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Crop-Livestock Interactions for Sustainable Agriculture

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This Gatekeeper Series is produced by the International Institute for Environment and Development to highlight key topics in the field of sustainable agriculture. Each paper reviews a selected issue of contemporary importance and draws preliminary conclusions of relevance to development activities. References are provided to important sources and background material.

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CROP-LIVESTOCK INTERACTIONS FOR SUSTAINABLE AGRICULTURE

Wolfgang Bayer and Ann Waters-Bayer

An important component of the "agricultural revolution" of 18th-century Europe was the introduction of forages into crop rotations. These increased animal production and, in turn, crop yields were raised through improvements in soil fertility due to higher manure output, and through the effects of the forage ley. In the tropics, this type of mixed farming is seldom found: most smallholders do not grow forage crops, and may not even keep any large animals. In many areas, cropping and livestock-keeping are practised by specialist ethnic groups. In view of this, European-oriented observers often tend to conclude that crops and livestock are not interlinked in tropical farming systems.

In fact, numerous links between crops and livestock have long existed in the tropics, but because they differ from those in temperate areas they tend to be overlooked. In the tropics, crops and livestock are often linked by way of:

- arrangements between specialist herding and arable farming groups;
- arrangements between two enterprises within the same family, such as when a man is engaged mainly in cropping while his son or wife migrates with the livestock; or
- interactions within smallholdings, in which a few cattle, buffalo, small ruminants, pigs, poultry etc. are kept.

Linkages between livestock-keeping and cropping found in many parts of the tropics include (McCown et al, 1979):

- Food linkage; almost all livestock-keepers, including nomads, consume cereals, and many farmers consume some meat and milk products;
- Investment linkage; income from crops is used to buy livestock, and animals are sold to finance cropping inputs;
- Manure linkage; animal manure is used to fertilise cultivated fields and home gardens;
- Forage linkage; crop residues and fallow fields are used as fodder and pasture;
- Draught linkage; animal traction is used for cultivation and transportation, also of cropping inputs and outputs; and
- Employment linkage; pastoralists sometimes keep animals for farmers, or members of farm families may be employed by pastoralists for herding or cultivation.

In smallholder farming systems, interactions between cropping and livestock-keeping serve the following functions:

- increasing subsistence security through diversification of the food-generating activities of farm families;
- transfer of nutrients and energy between animals and crops via manure and forage from cultivated areas and via use of draught animals; and
- modification of vegetation for the benefit of livestock and crop production and the farm families.

These crop-livestock interactions are essential for intensive use of local resources and for the social, economic and ecological sustainability of smallholder farming systems. It is therefore important that their functions be appreciated in the planning and implementation of agricultural development.

Crop-livestock interactions to increase subsistence security

In view of the large seasonal fluctuations in milk yields, very high numbers of animals would be required if pastoralists in the seasonally dry tropics were to depend solely on a diet of animal produce (Dahl and Hjort, 1976). By exchanging livestock for crop products or growing some crops themselves, pastoralists can subsist with fewer animals than would otherwise be the case. For smallholders who depend primarily on cropping, the importance of livestock holdings increases with the risk of crop production, e.g. with increasing aridity. Livestock serve as a buffer: an animal can be slaughtered for home consumption or sold to buy food when crop yields do not meet family needs.

Regardless of whether livestock-keeping is a primary or subsidiary enterprise for a smallholder family, livestock serve as a savings account, with offspring as interest. Animals are sold when cash is needed for specific purposes, including the purchase of inputs for cropping.

Even in arid areas, opportunistic cropping can be rational where ruminant livestock are present. When rainfall is not enough for grain formation, forage is also likely to be scarce and high in value. The immature crops can then be used or sold as fodder, thus generating at least some revenue from the cropping activity.

In years of good rainfall, opportunistic cropping yields both grain as food and stover as fodder. In poorer years it reduces the risks to livestock production.

Diversification into livestock-keeping extends the risk reduction strategies of crop farmers beyond mixed-species cropping, and diversification into cropping extends the risk reduction strategies of pastoralists beyond the keeping of mixed-species herds. This further diversification increases the economic stability of the production systems. Spreading risk by practising both crop and livestock production may lead to lower productivity within each

sector, but total production per unit area may even be increased, as both crop and livestock yields can be gained from the same areas.

Transfer of nutrients and energy via crops and livestock

Crop-livestock interactions provide a key to ecological sustainability by intensifying nutrient and energy cycles. Crop residues are an important source of forage in smallholder farming systems. In the early dry season in West Africa, cattle spend up to 80% of grazing time on harvested fields, mainly those belonging to farmers rather than cattle-keepers (Bayer 1986). In terms of digestibility as well as crude protein and phosphorus content, the quality of crop residues is far superior to that of natural range at the same time of year. On Kenyan smallholdings, an estimated 40% of annual forage energy is derived from crop residues (Stotz 1983). Weeds from cultivated fields, lower mature leaves stripped from standing crops, plants thinned from cereal stands, and vegetation on fallow fields offer additional fodder resources related to food cropping. Crop residues are often traded and sometimes their monetary value approaches that of grain.

