Energy flows on smallholder farms in the Ethiopian highlands*

Guido Gryseels and Michael R. Goe
Highlands Programme,
ILCA, Addis Ababa, Ethiopia

** Summary of a paper submitted to the Beijer Institute (the International Institute for Energy and Human Ecology), the Royal Swedish Academy of Sciences, Stockholm, Sweden.*

Summary

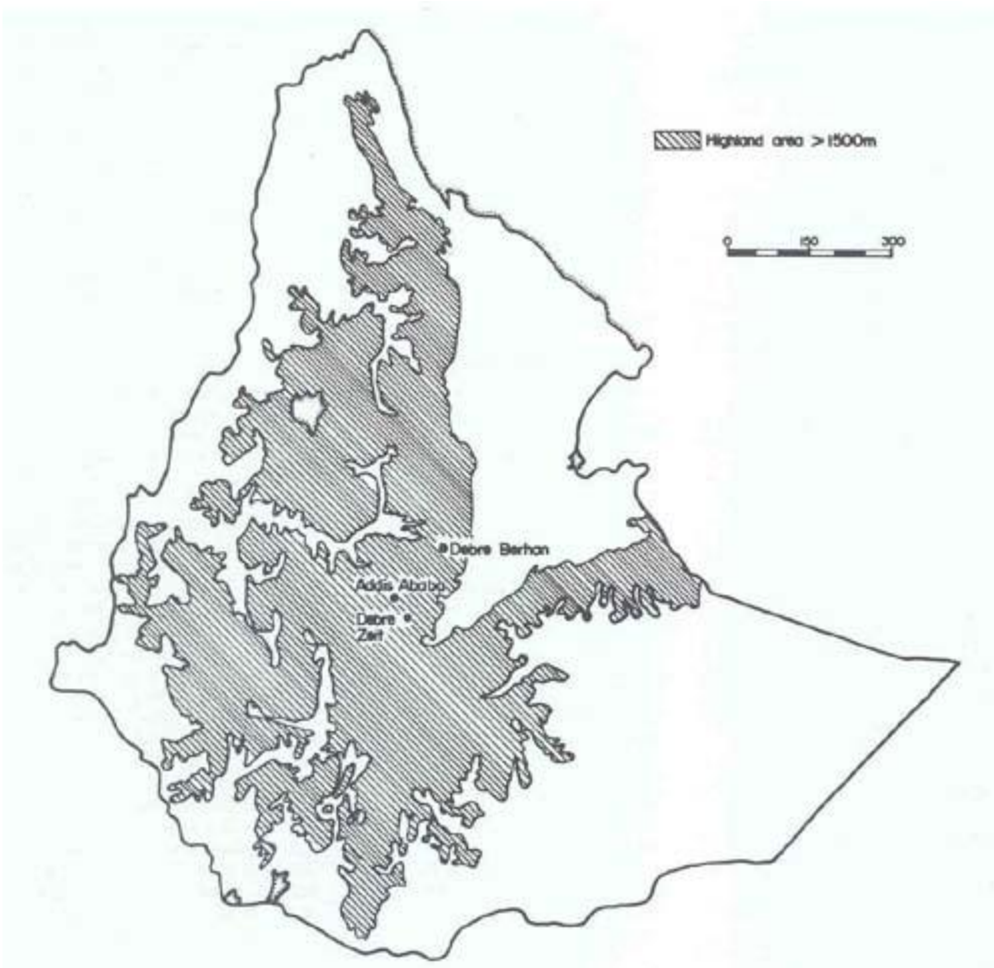
THIS PAPER *studies energy flows on smallholder farms in two areas of the Ethiopian highlands. The overall farming system and the resource base in these areas are described and an outline is given of how these resources are used. The use of energy in the household system is then discussed and the prospects for improvements in energy use in these areas are assessed. The authors conclude that any major improvements in present energy use will have to rely on technologies which are simple, effective and easily implemented and maintained. Energy problems must be seen in the wider perspective of agricultural and ecological development. Changes in the overall energy use on smallholder farms will be slow unless a proper infrastructure and adequate extension and technical support services are established.*

Introduction

Efficient management of energy resources is crucial to survival in subsistence agriculture. Although energy inputs into such farming systems are low compared to western agricultural practices, farmers are often forced into production methods which exploit current energy flows at the expense of a sustained, longer term output. In such situations, productivity is steadily declining. This, combined with an increasing population pressure makes it imperative to increase the efficiency of energy use. Efficiency gains within agricultural systems can be achieved by improving energy transformation in the use of resources and by reducing absolute losses.

