Prospects for integrating food and feed production in Welayita Sodo, Ethiopia

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ABSTRACT

Welayita Sodo is a densely populated and intensively cultivated mid-altitude area of Ethiopia. Smallholder mixed farming is the dominant mode of production. The crop and livestock subsystems are closely interdependent: livestock contribute to the cropping system in the form of draught power, manure and sources of cash for purchase of crop production inputs, while crop residues provide livestock feed, especially during the dry season.

Because of the high population density, land holdings per household are small. Inadequate feed supply is the main constraint to livestock production. In order to optimise overall productivity there is a need to integrate food and feed production. Introducing forage legumes seems an acceptable approach: forage legumes will improve soil fertility, crop yields and herbage quality, and make the system more sustainable. Hedgerows of multipurpose fodder trees, productive backyard forages and undersowing or interplanting improved forages with food or plantation crops will probably be the most successful forage development strategies in this area. Research should look at temporal interactions between forage supply and form of feeding and nutrient demand by animals to exploit opportunities for marketing animals and their products.

RESUME

Perspectives de l'intégration des cultures vivrières et de la production des aliments du bétail à Wolayita Sodo (Ethiopie)

Wolayita Sodo est une région d'altitude moyenne, densément peuplée, où l'agriculture constitue une activité extrêmement répandue dominée par le système de la petite exploitation mixte y est étroitement associé à l'agriculture: d'une part, le bétail fournit l'énergie de traction et le fumier et assure des revenus monétaires servant à l'achat des intrants agricoles; de l'autre, les résidus de récolte entrent dans l'alimentation des animaux, notamment au cours de la saison sèche.

Compte tenu de la forte densité de population de cette région, les ménages doivent se contenter de petits lopins de terres. Par ailleurs, les pénuries d'aliments du bétail constituent ici le principal obstacle au développement de l'élevage. Pour optimiser la productivité de l'ensemble du système, il convient de promouvoir l'intégration de la production des cultures vivrières et des aliments du bétail. L'introduction de légumineuses fourragères dans ces systèmes de la petite exploitation mixte semble constituer une stratégie viable. En effet celles-ci permettront non seulement d'améliorer la fertilité des sols, les rendements des cultures et la qualité du couvert herbacé, mais également de promouvoir la durabilité du système. La mise

en place de haies de ligneux fourragers d'usages multiples et de vergers d'embouche ainsi que l'introduction d'espèces fourragères améliorées sous culture ou entre les rangées de plantes vivrières ou pérennes constituent sans doute certaines des meilleures stratégies possibles dans cette région. Enfin il convient, pour promouvoir la commercialisation du bétail et des productions animales, d'effectuer une étude approfondie des interactions à long terme, entre d'une part les disponibilités fourragères et de l'autre, le mode d'alimentation et les besoins en éléments nutritifs des animaux.

INTRODUCTION

A diagnostic survey was carried out in 1988 to assess the feed resources and the animal production situation in Welayita Sodo, Ethiopia. Data were collected by interviewing 102 heads of households in the study area. In addition to the formal survey, supplementary information was collected from the Ministry of Agriculture. The information reported in this paper is partly based on this survey.

Welayita Sodo is located at 6° 49' N latitude and 39° 47' E longitude, about 400 km south-west of Addis Ababa at an altitude of about 1900 m. The area has moderately drained, acidic red soils (nitosols). The average monthly temperature in the area ranges between 11.9°C (August) and 26.2°C (January) with a mean annual temperature of 18.9°C. Rainfall averages 1100 mm a year and is bimodal, with the short rains from February or March until April and the long rains from June until September or October. The area is representative of medium altitude, medium rainfall, acid soil areas of western Ethiopia, Kenya, Tanzania, Uganda, Rwanda, Burundi and Cameroon.

The population density at Welayita Sodo is 250 inhabitants per km², similar to that of other densely populated areas in Ethiopia. Land holdings are very small, the average per household being 0.96 ha. More than 65% of the total holding is cultivated, of which 68% is under food crops. Cash crops occupy 32% while cultivated forages occupy only 0.04% of the cultivated land.