Manuring recycles nutrients more quickly than natural decay of vegetation. It transfers nutrients from range to cropland and concentrates them on selected areas, thus slowing down soil exhaustion and allowing more efficient cultivation over longer periods. Where herding and cropping are practised by specialists, such as in parts of West Africa, pastoralists provide manure for farmers' fields in return for crop residues, feed supplements, watering rights, land-use (including cropping) rights and/or cash (e.g. FAO, 1983; Powell Waters-Bayer, 1985; van Raay, 1975; Toulmin, 1983).

Also where farmers keep some animals and pastoralists cultivate some land, the former rarely have enough animals to manure all their fields and the latter rarely cultivate enough land to provide sufficient crop residues for their animals. Therefore, farmers still depend on pastoralists for manure and pastoralists on farmers for crop residues.

In smallholder farming areas, forage is derived primarily from land which is unsuitable for cropping ("wasteland" such as areas with rocky outcrops, wayside edges, and waterlogged land) and land which is temporarily not being cropped (harvested or fallow fields). These pieces of land are often interspersed between cultivated plots and are grazed by herded or tethered livestock, or the vegetation is cut for fodder. This permits a higher intensity of land use than if one area is used solely for cropping and another (e.g. ranch, grazing reserve) solely for livestock. Where livestock-keeping and cropping are spatially integrated, as in many tropical farming systems, a higher human population density can be supported than if they were spatially segregated.

Apart from the complementary use of land for cropping and grazing and the mutual benefits gained through manuring and crop residue grazing, the spatial integration of specialist pastoral and cropping groups permits easier market exchange of livestock and crop products between the two groups. Pastoralists also benefit from the infrastructure, e.g. roads, schools, dispensaries, designed primarily for settled farming communities. The resulting improvement in the pastoralists' quality of life contributes to the social and

economic sustainability of their production system. However, if the attractions of farming areas lead to sedentarisation of the pastoralists, the reduction in herd mobility and, thus, in the flexibility of forage resource use may reduce animal production and ecological sustainability.

Where animals are used for traction, as in Asia and North Africa, some of the energy gained from grazing range and temporarily noncultivated land is transferred to cropping. Farmers can cultivate larger areas with draught animals than by hoe. Since ploughs and harnesses can normally be manufactured locally, animal traction requires lower levels of external inputs than the use of tractors, which depends heavily on imports of fossil fuel and spare parts. An additional benefit of draught animals is that they provide manure. However, the ecological repercussions of keeping draught animals are site-specific: in some cases, they may cause overgrazing and environmental degradation on the pasture surrounding the village.

Modification of vegetation for cropping and herding

Modification of vegetation for cropping often improves conditions for livestock. On land cleared of dense shrub, it is easier to herd animals. The higher grass yield on fallow fields as compared with natural savanna provides more forage for grazing ruminants (Powell and Waters-Bayer, 1985). Clearing of savanna woodland destroys the habitat for tsetse flies, which transmit trypanosomiasis, and thus improves animal and human health. Clearing keeps tsetse much more effectively at bay than any chemical spraying campaign.

Traditional "clearing" does not mean complete removal of all trees and shrubs; e.g. farmers in West Africa retain 30–50 trees/hectare on arable land. Apart from their direct economic value (from firewood, timber, fruits, traditional medicine, resins, bee-keeping etc.), the trees provide valuable forage, particularly in the late dry season when other high-quality forage resources are usually not locally available.

In ecological terms, the primary functions of trees are to pump nutrients from deeper soil layers, to improve the water absorption and retention ability of the soil, to provide protection against water and wind erosion of the soil, and to improve the microclimate for livestock, crops and the people who tend them. The multiple functions of trees improve the economic sustainability of tropical farming systems and, in so doing, increase the likelihood that farmers apply ecologically sound agroforestry practices.

Grazing also modifies the vegetation. In subhumid areas, where grasses grow tall and dry off quickly, grazing around villages and farmsteads during the wet season lowers the risk of uncontrollable fires during the dry season by reducing the combustible standing biomass.