This paper describes energy flows on typical smallholder farms in the Ethiopian highlands. These farms are representative of a subsistence agricultural system that has remained basically unchanged for centuries. Surveys were conducted in the two main study areas of ILCA's Highlands Programme: around Debre Zeit, 50 km south of Addis Ababa at 1800 m a.s.l., and Debre Berhan, located 120 km northeast of Addis Ababa at 2800 m a.s.l. (Figure 1).

Figure 1. *The Ethiopian highlands*



Farming system and resource base

Some 70% of Ethiopia's human population of 32 million live in the highland areas. The highlands are ecologically diverse and agricultural conditions vary widely.

In Ethiopia nearly 80% of the population is directly employed in or dependent on agriculture. In many rural areas, people are acutely vulnerable to drought and starvation, and basic social services are seriously deficient. Ethiopia's rugged terrain is a major constraint to economic development because of the inherent transport and communication problems. It has been claimed that three quarters of the population live more than one day's round-trip walk from an all-weather road.

The bulk of agricultural output in Ethiopia is produced by individual subsistence smallholders who have `farming rights' over the land they till. Land is not owned individually but is allocated by the local Peasants' Association (PA), to one of which each farmer necessarily belongs. There is an average of 250 members per PA and each PA regulates the use of approximately 800 ha of land.

Farming system

A subsistence mixed farming system prevails in most of the Ethiopian highlands. Rainfed agriculture is dominated by the production of cereals, pulses and livestock. Average annual rainfall fluctuates between 600 and 1200 mm, with 70% of rain falling in the period between July and September. Temperatures are generally temperate, although extreme diurnal variations can occur in the dry season. Frosts are common at altitudes above 2100 m. The size of individual landholdings ranges from 0.5 to 5 ha. In addition, farmers have grazing rights on the communal pastures of the PA of which they are members.

Traditional agricultural tools and paired oxen are used for producing a wide range of crops including teff, wheat, barley, maize, sorghum, linseed, beans, peas and lentils. Annual crop yields range from 500 to 1000 kg/ha.

Generally, land is scarce and the human population growth rate is high (2.2% per annum; World Bank, 1982). As a result an increasing proportion of permanent pasture land is being cultivated, fallow periods are being reduced and the pressures caused by subsistence crop production on the available arable land are increasing. This has substantially added to erosion and to the decline in soil fertility.

Access to modern inputs such as chemical fertilizers or improved seeds is limited. Extension services are also very scarce and priority in the allocation of farm inputs is given to cooperatives. Most farmers own livestock: a typical inventory is two oxen, a cow, a few sheep and a donkey. Cattle (Zebu type) are kept mainly for draught power and manure. The manure is mainly used as household fuel, while a small amount is returned to the fields as fertilizer. Milk, meat and hides are relatively less important products. Sheep and goats require minimal inputs, they are kept as an investment and provide security in times of need. Donkeys are used extensively to transport agricultural inputs and farm produce.

Productivity is low for all livestock species. Milk offtake from indigenous cows kept under traditional management rarely exceeds 400 kg for a lactation period of 7 months, and calving intervals average 2 years. Various factors contribute to this low productivity, including unexploited genetic stock, extended periods of nutritional stress during the dry season, diseases and endoparasites.

Crops and livestock are closely linked in the smallholder mixed farming system of the Ethiopian highlands.

Labour availability

The labour required to operate a family farm depends on the season. Although most of the labour required is supplied by the family, non-family labour commonly has to be used to overcome bottlenecks.

Each farmer is required to supply labour to the cooperative enterprises of the PA with which he is affiliated. Additionally; farmers are expected to assist aged or disabled farmers and those families whose head is in military service.

Capital

Livestock holdings

The most important contribution of livestock to agricultural production in the Ethiopian highlands is through the use of oxen as draught animals. Table 1 gives average holdings of livestock per farmer as determined from ILCA surveys around Debre Zeit and Debre Berhan. Around 10% of the farmers in these areas have no livestock.

Table 1. *Livestock holdings per farmer on 60 farms around Debre Zeit and 60 farms around Debre Berhan, 1980.*

Livestock type	No. of livestock holdings per farmer (range)	
	Debre Zeit	Debre Berhan
Oxen	1.86 (0–4)	1.02 (0–3)
Cows	0.93 (0–4)	1.45 (0–4)
Heifers	0.33 (0–2)	0.88 (0–3)
Bulls	0.48 (0–5)	0.69 (0–2)
Calves	0.64 (0–3)	0.98 (0–3)
Sheep	1.55 (0–4)	10.69 (0–32)
Goats	1.00 (0–6)	0.12 (0–2)
Donkeys/Mules	0.98 (0–3)	1.81 (0–5)
Horses	0.05 (0–1)	1.12 (0–2)

Fuel sources

Dung cakes, firewood and straw are the major fuel sources available for heating and cooking in rural households. Straw is used as fuel during the harvest season from October to December. Firewood resources (mainly *Acacia* spp. and *Eucalyptus* spp.) are not uniformly distributed throughout the Ethiopian highlands. Ethiopia's forested area has declined from 40% at the beginning of this century to only 4% of its land area (FaWCDA,1982).