The cropping system of the area is very intensive. Major food crops include, in order of importance, maize, sweet potato, enset (false banana), teff (*Eragrostis tef*), haricot bean, taro, sorghum, Irish potato, yam and cassava. Coffee is the major cash crop. Intercropping is a common practice. Some farmers use chemical fertiliser, mainly diammonium phosphate, on food crops such as teff and maize.

About 93% of the farmers are engaged in livestock production in addition to cropping. The average livestock holding per household is 3.60 cattle, 0.74 sheep, 0.25 goats, 0.13 donkeys, 0.02 mules, 0.02 horses and 2.09 poultry. The predominant breed of cattle is the local zebu.

Animal manure is applied on garden crops; livestock also provide draught power for important farm operations. Crop residues are mainly used as dry-season feed for livestock. It seems that there is a strong positive interaction between crop and livestock production. This paper, therefore, attempts to assess this complementarity and the prospects for further integration of food and feed production in Welayita Sodo.

PREVAILING FEED RESOURCES IN WELAYITA SODO

Type and nutritional quality of available feed resources

Natural pasture is the main source of feed for most of the year, but because of population pressure grazing land is limited to about 0.23 ha/household. Some 65% of the respondents do not have access to common grazing land and so have to depend on their small individual holdings. About 50% of the farmers buy-in additional grass from outside their farm.

Quantitatively, therefore, stubble grazing and crop residues also serve as important sources of feed. Cereal crop residues (straws and stovers) are mostly stacked and fed to livestock during the dry season when the quantity and quality of available fodder from natural pasture declines drastically.

The use of concentrate feeds is very minimal or nonexistent. However, malted barley and boiled maize are occasionally fed to lactating cows to stimulate milk production. Agro-industrial byproducts such as meat and bone meal, oilseed cakes and flour mill byproducts are not available in the area.

Two mineral-rich soils, locally known as *Bole* and *Megadua* are used as mineral supplements for ruminants and equines, respectively.

Farmers also lop the leaves and branches of various trees and shrubs and feed them to their animals during the dry season. They also collect herbaceous wild plants, mostly legumes, as feed for lactating cows. Specimens of these plants were collected and identified at ILCA. They include *Acacia* spp, *Albizia* spp, *Buddleja polystachya, Clausena anisata, Combretum* spp, *Cordia abyssinica, Dodonaea viscosa, Dracaena steudneri, Ehretia cymosa, Erythrina brucei, Flacovirtia indica, Grewia* spp, *Ipomoea* spp, *Neonotonia wightii, Olea africana, Rubia cordifolia, Schrebera alata, Triumfetta rhomboidea, Vernonia amygdalina, Zornia glochidiata* and *Zornia setosa.* Enset and cassava leaves and sweet potato vines are also fed to animals during the dry season.

The chemical composition and *in vitro* dry-matter (DM) digestibility of some of these feeds were determined. Crude-protein (CP) content ranged from 3.38% (sweet potato tuber) to 24.19% (cassava tops). Neutral detergent fibre (NDF) content ranged from 31.28% (*Dracaena steudneri*) to 62.20% (sorghum leaves). Acid detergent fibre (ADF) content varied between 6.73% (sweet potato tuber) and 56.85% (*Cordia abyssinica*). Lignin content ranged from 1.35% (sweet potato tuber) to 27.86% (*Cordia abyssinica*). The ADF-ash content, which is indicative of the silica content, ranged from 0% in some of the feeds to 17.13% in *Combretum* sp. *In vitro* DM digestibility varied between 32.90 and 82.17% and was negatively correlated with ADF ($r = -0.71$) and lignin ($r = -0.60$) contents. About 74% of the feeds commonly used had *in vitro* DM digestibility values greater than 50%.

All the feeds analysed, with the exceptions of sweet potato tuber, *Schrebera alata* and sorghum leaves, had relatively high CP content - above the 7.5% considered necessary for optimum rumen function. Thus, most of them could be useful supplements to diets based on crop residues and poor quality natural pastures, which have low protein content.

Most of the feeds analysed contained adequate amounts of all the required minerals, with the exception of phosphorus and sodium. *Bole* and *Megadua* soils are rich in sodium, and could be used as sources of the mineral, but are low in phosphorus. Moreover, the high calcium content in the various feeds and mineral soils could aggravate the wide Ca:P ratio and precipitate the problem of phosphorus deficiency. Attempts should be made to correct the phosphorus levels of these feeds when they are used as dry-season supplements to diets based on crop residues and dry pastures.