Fire plays a large role in modifying savanna vegetation and is the subject of much controversy. In traditional "slash-and-burn" systems, fire is used to clear land for cropping. Its ecological effects are complex and site-specific. Regular fires reduce soil cover and may expose soil to wind and water erosion. On the other hand, in the humid and subhumid tropics, perennial grasses are so well adapted to low soil fertility that the forage value of

mature grass is extremely low. Perennial grasses decompose and mineralise slowly; plant litter can build up and inhibit new growth. Burning rapidly mineralises the standing biomass, permits new growth and raises the pH on acid soils, thus creating more favourable soil conditions for cropping. Burning also stimulates green growth of grasses and shrubs during the dry season and thus improves forage quality. Furthermore, it reduces the population of ticks, insects and pests. The functions of fire in a given agroecosystem must be well understood before attempts are made to influence farmers' burning practices.

Competition and conflicts between cropping and herding

In considering the interactions between cropping and herding in tropical farming systems, the potential for competition and conflict cannot be denied. Within a farm family, the two activities compete for labour. One reason given by agropastoralists in Nigeria for the late start of the herding day in the wet season was that the men and boys must cultivate or weed in the morning. Similarly, farmers often delay tethering their goats for grazing because of crop-related work. In densely populated areas, livestock and crops also compete for land use in the wet season. Farmers who invest their savings in ruminant livestock kept close to their homesteads compete for grazing resources with herders who bring their animals to farming areas in the dry season.

A common source of conflict is crop damage. Livestock management techniques such as herding, tethering, and overnight or seasonal enclosure have been evolved to keep animals out of cropped areas. Nevertheless, the possibility of crop damage is one reason why relations between farmers and herders are often tense during the growing season (van Raay, 1975). Relations improve markedly after grain harvest, when farmers are eager to obtain manure for their fields and herders are eager to gain access to crop residues for their animals.

Conflicts can arise as a result of externally-induced changes. If grazing reserves are established in areas where farmers claim land rights and are not adequately compensated, herder-farmer tensions will increase. Large-scale mechanised cropping may reduce availability of pasture and other forage resources (e.g. trees for browse). Introduction of new techniques which permit cropping throughout the dry season may deprive livestock of essential seasonal grazing sites.

Not only changes in land use but also promotion of external inputs can lead to conflicts and weaken existing crop-livestock linkages. For example, subsidies of mineral N-fertiliser can lead farmers to abandon their traditional manuring practices, with serious ecological and social consequences if herder-farmer relations are also disturbed. Similarly, the introduction of herbicides may eliminate a source of fodder, if weeds are customarily fed to livestock during the growing season or grazed after harvest.

Implications for agricultural development policies

As development projects often aim at changes in land-use and promotion of external inputs, herder-farmer conflicts often result. The project staff may then gain a one-sided view of the relations between the two groups, and remain oblivious to the traditional links between them and to traditional procedures for resolving conflicts without outside interference. In land-use systems where different ethnic groups use the same land for different purposes, it is remarkable how effectively the inevitable conflicts are resolved, with traditional leaders usually acting as intermediaries.

Such examples of externally-induced conflicts are not intended as an argument against changes in land-use or promotion of external inputs. The aim is, rather, to increase awareness of the manifold implications of intervention in complex traditional patterns of crop-livestock interaction. For sustainable agricultural development, the ecological and economic merits of the existing low-external-input systems of crop and livestock production must be appreciated, maintained and strengthened. Existing crop-livestock linkages often become apparent to outsiders only after intervention. Therefore, close monitoring of the effects of project activities is essential so that the activities can be amended or supplemented to minimise the conflicts and maximise the complementarities between livestock and crop production.

Research and development of crop-livestock integration for sustainable agriculture should aim not at designing new techniques to replace traditional ones, but rather at understanding and strengthening existing crop-livestock links. For example, the effectiveness of traditional manuring practices should be evaluated so that the economic use of mineral fertilisers can be promoted to supplement them. Good management of organic matter in the soil is a prerequisite for effective use of mineral fertiliser and for sustainable land use (Kotschi et al, 1989).

Soil fertility can also be improved by means of sown fallow using moderate levels of external inputs. Legume leys have well-documented positive effects on soil structure and nutrient status. Smallholders are more likely to apply techniques such as sown fallow to restore fertility or prevent erosion if they can also gain immediate economic advantages, e.g. fodder or firewood. Research is therefore required into multipurpose techniques of soil improvement.

The integration of crops and livestock for sustainable agriculture should thus be promoted by:

1. promoting dual-purpose crops which bring not only higher grain yield for food but also more or better fodder;
2. improving the efficiency of using crop residues as fodder;
3. promoting the use of draught animals rather than tractors;

4. maintaining farmers' tree-protecting practices on cropland and encouraging planting of additional trees and shrubs; and
5. gaining a better understanding of tropical agroecosystems, particularly the mechanisms and effects of nutrient transfer, the role of fire, and the implications of changes in vegetation composition and structure for crop and livestock production.

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