Typical weekly use of dung cakes. and firewood in two areas of the highlands of Ethiopia is given in Table 2.

Table 2. *Typical weekly use of dung cakes and firewood around Debre Zeit and Debre Berhan*[a].

Fuel	Fuel consumption (kg/week)	
	Debre Zeit family	Debre Berhan family
Dung cakes[b]	41	48
Firewood	10	13

a. From ILCA surveys during 1980 on 25 smallholder farms in each area.
b. Based on sun-dried weight.

Other capital items

The annual cash income of smallholder farms in the Ethiopian highlands rarely exceeds US$ 200. Surveys have indicated an average gross cash income in the region of US$ 155 per year, with US$ 90 coming from the sale of crops, US$ 50 from livestock and livestock products and US$ 15 from other sources. This modest cash component within the system limits the opportunity for internal financing of improvements and highlights the need for an efficient use of available resources.

Farmers usually possess a dwelling house, stores and livestock sheds. Farm tools and implements are made of wood fibre, leather and sometimes metal. Wood from the *Eucalyptus* spp. is used for ploughs, yokes, winnowing forks and spades; hides and skins are used for ropes, straps, whips and grain bags; and fibre materials are used for storage bins, and ox equipment such as ropes and whips. The value of this traditional agricultural equipment does not normally exceed US$ 60 per farm.

The two most common fertilizers used are diammonium phosphate and urea, with most farmers applying less than the recommended rates.

Resource use

The previous section has described the resource base available to the average smallholder farmer in the Ethiopian highlands. Certain resources such as animal traction have an intermediate role when used for farm production. Others provide end-products that can either be consumed at home or sold. This section describes the intermediate roles within the traditional farming system.

Animal traction: cultivation and transport

Oxen

The traditional agricultural system in the Ethiopian highlands depends on animals for draught power for cultivation and transport of agricultural products. ILCA surveys in 1980 around Debre Zeit and Debre Berhan showed that animal power used for crop-related work averaged 1050 hr/ farm/year. Most of this power was supplied by oxen, but other livestock were sometimes employed for threshing (50 to 80 hr were contributed by donkeys). Some 60 to 70% of the total animal power input was for seedbed preparation and planting, with approximately 350 hr per oxen pair used for these purposes per season.

The availability of draught power determines the size of area cultivated and the cropping pattern. Table 3 summarizes the effect of oxen holdings on crop areas among 42 traditional farmers in Debre Zeit in 1980. It should be noted that cereals are much more labour intensive than pulses.

Table 3. *Effects of oxen holdings on area cultivated and a cereals–pulses cropping mix around Debre Zeit, 1980.*

No. oxen per farm	Area cultivated (ha)	Area under cereals (%)	Area under pulses (%)
0	1.2	54	46
1	1.9	44	56
2	2.7	67	33
3 or more	3.6	92	8

Source: Gryseels (1983).

Cultivation throughout most of the Ethiopian highlands is done with a pair of oxen which pull the locally-made *maresha*. The power output of oxen pulling this traditional plough depends on the animal's body weight, its nutritional and health status, terrain, soil conditions, draught force required for ploughing at various depths, speed of travel, number of passes, training of the animal and skill of the handler.

Studies conducted on traditional farms near Debre Berhan demonstrate that oxen with an average body weight of 280 kg produce power outputs ranging from 0.35 to 0.70 kW/hr while ploughing (Goe,1983).

Energy requirements of mature working oxen vary according to their maintenance needs and actual power output over a given period. Results from trials conducted at the ILCA research stations show maintenance requirements of local oxen weighing between 300 and 350 kg to be 38.5 to 41.8 mega joules (MJ) per day of metabolizable energy (ME). Requirements for the same animals ploughing with the *maresha* were 3.8 MJ ME hr regardless of body weight (Abiye Astatke,1982).

Donkeys, horses and mules

Ethiopia has approximately 7 million horses, mules and donkeys (FAO, 1982). Horses and mules are used primarily for transport, carting and, in some instances, for packing. Mules are more valued than horses due to their temperament and packing ability. Donkeys are mainly used for packing, although carting is not uncommon in certain areas. All are used for threshing crops. Farmers in some regions employ horses and donkeys for draught, either hitching the same species together or in mixed pairs. Horses can also be yoked together with oxen or barren cows for ploughing.