Availability of feed resources in Welayita district

Estimated quantities of feed resources

The total quantities of feed obtainable from crop residues in 1982/83 and 1983/84 are shown in Table 1; there was drought in Welayita Sodo in 1983/84. Assuming 10% wastage, the quantity potentially available for actual animal consumption was estimated as almost 166 000 and 107 000 t of DM in 1982/83 and 1983/84, respectively. Among the many types of crop residue, maize stover and enset are quantitatively the most important, followed by teff,

sorghum, haricot bean and sweet potato.

In addition, natural sources provide more than 475 000 t of feed dry matter per year, about 73% of which is obtained from grazing and browsing of natural pasture (Table 2).

Table 1. *Estimated quantities of feed dry matter obtainable from different residues in Welayita district in 1982/83 and 1983/84 production years*

Crop	Crop production (t)		Conversion	Crop residue production (t DM)	
	1982/83	1983/84	factor	1982/83	1983/84
Teff	10 810	9 934	1.5	16 215	14 901
Barley	804	343	1.5	1 206	515
Wheat	241	331	1.5	362	497
Maize	37 973	31 122	2.0	75 946	62 244
Sorghum	3 699	1 628	2.5	9 248	4 070
Horse bean	1 025	306	1.2	1 230	367
Chick pea	66	122	1.2	79	146
Haricot bean	4 156	2 791	1.2	4 987	3 349
Field pea	135	66	1.2	162	79
Potato	512	391	0.3	154	117
Sweet potato	8 027	9 366	0.3	2 408	2 810
Yam	458	592	0.3	137	178
Cassava	1 025	365	1.0	1 025	365
Coffee	2 302	1 931	0.4	921	772
Lentil	17	-	1.2	20	-
Enset [a]	na	na	na	65 200	22 872
Banana [a]	na	na	na	4 880	5 272
Total				184 180	118 554

a Crop production data not available. Crop residue production based on area planted (8150 and 2859 ha of enset, and 610 and 659 ha of banana, in 1982/83 and 1983/84, respectively: MOA, 1984) and crop residue yields of 8.0 t/ha per year for both crop (FAO, 1987)

Sources: Crop production data from MOA (1984). Conversion factors from FAO (1987)

Availability of feed dry matter relative to livestock population of the district

The livestock population of Welayita district is estimated at 468 288 tropical livestock units (TLU) (MOA, 1984; Jahnke, 1982). The availability of feed DM was calculated to be 1.37 and 1.24 t DM/TLU per year, equivalent to 3.75 and 3.41 kg DM/TLU per day for the 1982/83 and 1983/84 production years, respectively. The maintenance requirement is estimated at 4.6 kg DM/TLU per day (Kearl, 1982), so the available feed supply satisfied only about 78% of the livestock feed requirement of the area. However, the animals are reared intensively; they are kept in the yards within the household and younger animals or smallstock are kept inside the family's house. Hence, the animals have very limited exposure to inclement weather and this minimises their maintenance requirement. The animals also have constant access to household wastes, which gives them a decided advantage with reduced movement resulting in minimum energy loss. This, among other factors, is reflected in near acceptable animal performance in spite of the estimated inadequate feed supply. On the other hand, the methods used in estimating the quantities of feeds available may not have been accurate and therefore there is a need to re-examine them.

Table 2. *Feed dry matter obtainable from different land use types in Welayita district*

Land use type	Area (ha)	DM yield (t/ha per year)	Annual DM production (t)
Natural pasture	172 602	2.0	345 204
Aftermath	53 410	0.5	26 705
Fallow land	9 261	1.8	16 670
Forest	12 771	0.7	8 940
Woodland, bushland and shrubland	65 016	1.2	78 019
Total			**475 538**

Source: FAO (1987)

LIVESTOCK PRODUCTIVITY IN WELAYITA SODO

The productivity of the ruminant livestock in the area is summarised in Table 3. In general, livestock productivity is low for all classes of animals. The relatively late age at maturity and the extended parturition intervals reflect an environment in which animals are subjected to long periods of nutritional stress. However, the estimated milk yield of cattle (about 500 kg/lactation, excluding milk consumed by the calf) can be considered acceptable for unimproved local zebu cows and this could be attributed to the practice of hand-feeding with various herbaceous and tree plants collected from the surroundings as well as with household wastes.

