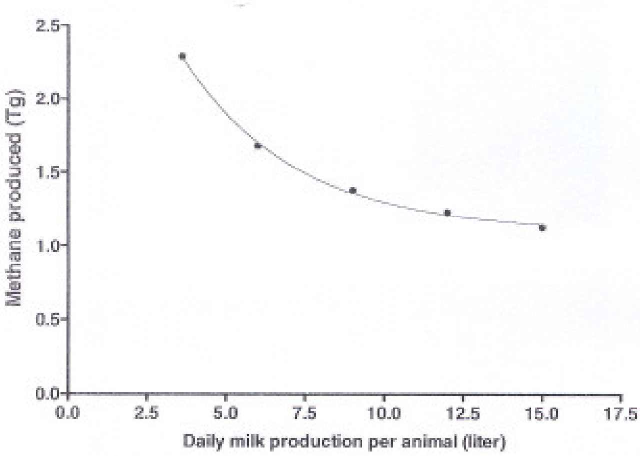

Fig. 6. Relations between average daily milk production and yearly methane emissions.

Possible levels of milk production on by-product based feeding systems

Miracle Fodder and Feeds Pvt. Ltd. (Shah, 2007) designed so-called densified total mixed ration (DTMR) feed blocks that consist largely of by-products such as sorghum stover (about 50%), bran, oilcakes, husks (about 36%) with the rest contributed by molasses (8%), maize grain, urea, minerals, vitamins etc. Miracle Fodder and Feeds Pvt. Ltd. offers DTMR feed blocks of three different qualities designed to produce daily milk yields (in dairy buffaloes) of 11-16 liters (DTMR Diamond with 14.5 to 15% crude protein, 3.5% fat and 64-65% TDN), 7-11 liters (DTMR Gold with 13.0 to 13.5% crude protein, 3.0% fat and 62% TDN) and 5-7 liters (DTMR Silver with 11.5 to 12.0% crude protein, 2.5% fat and 60% TDN). In a series of experiments with Miracle Fodder and Feeds Pvt. Ltd., Anandan *et al.* (2010) tested these feed blocks with two objectives. First, to estimate probable maximum productivity levels on crop residue based diets. Second, to estimate the importance of the quality of the basic crop residue going into the blocks on overall livestock performance. In an experiment with a large private dairy (Anandan *et al.*, 2010) two experimental feed blocks based on DTMR Diamond were produced from lower and premium quality sorghum varieties. Daily milk potential was 16.7 and 11.4 liters of milk on feed blocks produced from premium and lower quality sorghum stover, respectively (Anandan *et al.*, 2010). Thus respectable levels of milk production are feasible on almost completely by-product based feeding systems.

With current feed resources and no changes in the ratio of milk to no-milk producers the achievable level of milk production appears therefore to be between 6 and 9 liters per day (for more detailed reasoning see Blümmel *et al.*, 2009). In fact long term field studies from 1997 to 2001 of BAIF (Gokhale *et al.*, 2007) show average milk yields (converted to 365 days lactation) in cross-bred cows of 7.7 (on irrigated area) to 8.5 (irrigated area) liter per day. This was achieved by providing critical breeding and health care services coupled with regular guidance on feeding and culling of animals. The experience of BAIF, a leading NGO engaged in promoting dairy husbandry, has confirmed that with ownership of high yielding cattle and buffaloes, farmers prefer to adopt stall feeding, maintain a smaller herd and try to meet the fodder shortage by bringing marginal lands under drought-resistant fodder crops. This experience can be widely replicated across the developing countries for providing livelihood to small farmers (Hegde, 2006). Thus, an effective extension network will have to be established to create greater awareness among small farmers to adopt best practices in livestock husbandry to increase the production, without increasing the population.

Competition for crop residues between livestock feeding and needs for soil improvement

We have shown that enhancing the use of crop residues for livestock feeding in mixed systems has benefits in terms of water use and there is potential for increased productivity using by-product based diets with knock-on benefits for reduced animal numbers and GHG emissions. However there is increasing competition for biomass in mixed crop-livestock systems and crop residues are coming under increasing pressure. In mixed systems, crop residues are a strategic production component and major trade-off in those systems is the short term benefits

of using crop residues to feed livestock versus leaving the crop residues in the field for sustaining long term soil productivity (nutrient balance, erosion control, and soil health). For small scale resource poor farmers, often facing seasonal feed shortage for their livestock, it is very unlikely that long term soil conservation considerations will prevail over short term benefits obtained from livestock and livestock products (Giller *et al.*, 2009). Ongoing research by the Systemwide Livestock Programme (SLP, www.vslp.org) illustrates the increasing dependence of livestock on crop residues, due to a combination of drivers: population increase, reduction of communal grazing land and increased demand for livestock products. For instance, in more than 70% of surveyed villages in Zimbabwe, Ethiopia, Kenya, Bangladesh and India the use of crop residues as stall feed has increased in the last decade. The overall increasing importance of crop residues in livestock diet is occurring in parallel with strong efforts on the part of the research for development community to promote Conservation Agriculture Practices. CA has three pillars: zero-tillage, leaving crop residues as mulch and crop rotation particularly with legumes. For crop residues to be effective as mulch at least 30% soil coverage is suggested amounting to 2 to 3 tons per hectare of coarse stover such as from sorghum, millet or maize, the important rain fed area crops. However, this amount might be close to the overall stover yield farmers can harvest in those areas and demonstrates the challenge farmers face in allocating biomass between livestock feeding and longer term soil fertility management.

CONCLUSION

As livestock is, and will remain, an important source of livelihood, it is necessary to find suitable solutions to convert this industry into an economically viable enterprise, while reducing its contribution to global warming. In relation to climate change, livestock is part of the problem but also part of the solution where cropping becomes too risky and where livestock will serve as an important tool for risk mitigation and diversification. Increasing the efficiency of livestock production through achieving higher productivity from fewer animals will play a key role in mitigating environmentally adverse effects from livestock. There are, however, biological limits to this approach mainly defined by feed resources. Feeding of livestock should not lead to competition for human edible food sources and should be based on converting non-human edible feed sources into those edible by humans. Some trade-offs between the positive and negative effects of livestock have to be accepted.

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