Labour use

A typical subsistence farm with 2.5 ha of land under cultivation employs a total of approximately 1100 hr of labour for crop production per year[1]. This gives an average labour input of around 440 hr/ha/year. Of this total, around two thirds are usually supplied by the family, about one quarter by exchange labour, and less than 10% by hired labour. Most labour for cropping is supplied by adult males.

1. This assumes no quality differences between the labour inputs of the different age and sex groups. Women and children have specific tasks in crop production for which they are often as efficient as adult males.

The labour inputs for different crops vary both yearly and by location because of differences in rainfall, soil and land types, cultivation practices and crop yields. A high yield can be a result of more intensive weeding and better seedbed preparation. However, higher yields in turn require extra labour for harvesting and transport. Teff is the most labour intensive of all food crops grown in the highlands, requiring an average 600 hr/ha while pulses require only half this amount.

Labour inputs needed for livestock production are constant throughout the year. They involve basic management and are generally fulfilled by family members, except in cases where outside labour is hired for herding.

Other intermediate products

Milk for calves

The major role of cows is to produce male calves to be reared as draught oxen. As a result, approximately equal amounts of milk are suckled by calves and milked out for family consumption.

Crop byproducts

Grazing on communal lands and fallow plots is the main source of feed for livestock in the highlands. This is supplemented with hay, stubble grazing, straw and other crop residues. Work oxen and cows in milk are given priority in supplementary hand feeding. In the dry season they are supplemented with hay and straw and in the wet season with straw. Valley bottoms and crop stubbles are grazed during the dry season from December to April. From about May to November, livestock largely depend on fodder on hillsides, in field verges and roadsides.

A typical farm of 2.5 ha, with two thirds of the cultivated area sown to cereals, the remainder to pulses plus an additional 0.75 ha of communal grazing land, produces approximately 6.0 t of dry matter in a normal year. The average farm stock holding is around 3.67 animal units (AU[2]). Assuming 8.1 MJ ME/kg fodder for 4 months and 6.6 MJ ME/kg fodder for 8 months, the annual fodder requirement for maintenance of these AUs is 6.5 t DM. The available feed resources thus fall short of total requirements by 8%. The error in estimating total production, its yearly variation, and animal requirements would indicate that actual feed resources may be adequate for maintenance. However, there are only limited periods during the year when livestock can gain weight without supplementation.

2. One AU equals 250 kg liveweight.

Energy aspects of the household system

Consumption

Ethiopian families in rural areas depend heavily on home production of foodstuffs for consumption. The staple food of most people of the Amhara group—the dominant social group in the ILCA study areas—is *injera* and *wat*. *Injera* is a porous pancake, a few millimeters thick and 40 to 50 cm in diameter, its sourness depending on the length of the fermentation period. Although *injera* made from teff is preferred, it can also be prepared from barley, wheat, maize and sorghum or sometimes a mixture of these, depending on what is available and affordable. The ingredients of *wat*, the sauce which accompanies *injera,* also vary according to their availability as well as fasting requirements and local tastes. Meat *wat* is preferred, but most farmers can afford it only on feast-days. In a normal year farmers produce sufficient cereals and pulses from their own cropped land to have a modest surplus after meeting family requirements. Table 4 presents indicative total production and its allocation for an average household of five persons (two adults and three children) on a farm of 2.5 ha in an average year.

Table 4. *Annual production and disposal of food crops on a 2.5 ha family farm in the Ethiopian highlands.*

Crop	Total production[a](kg)	Seed required for following crop[b] (kg)	Consumption[c](kg)	Available for sale (kg)
Cereals (1.65 ha)	1 320	165	1 000	155
Pulses (0.85 ha)	510	85	250	175

a Assuming harvested yield of 800 kg/ha for cereals and 600 kg/ha for pulses.
b. Values are calculated on the basis of seeding rates of 100 kg/ha for both cereals and pulses.
c. Assuming a family of five with average annual consumption each of 200 kg of cereals and 50 kg of pulses.

Due to the large number of fasting days each year, there is a great demand for cereals, pulses and vegetables to meet household nutritional needs. Table 5 gives daily per caput intake of common foodstuffs and their energy values.

Table 5 . *Daily per caput food intake of basic foodstuffs.*

Foodstuff	g/day[a]	MJ ME/day [b]
Cereals	400–500	6.3–7.9
Pulses	80–100	1.2–1.7
Pepper	15	0.21
Oil-butter	15–20	0.45–0.59
Onions	80	0.12
Other vegetables	15–20	0.23–0.30

a. Source: Asfaw Alemu (1982).
b. Calculated from Agren and Gibson (1968).