Mortality rates could not be calculated from the data collected. However, farmers reporting mortality of young animals cited drought and nutritional stress as the main causes of death.

MAJOR CONSTRAINTS TO LIVESTOCK PRODUCTION

Shortage of grazing land and inadequate feed supply are the major problems facing livestock producers in the area. Most of the crop residues are used as livestock feed, but their supply is seasonal and they are used in the traditional way, without any pretreatment and/or strategic supplementation. The cultivation of fodder crops is limited due, among other reasons, to shortage of land. The integration of food and fodder crops in Welayita Sodo is nil to minimal due to inadequate research data and extension services and the lack of economic incentives to the farmers. Generally, available feed resources are not sufficient for optimum animal production. Lack of adequate financial resources and the absence of institutionalised credit services for investment in livestock production are other constraints identified in the survey.

Table 3. *Productivity data for ruminant livestock in Welayita Sodo, based on interview data from 102 households*

Performance parameters	Cattle		Sheep		Goats	
	Mean	SD	Mean	SD	Mean	SD
Weaning age (months)	9.8	2.9	4.8	1.8	5.3	1.0
Age at sexual maturity (months)	52.3	10.2	11.4	4.6	11.0	6.6
Age at first purturition (months)	65.0	10.2	18.4	7.1	16.9	6.7
Parturition interval (months)	26.2	6.6	12.9	4.3	11.1	2.3
Daily milk yield (litres/head)						
Maximum	2.4	0.9	-		-	
Minimum	1.0	0.5	-		-	
Mean	1.6	0.6	-		-	

Lactation length (months)	10.3	2.8	-		-	

PROSPECTS FOR INTEGRATING FOOD AND FEED PRODUCTION

The traditional complementarity of food and feeds in Welayita Sodo

Acute shortage of land and inadequate feed supply constrain animal output in Welayita Sodo but the farmers in the area are amenable to supplementary feeding of their animals. Where cash availability limits investment in livestock enterprises, as is the case in Welayita Sodo, the incorporation of forage legume production with the crop subsystem may be an acceptable approach.

Leguminous forages can contribute to better utilisation of cereal crop residues. Legumes are rich in protein and other nutrients such as minerals and vitamins. Some forage legumes such as *Desmodium intortum, Macrotyloma axillare* and *Stylosanthes guianensis* were shown in initial agronomic screening trials to be suitable and productive; the trials were conducted by the International Livestock Centre for Africa (ILCA), in collaboration with the Ministry of Agriculture, in mid-altitude areas of Welayita Sodo and in the Rift Valley region of Ethiopia. Some of the forage legumes were further evaluated in feeding and digestibility trials and were found to be useful supplements to crop-residue-based diets (Table 4).

Table 4. *Voluntary feed intake, nitrogen intention and body weight gain of lambs a basal diet of maize stover supplemented with different levels of legume hays*

Supplement g/head per day	Dry matter intake (g/kg$^{0.75}$ per day)			Nitrogen retention (g/day)	Liveweight gain (g/day)
	Maize stover	Legume hay	Total		
Desmodium intortum					
250	28.9a	26.8c	55.7b	-0.19	7.3b
350	26.9b	35.0b	61.9a	1.51	24.9a
450	17.0c	44.7a	61.7a	1.41	30.9a
Stylosanthes guianensis					
250	33.4a	26.0c	59.4b	0.82	15.0b
350	22.2b	36.6b	58.8b	1.61	13.9b
450	20.3c	44.4a	64.7a	1.37	30.3a

Within legume species, values in the same column followed by the same or no letter do not differ significantly (P>0.05)