Human energy expenditure in household activities

Household duties are the responsibility of women. These duties include food processing and preparation of meals, making *tella* (a local beer), fetching water, collecting dung and wood for fuel, cleaning, washing, taking care of the children and making baskets. Most of the labour inputs for livestock production such as feeding and watering, milking, barn cleaning, manure collection and handling are done by women and children. Women also help to deliver goods to the market place. Younger children are responsible for herding the cattle, delivering milk to collection stations, transporting ashes to the plots near the house, running errands and minor household chores. When boys reach the age of 12 years they begin to help their father with the field work, take goods to the market, make yokes, ploughs and handles for hand implements, collect honey, and learn the management aspects of keeping livestock and general farming. Weaving of the *shama* or *gabi* (a large wrap made from cotton) is done mostly by men. The time spent performing daily household chores and the energy expended on them is given in Table 6.

Table 6. *Time spent on daily household chores and energy expended.*

Activity	Time spent	Energy expended	
	(hr/month)	(MJ/hr[c])	(MJ/month)
Cooking	183	0.28	1.24

Food processing	5[a]	0.91	4.55
Collecting, preparing and drying cow dung	44[b]	0.91	40.04
Collecting firewood	61	0.91	55.51
Fetching water	91	0.91	82.81
Washing clothes	8	0.91	7.28
Herding livestock	213–343	0.28	59.64–68.04
Going to market	20–45	0.28	5.60–12.60

a. Source: Asfaw Alemu (1982).

b. Source: Baygell (1979).

c. Based on calculations from Clark and Haswell (1970), pp. 12–13.

Prospects for improvements in energy use

Animal traction

Single ox

A major constraint for crop cultivation in Ethiopia is the unequal distribution of oxen per farm household. Data available at the national level indicate that only 37% of the farmers have two or more oxen, 34% have one and 29% own no oxen at all (MOA, 1980). Since oxen are traditionally paired for work, more than 60% of the farmers have to rent or borrow one or two animals for cultivation.

A farmer owning less than two oxen has several options available for securing animals for ploughing. Households that already have one working ox can enter into a *mekanajo* agreement with another household in a similar position, whereby the pair of oxen is used on the partners' fields on alternate days. However this strategy has one serious disadvantage: if the ploughing season is short, the working capacity of the animals may not allow both farmers to cultivate at the optimum time. Moreover, the changing of oxen handlers and yoking of animals not used to each other can result in a loss in daily work output.

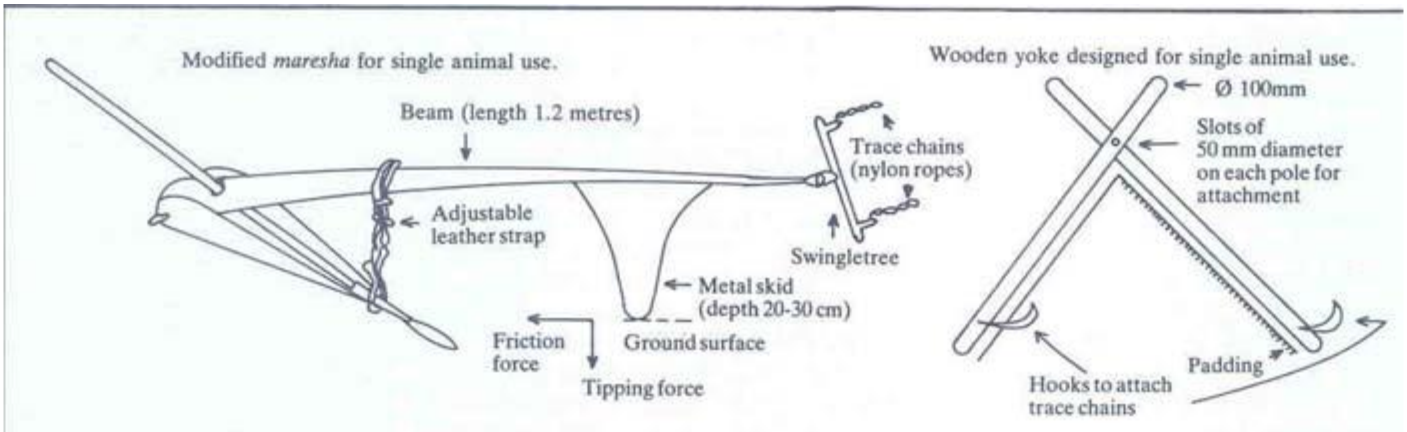
In another arrangement called *minda,* a farmer in need of an ox can rent it from a farmer owning surplus oxen at an annual cost of between 200 and 225 kg of grain, or in exchange for human labour. Sometimes oxen are rented on a cash basis, at US$ 1.50/day/pair or US$ 2.50/day/pair if a handler is included.

Throughout most of the Ethiopian highlands the areas of fallow and permanent pasture have been reduced due to the high demand for food crops from an increasing human population. Thus it is becoming more difficult to maintain the present cattle population, as well as to prevent ecological degradation.