Leguminous fodders also make a very important contribution to the crop subsystem. In systems with minimum fertiliser inputs legumes enhance crop yields by reducing the rate of decline of soil fertility. Nitrogen fixed by the legumes will be available to food or plantation crops grown by the smallholders during concurrent and/or subsequent seasons. For example, the planting of *Desmodium intortum* cv Greenleaf under coffee increased coffee berry yields by up to 19% on peasant holdings in Welayita Sodo (Lazier, 1987). Similarly, Haque (1990) found that intercropping maize with *Macrotyloma axillare* produced significantly more total dry matter than sole maize plots, although the intercropped plots yielded less than half as much grain as maize in pure stand. From this finding, it was concluded that the production of large amounts of high quality feed during the dry season by *Macrotyloma axillare* may be sufficient to offset the loss in maize grain yield for farmers with mixed crop-livestock farms and encourage them to adopt cereal-legume intercropping (Haque, 1990). But this tentative assumption needs to be tested in the field against farmers' responses/reactions to low grain

yields *vis-à-vis* potential animal productivity and marketing in Welayita Sodo. Alley cropping with leguminous multipurpose trees such as *Sesbania sesban, Leucaena leucocephala* and *Gliricidia* spp offers alternatives to intercropped forage legumes.

Stratification of livestock production

The adoption of forage legume technologies would also assist in stratification of livestock production. During the dry season there is an acute shortage of feed in the lower altitude rangelands (mainly inhabited by pastoralists), resulting in substantial body weight loss and/or, during severe droughts, even death of the animals. These losses could be partially averted by selling some meat animals (steers and small ruminants) to highland farmers for fattening, but this exercise would only be feasible if adequate feed can be made available in the highlands, through improved forage production and if there are suitable marketing facilities.

In general, stratification of animal production is an advantageous strategy for both the lowland pastoralists and the mixed crop-livestock farmers of the highlands. Studies on animal health and on marketing are needed to assess the sustainability of this intervention. For the pastoralists, this strategy will:

- reduce feed problems for animals domiciled in the rangelands
- protect the rangelands from the likely slow land degradation by adjusting stocking rates through increased offtake
- generate some cash income

And the highland mixed farmers will benefit from:

- increases in income, general welfare and cash input for crop production
- enhanced soil fertility in the cropping areas from animal manure and from the forage legumes

Temporal interaction between forage supply and demand

If farmers are to adopt a sustainable integrated crop-livestock production system there is a need to develop packages that will fit forage production and conservation with the nutrient demand curves by the animals to exploit market opportunities for livestock and livestock products. Researchers need to work in a more problem-oriented and integrated approach to overcome the isolation of disciplines like nutrition, forage agronomy and socio-economics. Research should be extension-oriented, addressing the needs of the smallholder in Welayita Sodo.

The four "I"s

Irrespective of the locality or the scale of operation, successful integration of food and feed production subsystems will depend on:

- institutional factors resulting from government agricultural policy
- infrastructure that is conducive to agriculture production and marketing, nationally, regionally or internationally
- inputs to the production systems—credit and financial facilities
- incentives, interrelated to agricultural policy, infrastructure and ease with which inputs are available.

In most cases farmers' incentives to increasing agricultural productivity are spontaneous and self-triggered. Lamentably the natural wisdom of the peasantry in rationalising the

practicabilities of these issues, as they affect their well-being, is often assumed not to exist, underplayed or neglected by policy makers, research workers and even by extension services. We might be excused, sometimes, for assuming that, as researchers, we have better tools to evaluate sustainability issues and other long-term interests of the farmers we are supposed to help. That should not blind us to the fact that they, the farmers, also know what are their priorities, in the short and medium term.

CONCLUSIONS

Our success in increasing agricultural production within the multiplicity of existing subsystems in sub-Saharan Africa depends upon our ability to recognise and appreciate the interrelationships of the four "I"s outlined. There is a need to develop these infrastructures at the rural level and especially, in these days of gender issues, to lessen the load of women in feeding their families. For Welayita Sodo, forage production technology will be more acceptable if it fits into the existing production system, based on the available marketing infrastructure and financial inputs. Forages should be integrated with cropping systems rather than displace crops. Other forages could be produced from fence lines and hedges or in a backyard forage bank. We advocate that research should be devoted to the temporal interaction between forage supply and nutrient demand curves as they relate to a possible exploitation of market opportunities of animals and their products in Welayita Sodo.

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