In these circumstances, it is likely that it will become increasingly difficult for farmers to keep the breeding stock required for raising replacement oxen in addition to maintaining a working pair. However, by introducing a change in the farming system, whereby cultivation would be done by a single ox, rather than a pair, it may be possible to substantially increase the productivity of livestock and the smallholder farm. More cattle could be sold, resulting in an increase in farmers' incomes. At the national level such a development would bring more meat supplies to urban areas. Reduced grazing pressures would enable better control of erosion and would help to improve livestock nutrition. Farmers who have to rent or borrow one or two oxen will be able to practise more timely cultivation.

ILCA has developed a suitable yoke and harness, as well as a modified *maresha* plough (Figure 2), for use by a single ox. This technology has been tested at the experimental level, and trials are currently being conducted on traditional farms to test the applicability and effectiveness of this new technology within the Ethiopian highlands.

Figure 2. *Modified* maresha *and yoke designed for single ox cultivation.*



Use of crossbred cows for draught

Another option which may also help to reduce cattle herd size and grazing pressures, and extend stored feed supplies, is the use of crossbred cows for both milk production and draught. ILCA studies with farmers have demonstrated that crossbred cows are able to provide adequate draught power during the cropping season, as well as a higher milk yield and a crossbred calf of higher value compared to local Zebu cows. Although the study is not yet complete, data indicate that cows can be adapted to work without any negative effects on their reproduction rate, lactation length and milk yield, provided that adequate feed supplies and veterinary care are available and proper management is maintained.

The most promising area for the use of crossbred cows as traction animals would be in or around urban areas where the scarcity of land is more acute than in the rural areas. Farmers would be guaranteed a constant market for milk, access to supplements and veterinary services, and high market prices for calves. Such farmers would be more inclined to change or modify their management system since their proximity to urban services would help minimize production risks.

Improved implements

Cultivation trials with improved implements were conducted by ILCA from 1980 to 1982. Trials were carried out on three different soil types—clay, clay loam and silty clay loam. Three cultivation systems were tested using the traditional *maresha,* a conventional mouldboard plough and a spring-tine harrow for the primary passes: Seed covering was done with the same implements and a zig-zag harrow (Abiye Astatke and Matthews, 1982). Dynamometer measurements were made for the three implement/soil combinations to determine the amount of draught power required.

On each soil type, better weed control and crop yields were obtained using the conventional mouldboard plough and spring-tine harrow compared to the *maresha.* The total kWhr/ha required was highest for the mouldboard plough on all soil types, followed by the *maresha* on clay soils and the spring-tine on silty clay soils. In all cases, the zig-zag harrow provided more uniform seed covering in less time and required less draught power than did the three other implements.

Trials to reduce waterlogging of bottomlands have also been initiated. A single winged-tine which can be fitted on the same frame as the mouldboard plough, was used to aerate and drain surface water. Results from the first season of trials demonstrated that natural forage yields (fresh weight) can be increased if the tine and winged-tine are used before the rains start. Further work will be done to better assess yield differences and kWhr/ha requirements.

These improved implements have not yet been tested off-station, the main obstacle being their cost, which is beyond the means of the smallholder. For example, the basic frame for use with a mouldboard plough and a winged-tine costs US$ 100, while the costs of the plough share and the tine are US$ 20 and US$ 25 respectively. The spring-tine unit costs US$ 200 and the zig-zag harrow US$ 35–40. Compared to the total cost of the traditional *maresha* of US$ 15, the above represents a substantial investment for a farmer operating at the subsistence level. Thus unless an effective agricultural credit programme can be developed, most farmers will continue to rely on the *maresha* for cultivation.

Fuel consumption

About 95% of the total energy consumption in Ethiopia is provided by wood, dung, charcoal and crop residues. Biomass consumption for fuel in 1980 was about 24 million m^3 of firewood, 7 million t of dung, 170 000 t of charcoal and 6 million t of crop residues (FaWCDA,1982). Given the current firewood consumption of 1 to 1.2 t/caput/year, it has been estimated that forests in Ethiopia will be completely destroyed by the year 2000 unless drastic measures are taken to reduce the present consumption level and to strengthen both the financial and manpower budgets of the relevant institutions (Beijer Institute, 1981). More efficient ways of firewood utilisation need to be investigated. Substantial savings in firewood consumption could be achieved by the use of improved stoves and different cooking methods.

The major tree species being planted in the highlands is *Eucalyptus globulus*. However, even if present reafforestation programmes attain the projected planting goal of 56 000 ha per year, this will not be sufficient to maintain the existing woodlots which are being cut at an estimated rate of 200 000 ha per year (Beijer Institute, 1981). Furthermore although *Eucalyptus* spp. are highly suitable for woodlot establishment, they are not very effective in controlling hillside erosion.

Urgent reforms are therefore needed. Possible measures to be taken include controlled livestock grazing on hillsides, which should be enforced so that slopes do not become denuded. In areas where erosion has become severe, livestock should be kept off hillsides for at least 3 to 4 years to allow the total biomass to regenerate. In addition, conifer species should be emphasized in these areas.

Wind energy

In the Geleb area north of Lake Rudolf in the Gamo Gofa administrative region, windmills are used to supply households with water and for irrigation (Fraenkel, 1975). Prototype windmills for electrical and mechanical applications are to be built in the Melka Werer area of the Awash valley (Cocks, 1981). By employing windmills for irrigation, it should be possible to grow two or three crops a year instead of one.

The potential for increasing the use of windmills or wind generators in Ethiopia depends on the altitude of the chosen site, the average wind speed and the duration for which a particular wind velocity is maintained. Even very efficient units cannot operate when wind velocities are 3 m/s or less (Earthscan, 1981). As the altitude increases air density decreases. A study done by ILCA at Debre Berhan showed that the power available from wind at a particular velocity was three quarters of what it would be at sea level. In addition, a windmill could be expected to pump the required amount of water only for 2 to 3 months a year because there would either be no wind or average wind speed would be too low during the rest of the year (Campbell, 1982).

Solar energy

In Ethiopia solar radiation is used extensively for drying crops, animal forages, fruits and fish, for the production of salt by evaporation of seawater or inland brines, and as fuel. However, harnessing its power in the form of electricity, heat storage or mechanical energy at the village level has so far been minimal or non-existent, despite the successful research into solar cookers, heaters and distillation plants (Hobbs, 1965).

Potential areas for developing solar energy should probably be limited to passive solar driers and ovens, irrigation pumps powered by photo-voltaics and flat plate collectors (Beijer Institute, 1981). However the cost of such solar apparatus would be prohibitive to smallholders, and the equipment is still complex, difficult to maintain and potentially hazardous to the ill-trained. Therefore, compared with existing sources of energy, the prospects for large-scale introduction of solar power remain poor in the immediate future.

Biogas

Given the scarcity of firewood and the prevalent use of dung for cooking, biogas plants would appear to be an appropriate means of reducing the current usage of these renewable energy resources. However, despite the expensive experimental work undertaken by the Ethiopian National Energy Commission only a few biogas plants have so far been established in the Ethiopian highlands. The major difficulties encountered are maintenance, proper management and public acceptance and cooperation.

Thermal and hydroelectric power

Most thermal plants producing electricity in Ethiopia operate on diesel fuel. While these units generated 26.6% of the total electricity produced in the country in 1970, their output in 1978 fell to 14.7%, largely due to an increase in the number of hydropower plants and problems in operating thermal plants efficiently (ECA, 1980a). It is reported that only 2.3% of Ethiopia's hydropower potential has been developed, and that of the electricity generated only 50% is being utilized, primarily because electrical appliances are beyond the reach of most of the population and electrification has yet to reach many rural areas of the country (Varet, 1978).

Increased use of electrical power in the country will depend on more accurate long-term planning in all sectors of the economy (especially the industrial sector), better returns on assets and better adherence to projected time schedules for completion of new generating plants. At present, little progress has been made in tackling these problems (Beijer Institute, 1981).

Geothermal energy

Geothermal exploration began in Ethiopia in 1967. Three sites were selected for drilling, two in the Afar depression and one in the Rift Valley (ECA, 1980a). Depending on the outcome of the drilling in the Lake Langano area of the Rift Valley, additional wells may be drilled (ECA, 1980b). The use of geothermal energy would extend electrification to isolated rural areas where the supply of electricity through other means may not be feasible.

Conclusion

Any major inroads to be made in changing the present energy usage will have to rely on technologies which are simple and effective, and easily implemented and maintained. In addition, these technologies should be well tested to determine whether by improving the efficiency of one resource a reduction in another does not occur.

However, although improvements in the use and availability of energy sources play a major part in improving agricultural productivity, other aspects also need to be considered. Energy problems must be seen in the wider perspective of agricultural and ecological development. The energy base necessary for this development will have to be both animal and human power. In the short term there is no scope for the mechanization of Ethiopian agriculture. Cultivation will continue to be carried out using animal traction. Improvements in the animal traction component, as discussed above, will not only lead to direct increases in agricultural productivity, but will also make it possible to drain and cultivate valley bottomlands, which are presently seasonally flooded and used only for dry-season grazing and hay production. At present food crops are mostly cultivated on hillsides. If appropriate short-seasoned or frost-resistant varieties can be found and if bottomlands can be drained, a major review of this agricultural practice could be considered: food crops could be cultivated on drained bottomlands, and the less fertile slopes could then be used by livestock, thus reversing the present situation. This would improve the fertility of soil on the degraded slopes and ensure the future survival of the local farming community. Studies done by ILCA have demonstrated that it is feasible to construct ponds with locally made earth scoops drawn by animals. Ponds would not only provide water for human and animal consumption, but could also be used for irrigation.

One important area in which energy inefficiency could be reduced is that of post-harvest losses. Introduction of improved threshing and storage methods could substantially improve the welfare of subsistence farmers. Other areas where progress could be made are veterinary and extension services. Reducing livestock mortality, and improving animal nutrition and management would allow for increased energy use throughout the traditional agricultural system.

Regardless of the approaches taken to improve the overall energy use on smallholder farms, changes will be slow to take place unless a proper infrastructure and adequate extension and technical support services are established. Until this is accomplished any so called improvements in energy use will be short-lived, and ultimately have a negative impact on the selected target population.

References

Abiye Astatke. 1982. Comparison of efficiency between crossbred and local oxen as pairs. Internal document. ILCA, Addis Ababa.

Abiye Astatke and Matthews M D F.1982.1981. *Progress report of cultivation trials and related cultivation work at Debre Zeit and Debre Berhan.* ILCA, Addis Ababa.

Agren G and Gibson R.1968. *Food composition table for use in Ethiopia.* Children's Nutrition Unit Report No. 16. Swedish International Development Authority, Stockholm and Ethiopian Nutrition Institute, Addis Ababa.

Asfaw Alemu. 1982. Domestic energy use in rural Ethiopia (a case study in Ada district). Paper II. Draft Report. ILCA, Addis Ababa.

Baygell N A. 1979. Energy use in Ada Wereda. Internal document. ILCA, Addis Ababa.

Beijer Institute. 1981. *Policy issues in Ethiopian energy development.* Summary of workshop proceedings. Stockholm, Sweden.

Campbell J K. 1982. Feasibility study on employing windmills to provide water for livestock at ILCA's Debre Berhan Station, Ethiopia. Internal document. Department of Agricultural Engineering, Cornell University, Ithaca, New York.

Clark C and Haswell M. 1970. *The economics of subsistence agriculture.* Fourth Ed. Macmillan, St. Martin's Press, UK.

Cocks R J. 1981. Environmental degradation in the Ethiopian highlands. Internal document. Dept. of Agriculture, University of Reading.

Earthscan. 1981. *New and renewable energies 1 and 2.* Published in association with Development Forum and for the Joint United Nations Information Committee, London.

ECA (Economic Commission for Africa). 1980a. Report of the technical panel of experts on biomass (including fuelwood and charcoal). Regional preparatory meeting on new and renewable sources of energy. ECA, Addis Ababa.

ECA (Economic Commission for Africa). 1980b. Report of the technical panel of experts on geothermal energy. Regional preparatory meeting on new and renewable sources of energy. ECA, Addis Ababa.

FAO (Food and Agriculture Organization). 1982. FAO *production yearbook. Vol.* 36. FAO, Rome.

FaWCDA. (Forestry and Wildlife Conservation Development Authority). 1982. FAO/Ethiopia national workshop on fuelwood. FaWCDA, Addis Ababa.

Fraenkel P. 1975. *Food from windmills.* Intermediate Technology Publications Ltd., London.

Gill G. 1975. Improving traditional Ethiopian farming methods: Misconceptions, bottlenecks and blind alleys. *Rural Africana,* No. 28., Kenya.

Goe M R. 1983. Field research on power output and nutritional status of oxen in Amategna and Kormagafia Peasant Associations in Debre Berhan. Internal document. ILCA, Addis Ababa.

Gryseels G. 1983. Livestock in farming systems research for smallholder agriculture. Paper presented at the *'Seminar on Agricultural Research in Rwanda,'* Kigali.

Hobbs W. 1965. *Heating water with solar energy for household use in Ethiopia.* Miscellaneous Publication No. 6. College of Agriculture and Mechanical Arts, Dire Dawa, Ethiopia.

ILCA (International Livestock Centre for Africa). 1980. ILCA: The first years. ILCA, Addis Ababa.

MOA (Ministry of Agriculture). 1980. *Distribution of land and farm inputs among the farmers in Ethiopia with special reference to the distribution of traction power.* The Provisional Military Government of Socialist Ethiopia, MOA, Addis Ababa.

Varet J. 1978. Prospects of geothermal energy utilization in Ethiopia. *Ethiopian Journal of Science* 1(1): 11.

World Bank. 1982. *1981 World Bank Atlas.* World Bank, Washington.